# SNL 2023

*Marseille, France*


# *Program*

# SNL 2023

*October 24 - 26, 2023*
*Palais du Pharo*
*Marseille, France*

National Institutes of Health

Neurobiology of Language

Language, Cognition and Neuroscience

Rogue Research Inc.

RÉGION SUD PROVENCE ALPES CÔTE D'AZUR

ILCB Institute of Language, Communication and the Brain

# Welcome to SNL 2023!

Welcome to Marseille and the Fifteenth Annual Meeting of the Society for the Neurobiology of Language! We are excited to have our meeting in such a beautiful city and vibrant hub of language and neuroscience research. Judging by our registration numbers, so are you! We have an unprecedented turnout of over 750 participants, a remarkable 50% increase from our average attendance. We hope this is indicative of growth within our field and a sign that SNL is seen as a home society by a diverge range of language neurobiologists.

We are deeply indebted to our local organizers Cheryl Frenck Mestre and Xavier Alario for bringing us to their stunning city and setting us up for success here. Our meeting organizers Shauney Wilson, Shawna Lampkin and their team deserve an especially significant recognition this year for managing the added demands resulting from the remarkable surge in attendance. Thank you for your exceptional efforts! Special thanks are also due to Stephen M. Wilson, our program committee chair, for skillfully managing the record number of abstract submissions!

Our scientific program features an exciting menu of talks and posters, including our symposium winners: NLP-based brain modelling organized by Shailee Jain, hemispheric asymmetry by Benjamin Morillon and language development by Ola Ozernov-Palchik and Ev Fedorenko. Katie Slocombe will give a keynote lecture on the evolution of language, Jean-Rémi King on the languages of brains and machines, and Asli Özyürek on multimodality as a design feature of human language.

We are thrilled to acknowledge the exceptional career of Nina Dronkers with this year's Distinguished Career Award. Prof. Dronkers will deliver her Distinguished Career Lecture on Tuesday afternoon before our Welcome Reception.

This year's Early Career Award will be presented to Maaike Vandermoste and the Dissertation Award to Shailee Jain. Our society journal, Neurobiology of Language, is introducing a Best Paper Award, which goes to Kelly C. Martin this year, with Eleanor Huizeling receiving an honorable mention. Please join us to congratulate our award winners and to hear their talks on Wednesday afternoon!

For our students and postdocs, a special social lunch is organized by Suhail Matar on Tuesday. During our lunch breaks on Wednesday and Thursday, you also have the opportunity for one-on-one meetings with a representative from the NSF, Betty Tuller, program director for the Perception, Action, and Cognition (PAC) program.

Acknowledging global challenges, we will also host a Climate Change Discussion during Wednesday's lunch, with Daniele Schon speaking on academia's role in this critical time. To promote sustainable practices, we will also present a Carbon Prize to the conference attendee with the smallest carbon emissions, given their distance traveled to our meeting. Thanks to our local organizers Xavier Alario and Cheryl Frenck Mestre for this great idea!

This year, we are proud to partner with Black-in-Neuro and the Spark Society, two organizations with a mission to diversify the cognitive and neurosciences. We also launched a

web platform for member-initiated virtual activities outside our annual meeting. These initiatives aim to enhance the diversity and accessibility of our society's offerings.

A heartfelt thanks to our diligent program committee, who invested countless hours in planning: Stephen M. Wilson as Chair, Yanchao Bi, Michele T. Diaz, Andrea E. Martin, Suhail Matar, William Matchin and Sophie Scott. To all who contributed their time and expertise in reviewing abstract submissions, we extend our deepest appreciation.

We would like to acknowledge our sponsors: National Institutes of Health (Major Sponsor),

Neurobiology of Language (The MIT Press) (Gold Sponsor); Brain & Language (Elsevier) (Awards Sponsor); Language, Cognition & Neuroscience (Routledge) (Awards Sponsor); Rogue Research Inc. (Silver Sponsor); Artinis (Bronze Sponsor).

Wishing you a wonderful time at the conference and don't forget to tag us #SNL2023 and @SNLmtg on social media during the meeting!

Liina Pylkkanen,
Chair, Society for the Neurobiology of Language


*All times are shown in Marseille local time.*

| Tuesday, October 24, 2023 | | |
|---|---|---|
| 8:00 - 8:30 am | Coffee Break | Espace Vieux-Port |
| 8:00 am - 6:00 pm | Registration Open | Hall Est |
| 8:30 am - 5:30 pm | Exhibits Open | Hall Est |
| 8:45 - 9:00 am | Opening Remarks | Auditorium |
| 9:00 - 10:00 am | Keynote Address: Jean-Remi King | Auditorium |
| 10:00 - 10:15 am | Lightning Talks A | Auditorium |
| 10:15 - 10:45 am | Coffee Break | Espace Vieux-Port |
| 10:15 am - 12:00 pm | Poster Session A | Espace Vieux-Port |
| 12:00 - 1:30 pm | Lunch Break | Espace Vieux-Port & Terrasse Lacydon |
| 12:00 - 1:30 pm | Student & Postdoc Social Lunch | Hall Ouest |
| 1:30 - 3:30 pm | Symposium Session 1 - Can we investigate linguistic modularity in the brain with non-modular NLP systems? | Auditorium |
| 3:30 - 4:00 pm | Coffee Break | Espace Vieux-Port |
| 3:30 - 5:15 pm | Poster Session B | Espace Vieux-Port |
| 5:15 - 6:00 pm | Distinguished Career Award | Auditorium |
| 6:00 - 7:45 pm | Welcome Reception | Espace Vieux-Port |

## Wednesday, October 25, 2023

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|---|---|---|
| 7:30 - 8:00 am | Coffee Break | Espace Vieux-Port |
| 7:30 am - 6:00 pm | Registration Open | Hall Est |
| 8:00 - 10:00 am | Symposium Session 2 - Origin and function of hemispheric asymmetry for language: insights from neuroscience, animal models and clinical practice. | Auditorium |
| 8:00 am - 6:00 pm | Exhibits Open | Hall Est |
| 10:00 - 10:15 am | Lightning Talks C | Auditorium |
| 10:15 - 10:45 am | Coffee Break | Espace Vieux-Port |
| 10:15 am - 12:00 pm | Poster Session C | Espace Vieux-Port |
| 12:00 - 1:30 pm | Lunch Break | Espace Vieux-Port & Terrasse Lacydon |
| 12:00 - 1:30 pm | Meet with NSF Representative Betty Tuller | Hall Est |
| 12:15 - 1:30 pm | Climate Change Discussion | Salle 120 |
| 1:30 - 2:30 pm | Slide Session A | Auditorium |
| 2:30 - 3:25 pm | Awards Session: Early Career Award, Dissertation Award, and NoL Best Paper Award | Auditorium |
| 3:25 - 3:45 pm | Coffee Break | Espace Vieux-Port |
| 3:45 - 4:45 pm | Keynote Address: Katie Slocombe | Auditorium |
| 4:45 - 6:30 pm | Poster Session D | Espace Vieux-Port |
| 6:30 - 7:30 pm | Social Hour | Espace Vieux-Port |

## Thursday, October 26, 2023

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|---|---|---|
| 7:30 - 8:00 am | Coffee Break | Espace Vieux-Port |
| 7:30 am - 5:30 pm | Registration Open | Hall Est |
| 8:00 - 9:00 am | Slide Session B | Auditorium |

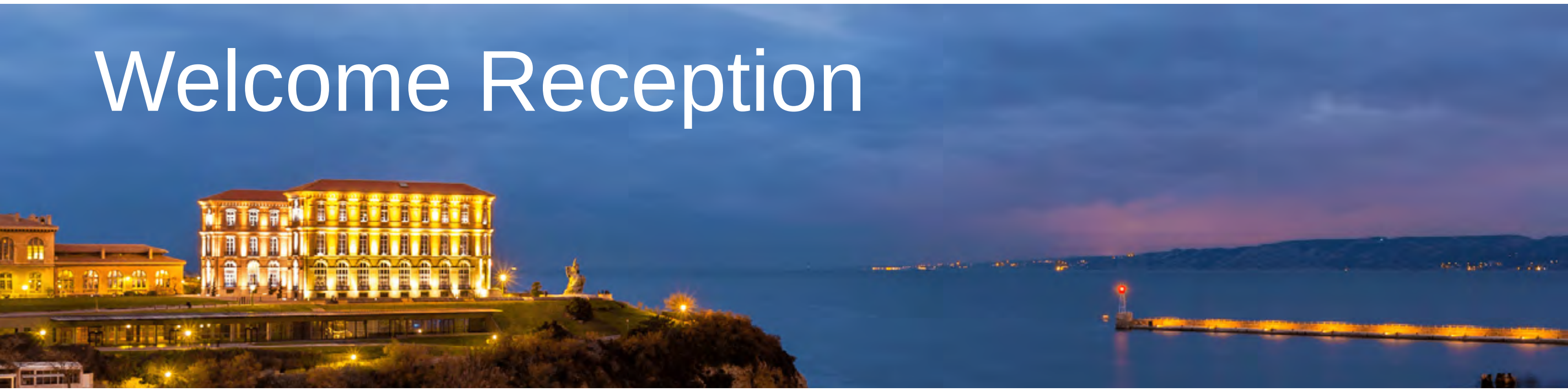
| | | |
|---|---|---|
| 8:00 am - 5:00 pm | Exhibits Open | Hall Est |
| 9:00 - 10:00 am | Keynote Address: Asli Ozyurek | Auditorium |
| 10:00 - 10:15 am | Lightning Talks E | Auditorium |
| 10:15 - 10:45 am | Coffee Break | Espace Vieux-Port |
| 10:15 am - 12:00 pm | Poster Session E | Espace Vieux-Port |
| 12:00 - 1:30 pm | Lunch Break | Espace Vieux-Port & Terrasse Lacydon |
| 12:00 - 1:30 pm | Meet with NSF Representative Betty Tuller | Hall Est |
| 1:30 - 3:30 pm | Symposium Session 3 - Unveiling the Neural Substrates of Early Language Development through Precision fMRI | Auditorium |
| 3:30 - 4:00 pm | Coffee Break | Espace Vieux-Port |
| 4:00 - 4:30 pm | Annual Business Meeting | Auditorium |
| 4:30 - 5:30 pm | Slide Session C | Auditorium |
| 5:30 - 5:45 pm | Closing Remarks and Outlook to SNL 2024 | Auditorium |

# Opening Remarks

*Tuesday, October 24, 2023, 8:45 – 9:00 am, Auditorium*

Prior to the first Keynote of the meeting, SNL Chair, Liina Pylkkänen, will welcome attendees to SNL 2023 in Marseille, France, and give an overview of what to expect at this year’s meeting.

# Welcome Reception



*Tuesday, October 24, 2023, 6:00 – 7:45 pm, Espace Vieux-Port*

SNL will host a Welcome Reception open to all SNL 2023 attendees. Meet us in the Espace Vieux-Port (poster room) for drinks and hors d’oeuvres. Use your SNL drink ticket to get a free drink. Alcoholic and non-alchoholic drinks are also available for purchase.

# Keynote Lecture: Jean-Rémi KING

## Jean-Rémi KING

### The languages of brains and machines.

*Tuesday, October 24, 2023, 9:00 – 10:00 am, Auditorium*

**Chair:** Stephen M. Wilson, University of Queensland
**Speaker:** Jean-Rémi KING, Meta AI, École Normale Supérieure, CNRS

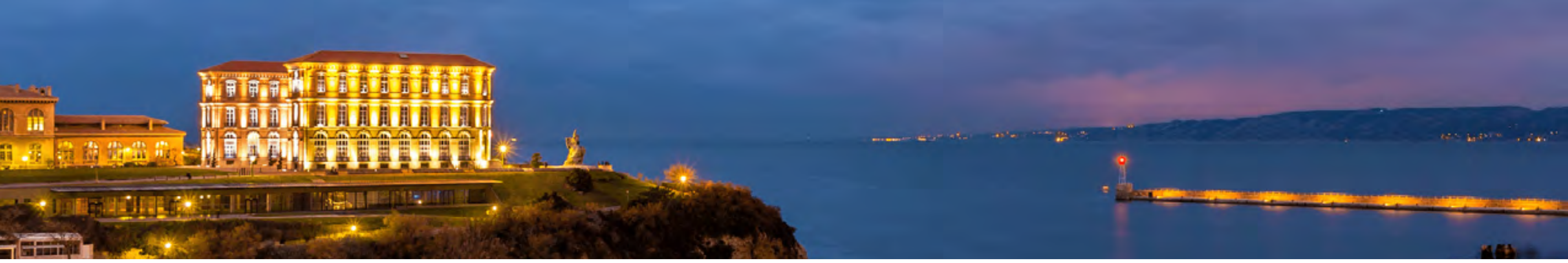
Deep learning has recently made major progress in speech and natural language processing. These models thus provide an unprecedented framework to understand and decode the representations of language in the human brain. Here, we study the similarities and differences between brains and large language models using large-scale datasets of magneto/electro-encephalography (M/EEG), functional Magnetic Resonance Imaging (fMRI), and intracranial recordings. Our analyses show how deep learning helps decomposing, interpreting and decoding the unfolding of syntactic and semantic representations in the adult human brain. More generally, these results delineate a clear path to understand the computational organization of natural language processing.

### About Jean-Rémi King

Jean-Rémi King, is a CNRS researcher at École Normale Supérieure in Paris, France, and is currently detached to Meta AI, where he leads the Brain & AI team. This team aims to identify the brain and computational bases of human intelligence, with a focus on language. For this, they develop deep learning algorithms to decode and model brain activity recorded with MEG, EEG, electrophysiology, fUS and fMRI.

The SNL 2023 Keynote Lecture is Sponsored by The MIT Press.

# Keynote Lecture: Katie Slocombe



## Katie Slocombe

### The evolution of language: What do chimpanzees have to say?

*Wednesday, October 25, 2023, 3:45 – 4:45 pm, Auditorium*

**Chair:** Sophie Scott, University College London
**Speaker:** Katie Slocombe, University of York

Language is unparalleled in its complexity and understanding its evolutionary origins is a scientific question of enduring interest. One powerful approach to understanding how language evolved is to compare the communication systems of humans with those of other primates. Patterns of similarities and differences between species within a comparative framework allows us to infer which structural or socio-cognitive elements of language are uniquely human and which may have more ancient evolutionary roots. As one of our closest living relatives, chimpanzees are a particularly informative comparator species. I will discuss the degree to which there are commonalities and differences between aspects of chimpanzee vocal communication and human language, such as reference. I will then consider the psychological mechanisms underpinning signal production in chimpanzees, focussing on flexibility and intentionality. Finally, I will consider the degree to which aspects of social cognition, such as joint attention, which provide crucial scaffolding for human language, may be present in our closest living relatives.

### About Katie Slocombe

Dr Slocombe's research interests center around using the comparative approach to understand how key aspects of human cognition evolved, including human language. Her work focuses on chimpanzee vocal communication and in particular, the extent to which our closest living relatives can use calls to refer to objects and events in the external environment and the psychological mechanisms underlying call production. This behavioral work has been conducted with both wild and captive populations of chimpanzees. Her current core research topics include multimodal communication and joint attention in chimpanzees and human infants, cognition in parrots and corvids, and chimpanzee welfare.

The SNL 2023 Keynote Lecture is Sponsored by The MIT Press.

# Keynote Lecture: Asli Özyürek

## Asli Özyürek

### Multimodality as a design feature of human language: Insights from brain, behavior and diversity

*Thursday, October 26, 2023, 9:00 – 10:00 am, Auditorium*

**Chair:** Andrea E. Martin, Radboud University

**Speaker:** Asli Özyürek, Max Planck Institute for Psycholinguistics

Understanding how brain processes language requires certain assumptions about how we define language. Most theories and models about the nature of human language have been based on aspects of language that can be either spoken or written. For example, traditionally language has been defined uniquely as a system composed of uni-modal combinatorial units with arbitrary form-meaning mappings, and sequential organization, etc. These assumptions still drive LLMs (e.g., ChatGPT), many neuro and psycholinguistic studies, and proposed processing mechanisms in brain and cognition (e.g., prediction of upcoming words etc).

However a mostly ignored but universal aspect of language is that all languages of the world embody “visible” components; spoken languages are accompanied by manual and facial gestures and language can be expressed by signed languages as well as spoken languages. I will argue that taking into account such universally shared visible components and their modality specific characteristics such as visible iconicity and indexicality and simultaneity (e.g., saying “play” in speech and performing a piano playing gesture at the same time) question some of our assumptions about language structure, its use in interaction, (neural) processing, acquisition and evolution. To do so I will present evidence from interdisciplinary multimodal research (e.g., language production, eye tracking, imaging) conducted in diverse spoken and signed languages and with individuals who lack accessibility to different sensory experiences (e.g, deaf, blind). I will argue that a multimodal but not a unimodal view of language can explain its adaptive structure, resiliency and learnability in different contexts and cultures with individual variations.

## About Asli Özyürek

Asli Özyürek, received a joint PhD in Linguistics and Psychology from the University of Chicago. She is currently the Director of Multimodal Language Department at the Max Planck Institute for Psycholinguistics and is a Professor at Radboud University. She is also a PI at Donders Institute for Brain Cognition and Behavior and an elected member of Academia Europea. She has received many prestigious grants from NSF, NIH, Dutch Science Foundation, ERC and Turkish Science Foundation. Özyürek investigates the inherently and universal multimodal nature of human language capacity as one of its adaptive design features. To do so she studies how brain supports multimodal language, how typologically different spoken and signed languages pattern their structures given their multimodal diversity, and how the learning constraints and communicative pressures of interaction shape multimodal language, its acquisition and evolution as an adaptive system. She uses a variety of methodologies such as behavioral and kinematic analyses of multimodal linguistic structures, eye tracking, machine learning and brain imaging to understand the complex multimodal nature of human language capacity.

The SNL 2023 Keynote Lecture is Sponsored by The MIT Press.

# Distinguished Career Award Recipient

## Nina Dronkers

**The Society of the Neurobiology of Language is pleased to announce the 2023 Distinguished Career Award recipient: Nina Dronkers**


The Distinguished Career Award is generously sponsored by Language, Cognition and Neuroscience.

*Tuesday, October 24, 2023, 5:15 – 6:00 pm, Auditorium*

**Chair:** Kate Watkins, University of Oxford
**Speaker:** Nina Dronkers, University of California, Berkeley and University of California, Davis

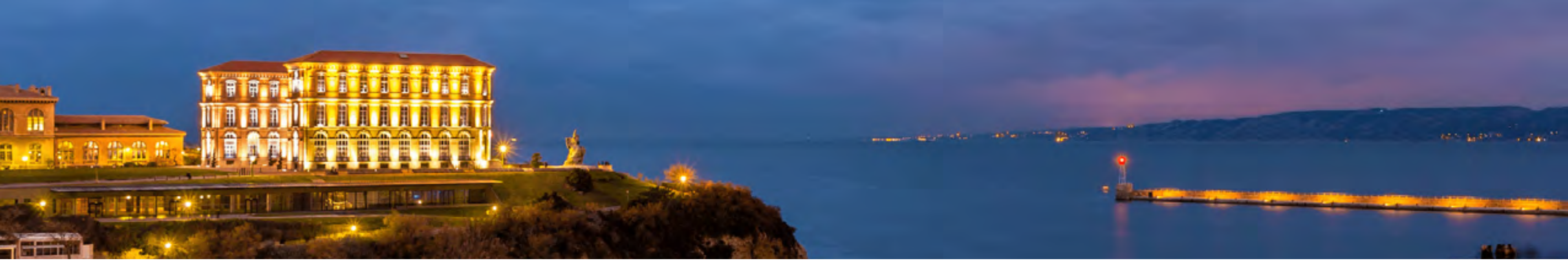
Nina Dronkers is an inspirational leader in the field of neurobiology of language. Her careful attention to the neuroanatomical correlates of symptoms of aphasia has significantly advanced our understanding of the neural basis of language, challenged dogma, and stimulated new avenues of investigation. She and her colleagues pioneered the use of voxel-based lesion-symptom mapping, which has become an important tool for relating cognitive functions to discrete brain regions. She examined lesion overlap maps in stroke patients and demonstrated that damage to a small part of the anterior insula, not the overlying cortex of classical “Broca’s area”, was associated in all cases with apraxia of speech. Further, when the insula was spared, speech apraxia was not evident. This dissociation was groundbreaking, and led to a reevaluation of the importance of the lateral inferior frontal cortex to speech function. She extended this by scanning the two brains evaluated by Broca in his original 1861 paper establishing “Broca’s aphasia”. Dr Dronkers described how the lesions extended much more medially than originally determined and included the insula and important fiber pathways. These new findings further challenged the field’s century-old reliance on Broca’s original description of the left inferior frontal cortex as critical to expressive language.

For over 40 years, Dr Dronkers has carefully characterised the language deficits in large numbers of patients with acquired brain damage through stroke. Her linguistic training and clinical expertise, coupled with detailed anatomical information from brain scans, has allowed her to relate specific brain areas to detailed language and cognitive functions. She was also early to embrace the potential of diffusion imaging to understand the role of damage to white matter pathways underpinning communication between brain areas in the language network. This work has influenced clinic practice by improving diagnostic tools and developing interventions for patients with aphasia.

In addition to extensive and remarkable scientific contributions, Dr Dronkers has been an outstanding leader. She has led and participated actively in both the Society for Neurobiology of Language and the Academy of Aphasia. She has reviewed extensively for the journals in our field and served on numerous funding committees. She is frequently asked to contribute to teaching and give invited talks in clinical and university settings at home and abroad. She has also created a patient referral pool of left hemisphere stroke patients with aphasia who are eager to participate in research, with new participants constantly being referred from fellow clinicians, colleagues, or former patients.

Dr Dronkers is an exceptional teacher, and loves to collaborate and share her expertise with colleagues. She fosters a nurturing and intellectually stimulating environment, and has mentored, and inspired, many in our community. She has facilitated the careers of many young scientists and influences colleagues at all levels who seek to follow her example of leadership.

# Dissertation Award



## Shailee Jain

**The Society for the Neurobiology of Language is pleased to announce the 2023 Dissertation Award recipient: Shailee Jain**


The Dissertation Award is generously sponsored by *Brain and Language*.

### Investigating the neurobiology of language with artificial language systems

*Wednesday, October 25, 2023, 2:30 – 3:25 pm, Auditorium*

**Chair:** Liina Pylkkänen, New York University
**Speaker:** Shailee Jain, University of Texas at Austin

Shailee Jain completed her PhD in Computer Science at the University of Texas at Austin in July 2023, where she was advised by Dr. Alexander Huth. In August 2023 she started as a postdoctoral fellow with Dr. Edward Chang in the Department of Neurosurgery at the University of California, San Francisco. Before pursuing her PhD Shailee did her bachelors at NITK, Surathakal, India where she was a university gold medalist. In her dissertation, Shailee Jain blazed a new trail for computational neurolinguistics by bridging computer science and neuroscience. Shailee's thesis work includes some of the earliest links between neural network language models and fMRI recordings, as well as a roadmap for how those models can be interpreted to gain insights into the brain. Papers describing this work have appeared in NeurIPS, ICML, Nature Neuroscience, Neurobiology of Language, and the Journal of Neuroscience. Shailee has also worked hard to build a community around these new computational approaches by co-organizing workshops on neuroscience & AI at NeurIPS (2019, 2022) and ICLR (2020), and she will be hosting a related symposium at SNL 2023. During her PhD, she was supported by fellowships from the William Orr Dingwall foundation and the UT Austin Graduate School. Shailee was selected as a MIT EECS Rising Star in 2021.

# Early Career Award

## Maaike Vandermosten


**The Society for the Neurobiology of Language is pleased to announce the 2023 Early Career Award recipient: Maaike Vandermosten**

The Early Career Award is generously sponsored by Brain and Language

### Neuroprediction and neuroplasticity in developmental dyslexia and aphasia

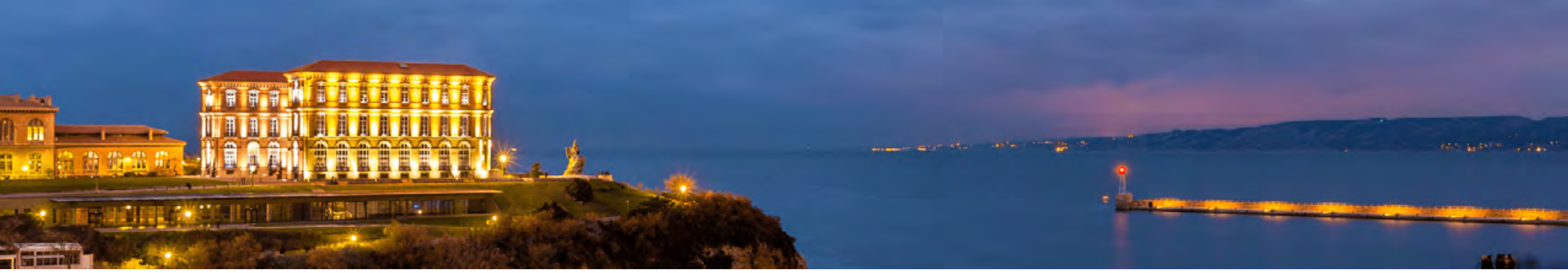
*Wednesday, October 25, 2023, 2:30 – 3:25 pm, Auditorium*

**Chair:** Liina Pylkkänen, New York University
**Speaker:** Maaike Vandermosten, KU Leuven

Maaike Vandermosten received in 2012 her PhD from KU Leuven, after which she did a postdoc with research stays at the Medical School of UCSF, the Cognitive Neuroscience Unit of Maastricht University and the Brain & Language Lab of Université de Genève. In 2017, she started her tenure track at the department of Neurosciences of KU Leuven, where she is now associate professor and head of the Speech and Language Research lab.

During her PhD, she examined the interrelations between reading, speech processing and brain connectivity in persons with dyslexia. She first gained expertise in designing psychophysical auditory and speech experiments (e.g. Vandermosten et al., 2010, PNAS), followed by expertise in diffusion MRI tractography, a technique which she was one of the first to apply within the field of dyslexia (e.g. Vandermosten et al., 2012, Brain). During her postdoctoral years, she extended her knowledge towards the neurodevelopment of reading, and played a pioneering role in setting up MRI-studies in pre-reading children, with longitudinal follow-up throughout primary school (e.g. Vandermosten et al., 2015, DevCognNeuroSci; Phan et al., 2021, HBM). This provided unique insights into the neural origins of later reading problems as well as neuroplasticity. At the start of her tenure track, she continued her research on dyslexia, but also established a new research line on stroke-induced aphasia. Relying on her expertise with predictive and longitudinal studies in young children, she led a project on the prediction and neuroplasticity in aphasia from the acute to the chronic stage (e.g. Schevenels et al., 2022, NeuroImageClinical). In her recent studies, natural speech takes a central role, as this allows to gain rich and ecologically-valid information on language processing in difficult-to-test populations such as very young children and persons with aphasia.

# 2023 Award Winners



## Merit Awards

**Graduate Student Abstract Merit Awards**

Kathryn Snyder, *UTHSC, USA*

Zaid Zada, *Princeton University, USA*

**Postdoctoral Merit Awards**

Amirhossein Khalilian-Gourtani, *New York University, USA*

Anni Nora, *Aalto University, Espoo, Finland*

**Honorable Mention**

Maya Inbar, *Hebrew University of Jerusalem, Israel*

Jiahui Lu, *Beijing Normal University, China*

Chiara Luna Rivolta, *Basque Center on Cognition, Brain and Language (BCBL), Spain*

Terri L. Scott, *UCSF, USA*

Lin Wang, *Harvard Medical School, Charlestown, MA, USA*

## Travel Awards

Katherine Andrade, *San Diego State University/University of California, San Diego, USA*

Eleonora Judith Beier, *University of California, Davis, USA*

Ilina Bhaya-Grossman, *University of California, San Francisco, USA*

Tifani Biro, *University of Pennsylvania, USA*

Olivia Bizimungu, *McGill University, Canada*

Christina Blomquist, *University of Maryland – College Park, USA*

Cristina Cano Melle, *Jaume I University, Spain*

Isaac Falconer, *Boston University, USA*

Xuancu Hong, *The Chinese University of Hong Kong, Hong Kong*

Maya Inbar, Hebrew *University of Jerusalem, Israel*

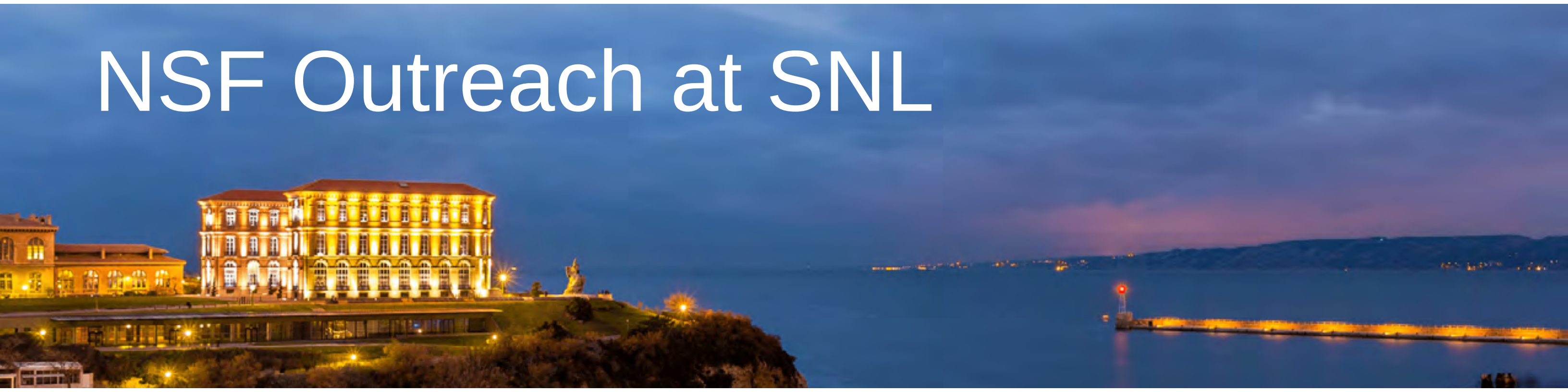
Jessie R. Liu, *University of California San Francisco, USA*

Jordi Martorell, *Basque Center on Cognition, Brain and Language (BCBL), Spain*

Aline-Priscillia Messi, *New York University, USA*

Arielle Moore, *Boston University, USA*

Hongbin Qing, *City University of Hong Kong, Hong Kong*
Juliana Ronderos, *Boston University, USA*
Ashley Symons, Birkbeck, *University of London, United Kingdom*
María José Torres-Prioris, *University of Malaga, Spain*
Agata Wolna, *Institute of Psychology*, *Jagiellonian University, Krakow, Poland*
Leyao Yu, *New York University, USA*



# NSF Outreach at SNL

## Meet with NSF Representative Betty Tuller

*Wednesday, October 25, 2023, 12:00 – 1:30 pm, Hall Est*

*Thursday, October 26, 2023, 12:00 – 1:30 pm, Hall Est*

The Perception, Action, and Cognition (PAC) program at the National Science Foundation supports empirically grounded, theoretically engaged and methodologically sophisticated research in a wide range of topic areas related to human perceptual, motor, and cognitive processes and their interactions. The program funds a variety of projects involved in understanding the human capacity for language. Betty Tuller, program director for the PAC program will be available during the lunch breaks on Wednesday and Thursday to meet one-on-one with interested scientists to discuss the PAC program specifically or language funding at NSF funding more generally.

Stop by the NSF table located near the Registration desk to sign up for a slot to meet one-on-one with Betty. You can also email Betty to meet with her outside the scheduled lunch breaks.

# Student & Postdoc Social Lunch

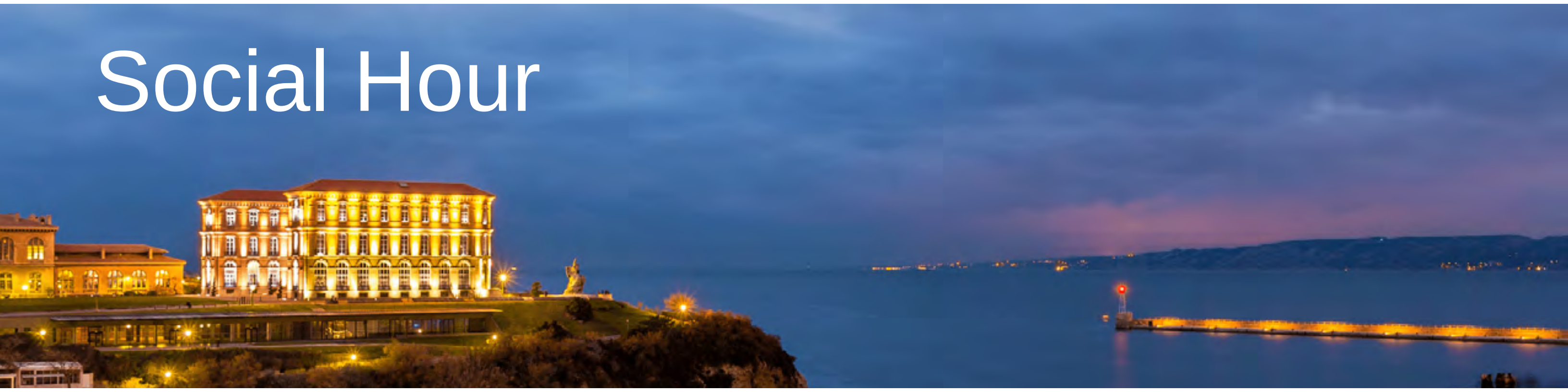
*Tuesday, October 24, 12:00 – 1:30 pm, Hall Ouest*

Join us for the Student and Postdoc Social Lunch! Come make new connections, mingle with old friends, and meet people you've only ever seen via Zoom. The current student and postdoc representative, Suhail Matar, will plan activities to encourage participants to get to know each other on a personal and professional level.

Lunch is included for students and postdocs who register to attend the social hour.

**The Student & Postdoc Social Lunch is SOLD OUT.**

# Social Hour

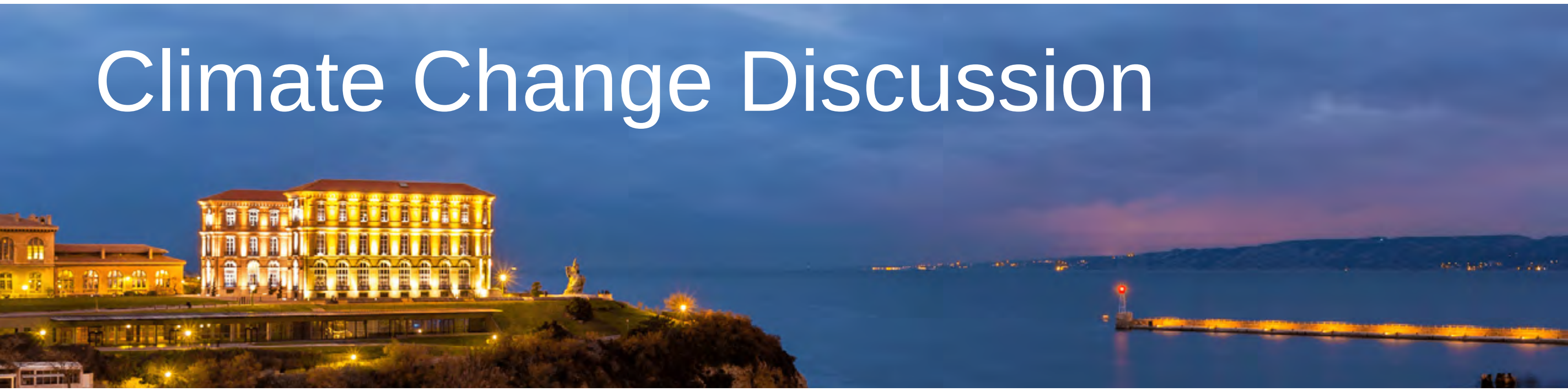


*Wednesday, October 25, 2023, 6:30 – 7:30 pm, Espace Vieux-Port*

Join us for social hour in the Espace Vieux-Port, immediately following Poster Session D, to relax with your colleagues.

Drinks and hors d'oeuvres will be served. Use your SNL drink ticket to get a free drink. Alcoholic and non-alchoholic drinks are also available for purchase.

# Climate Change Discussion



## Scientia quo vadis?

*Wednesday, October 25, 12:15 – 1:30 pm, Salle 120*

**Speaker**: Daniele Schon, Institut de Neuroscience des Systèmes, Inserm & Aix-Marseille Université

In this talk I will discuss the changes of scientific practices in light of the climate changes. In particular I will show that science has followed a growth model, similar to the one of CO2 emissions. I will then discuss the great challenges that science has to face and how we need to rethink academia in a time of climate crisis.

Feel free to grab your box lunch and bring it with you to the discussion in Salle 120.

# NoL Best Paper Award

## Neurobiology of Language Best Paper Award 2022

The Editors-in-Chief selected the following Neurobiology of Language papers from those published in 2022 (Volume 3):

### Best Paper Award

**Kelly C. Martin**, *Georgetown University,* receives the Best Paper Award 2022 for the paper:

Martin, K. C., Seydell-Greenwald, A., Berl, M. M., Gaillard, W. D., Turkeltaub, P. E., & Newport, E. L. (2022). A weak shadow of early life language processing persists in the right hemisphere of the mature brain. *Neurobiology of Language*, *3*(3), 364-385.

Kelly will give a short talk at the Awards Session on Wednesday, October 25 at 2:30 pm in the Auditorium.

### Honorable Mention

**Eleanor Huizeling**, *Max Planck Institute for Psycholinguistics,* receives an Honorable Mention for the paper:

Huizeling, E., Arana, S., Hagoort, P., & Schoffelen, J. M. (2022). Lexical frequency and sentence context influence the brain's response to single words. *Neurobiology of Language*, *3*(1), 149-179.

Both Kelly and Eleanor will be recognized at the SNL Awards session.


*Thursday, October 26, 2023, 4:00 – 4:30 pm, Auditorium*

Join the SNL Board of Directors for the Annual Business Meeting. SNL leadership will review what the Society has accomplished in 2023 and discuss the outlook and priorities for 2024. The Business Meeting is an opportunity for SNL members to ask questions of the SNL Board and bring up issues of concern to the general membership.

You may send questions before the start of the Business Meeting to info@neurolang.org.

# Attendee Resources

## Airport Information

The Marseille Provence Airport (MRS) is located approximately 16 miles from the Palais du Pharo.

## Audio-Visual

An LCD projector (e.g., for PowerPoint presentations) will be provided in the Auditorium; however, computers are NOT provided. Presenters must bring their own computers and set them up BEFORE the start of the session in which they are presenting. Presenters must arrive at the auditorium a minimum of 30 minutes before their talk. Talk presenters should review Speaker Instructions.

## Business Meeting

The SNL Business Meeting is Thursday, October 26 at 4:00 p.m. All SNL members are encouraged to attend. This is your opportunity to hear about SNL, ask questions, and give feedback.

## Certificate of Attendance

Certificates of Attendance will be available in your SNL account the last day of the meeting. If you require additional assistance, visit the Registration Desk.

## Childcare

SNL is pleased to offer onsite childcare at this year's meeting in Marseille.

**Childcare Hours**

Tuesday, October 24, 8:30 am – 6:30 pm

Wednesday, October 25, 7:45 am – 7:15 pm

Thursday, October 26, 7:45 am – 5:45 pm

## Code of Conduct

The Society for the Neurobiology of Language is committed to providing a safe and professional environment during our annual meeting. All Attendees are expected to conduct themselves in a professional manner. It is unlawful to harass any person or employee because of that person's gender, sexual orientation, or race. In addition, we require that all questions and comments to speakers and poster presenters be respectful and collegial. Verbal aggression will not be tolerated.

# Contact Us

To contact us onsite, visit the Registration Desk in the Hall Est, or send an email to info@neurolang.org. We will respond to your email at our earliest opportunity.

# Copying & Printing

For local poster printing, please inquire at either Marseille Imprimerie or CopyTop.

# Disclaimer

The SNL Program Committee reserves the right to make changes to the meeting program at any time without notice. This program was correct at the time of printing.

# Emergency

European emergency number: 112

# Exhibits

SNL is pleased to have the following companies exhibiting this year: The MIT Press, Rogue Research and Artinis

All exhibits are located in the Hall Est.

**Exhibit Hours**
Tuesday, October 24, 8:30 am – 5:30 pm
Wednesday, October 25, 8:00 am – 6:00 pm
Thursday, October 26, 8:00 am – 5:00 pm

# Food Service

## Complimentary Food and Beverage Service:

**Tuesday**
Coffee Break, 8:00 – 8:30 am
Coffee Break, 10:15 – 10:45 am
Coffee Break, 3:30 – 4:00 pm
Welcome Reception, 6:00 – 7:45 pm

**Wednesday**
Coffee Break, 7:30 – 8:00 am
Coffee Break, 10:15 – 10:45 am
Coffee Break, 3:25 – 3:45 pm
Social Hour, 6:30 – 7:30 pm

**Thursday**

Coffee Break, 7:30 – 8:00 am
Coffee Break, 10:15 – 10:45 am
Coffee Break, 3:30 – 4:00 pm

**Lunch Breaks**
SNL provides a 1.5-hour lunch break each day. With limited restaurant options within walking distance of Palais du Pharo, for your convenience, SNL is offering a subsidized gourmet box lunch option hosted by La Truffe Noire for each day of the meeting, for a nominal fee of $10 per lunch. Pre-ordering is required by September 25. A limited number of lunch boxes will be available onsite. See the Registration Desk for more information.

# Future Meetings

SNL 2024 will be held October 24-26 in Brisbane, Australia.
Proposals for SNL 2025 and 2026 are now being accepted.

# Guest Policy

Guests are allowed complimentary entry into one SNL session (for the purposes of seeing the poster or slide of the person they are a guest of).

Guests must register at the SNL Registration Desk upon arrival and must be accompanied by the SNL attendee. Guests must wear a badge for entrance into the session they are attending.

# Internet Access

Internet access is complimentary in all meeting rooms at Le Palais du Pharo.

# Lost & Found

Please check with the SNL Registration Desk for lost and found items.

# Meeting Rooms

All general sessions (Keynotes, Award Talks, Slides, Lighting Talks, and Symposia) will be held in the Auditorium. Posters will be presented in Espace Vieux-Port.

# Messages

A bulletin board will be available for messages and job postings near the SNL Registration Desk.

# Mobile Phones

Attendees are asked to silence their mobile phones when in sessions.

# Name Badges

For security purposes, all attendees must wear their name badge to all sessions and social functions. Entrance into sessions is restricted to registered attendees only. If you misplace your name badge, please go to the Registration Desk for a replacement.

# Phone Charging Station

For your convenience, a phone charging station is located at the Registration Desk.

# Poster Printing

See Copying and Printing.

# Poster Sessions

Posters are located in Espace Vieux-Portl. See Poster Sessions.

Lighting Talk Sessions are located in the Auditorium. See Lighting Talks.

# Registration

The SNL Registration Desk is located in Hall Est.

**Registration Desk Hours**

Tuesday, October 24, 8:00 am – 6:00 pm

Wednesday, October 25, 7:30 am – 6:00 pm

Thursday, October 26, 7:30 am – 5:30 pm

# Smoking

Smoking, including the use of e-cigarettes, is not permitted inside the Palais du Pharo.

# Social Events

**Opening Night Reception**

This year's Welcome Reception will be held at the Palais du Pharo. Join your colleagues on Tuesday, October 24 at 6:00 pm in Espace Vieux-Port for great science and some delicious food and drink. The first drink is on SNL – look for a drink ticket in the back of your badge!

**Social Hour**

Join us for social hour in the Espace Vieux-Port, immediately following Poster Session D, to relax with your colleagues. Drinks and hors d'oeuvres will be served. Use your SNL drink ticket to get a free drink. Alcoholic and non-alchoholic drinks are also available for purchase.

# Social Media

Join the SNL discussion on Twitter!

- Follow @SNLmtg for meeting information
- Follow SNL colleagues (like @kemmorey1, @jpeelle and @smwilsonau)
- Tag meeting-related tweets with #SNL2023
- Join in the conversation by searching for tweets tagged #SNL2023

## Speakers

See the Audio-Visual section above.

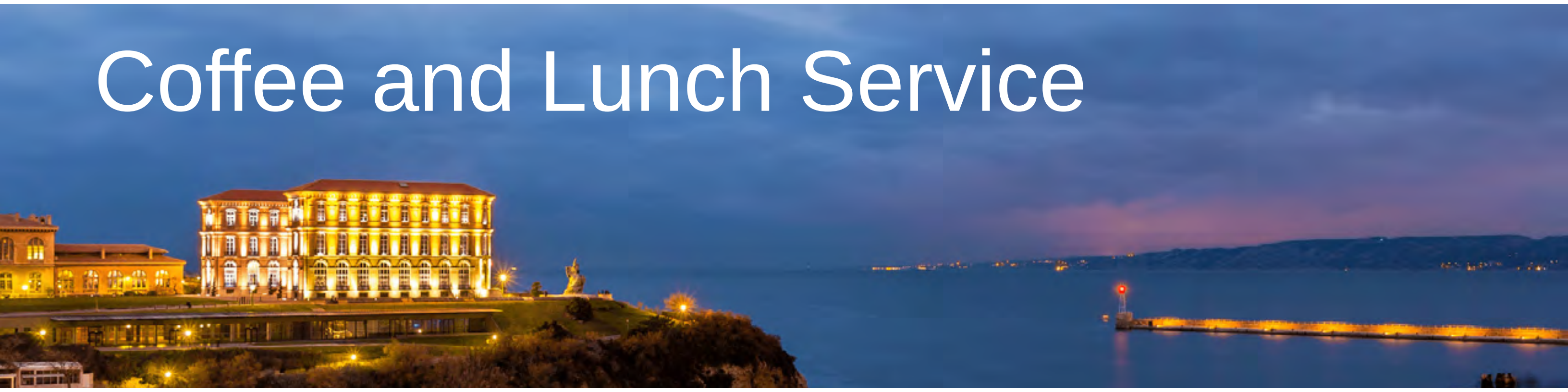
## Transportation

For directions from the Marseille airport and the train station to the Palais du Pharo, seeTransportation.

## Venue Location

Palais du Pharo is located at 58 Bd Charles Livon, 13007 , Marseille, France.

# Coffee and Lunch Service



## Coffee Service

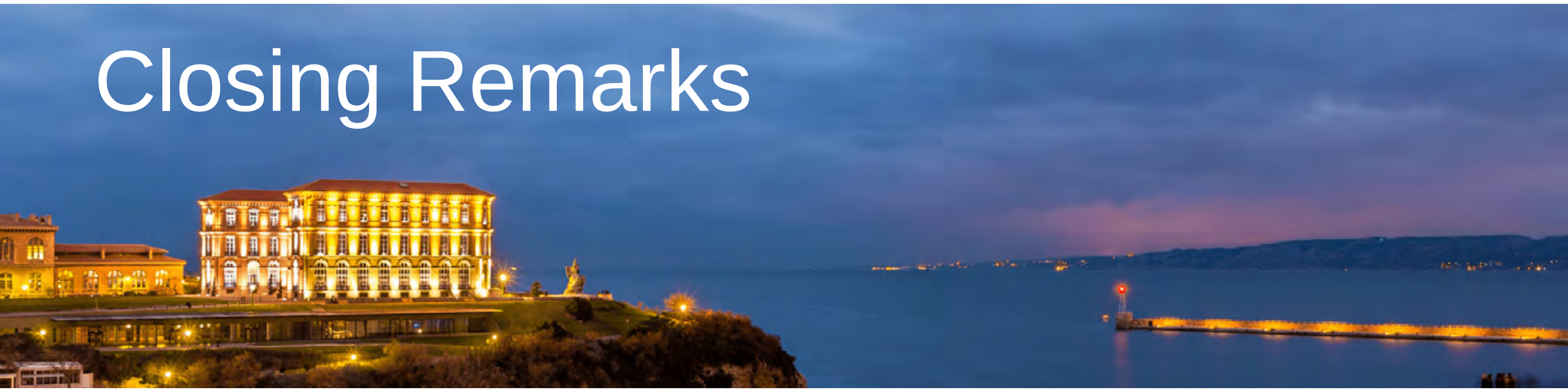
Coffee breaks are scheduled twice each morning and once each afternoon throughout the meeting. Coffee service is in Espace Vieux-Port (the back of the poster room). Coffee, tea and fruit juice is available. Mini pastries are available at the morning coffee breaks.

## Lunch Service

Box lunch by *La Truffe Noire* is served every day from 12:00-1:30 pm in Espace Vieux-Port (the back of the poster room). Box lunches were pre-ordered. A limited number of box lunches will be available onsite. Please see the Registration desk.

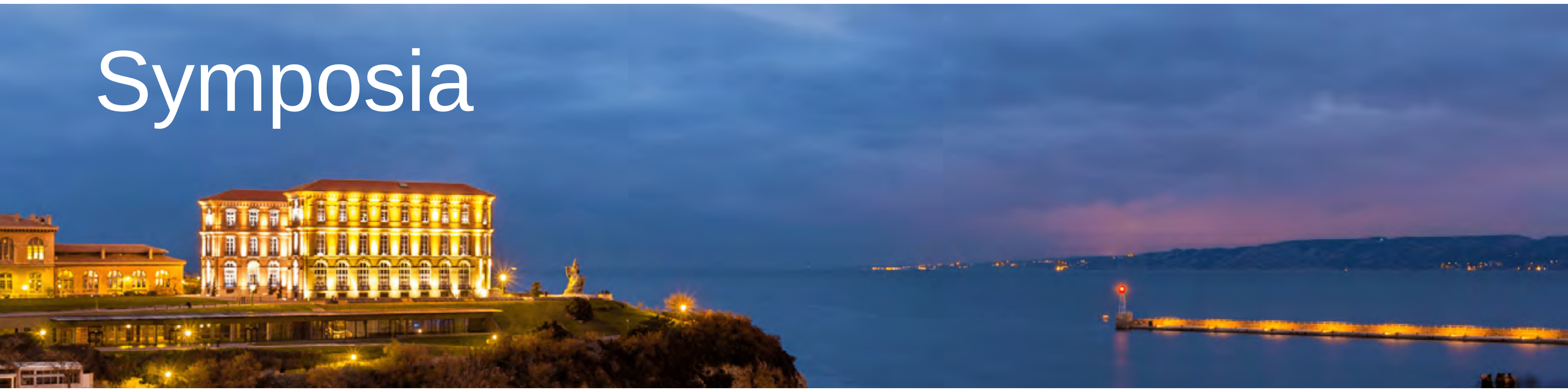
Additional seating is available outside on the Terrasse Lacydon and Hall Ouest.

# Closing Remarks



*Thursday, October 26, 2023, 5:30 – 5:45 pm, Auditorium*

Outgoing SNL chair, Liina Pylkkänen, will deliver closing remarks and hand the reins to Sophie Scott, the incoming SNL chair. Sonia will discuss plans for the 2024 meeting in Brisbane, Australia!



# Symposia



## Can we investigate linguistic modularity in the brain with non-modular NLP systems?

*Tuesday, October 24, 1:30 - 3:30 pm CEST, Auditorium*

**Organizer:** Shailee Jain[1,2]; [1]The University of Texas at Austin, [2]The University of California, San Francisco

The rise of natural-language-processing (NLP) systems has led to an overwhelming paradigm shift in language neuroscience. These systems jointly capture linguistic information at many different levels like syntax, semantics and discourse. Proponents of NLP-based brain modeling believe that this integration facilitates investigation of multiple brain processes simultaneously, unlike traditional paradigms that target specific manipulations. Critics believe that their lack of modularity and "black-box" nature hampers isolation of distinct processes and leads to biases. Our field has reached an impasse where "global organization" claims from NLP-based models often contradict "functional localization" claims from controlled experiments, lesion-mapping and neural disorders. In a rare event, we bring together neurolinguists/psychologists/computer-scientists for a general audience to discuss which brain mechanisms we can infer from these vastly different artificial systems, perils of NLP-systems not grounded in linguistic theory vs. pigeonholing brain function into known theories and utility of NLP interpretability tools to isolate distinct brain processes. View Talks

## Origin and function of hemispheric asymmetry for language: insights from neuroscience, animal models and clinical practice.

*Wednesday, October 25, 8:00 - 10:00 am CEST, Auditorium*

**Organizers:** Benjamin Morillon[1,2]; [1]Aix Marseille Université, [2]Inserm

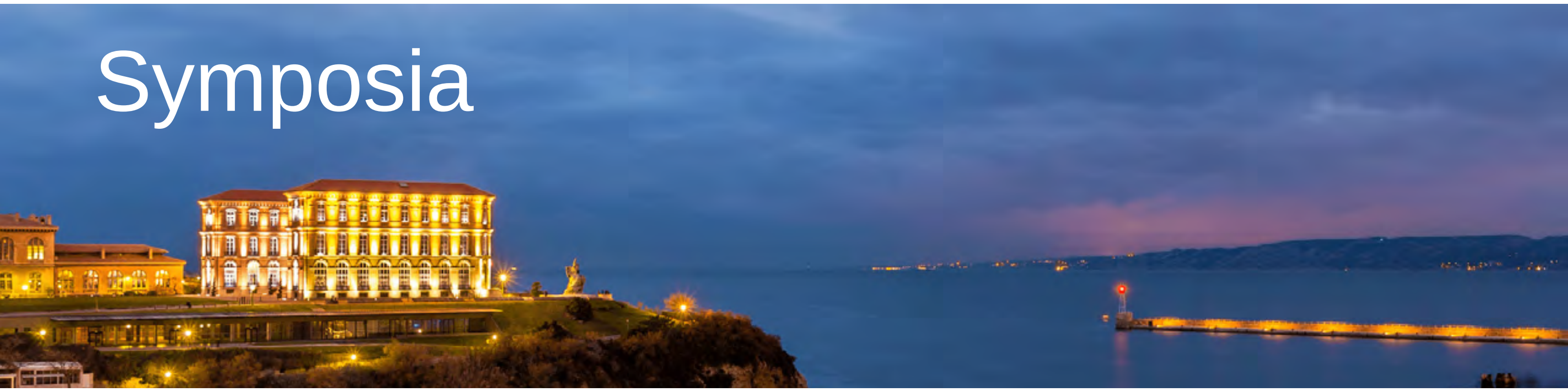
Our interdisciplinary symposium aims to shed light on the origin and function of hemispheric asymmetry for language through fundamental and clinical research, language perception and production research, as well as comparative evolutionary approaches across primates. It offers the latest perspectives on this historic question in cognitive neuroscience, with the comparison of complementary and even incompatible points of view. In particular, the sensory or motor origin of brain asymmetry will be debated, together with the presence or absence of lateralization of specific cognitive processes. The symposium is suitable for students and faculty interested in cognitive neuroscience, linguistics, and communication disorders. Attendees will benefit from gaining knowledge on the latest theories and empirical findings that describe the complex relationship between brain asymmetry and language processing. Overall, this symposium offers a unique opportunity to explore the cutting-edge research on hemispheric specialization in the brain and its implications for language and communication. View Talks

# Unveiling the Neural Substrates of Early Language Development through Precision fMRI

*Thursday, October 26, 1:30 - 3:30 pm CEST, Auditorium*

**Organizers:** Ola Ozernov-Palchik[1], Ev Fedorenko[1]; [1]MIT

Linguistic skills develop extremely rapidly early in life: by age 3-4, children can already understand and express complex ideas. Furthermore, formal education, including learning to read, fosters the development of vocabulary and the acquisition of complex structures. Despite comprehensive behavioral characterization, the neural substrates of early language learning and processing remain poorly understood. This symposium focuses on the individual-subject (precision) fMRI approach and tackles several open questions in the field: 1) Is the language network already selective and left-lateralized early in life? 2) What role do non-linguistic capacities play in language learning? 3) How does learning to read (or struggling to do so) affect the language system and the brain in general? Jointly, these talks from an all-female panel from different institutions, countries of origin, ethnic backgrounds, and career stages highlight complementary lines of work at the cutting edge of the neurobiology of language development. View Talks






# Can we investigate linguistic modularity in the brain with non-modular NLP systems?

*Tuesday, October 24, 1:30 - 3:30 pm CEST, Auditorium*

**Organizer:** Shailee Jain[1,2]; [1]The University of Texas at Austin, [2]The University of California, San Francisco

**Presenters**: Gina Kuperberg, Leila Wehbe, Andrea E. Martin, Alexander G. Huth, Christophe Pallier

The rise of natural-language-processing (NLP) systems has led to an overwhelming paradigm shift in language neuroscience. These systems jointly capture linguistic information at many different levels like syntax, semantics and discourse. Proponents of NLP-based brain modeling believe that this integration facilitates investigation of multiple brain processes simultaneously, unlike traditional paradigms that target specific manipulations. Critics believe that their lack of modularity and “black-box” nature hampers isolation of distinct processes and leads to biases. Our field has reached an impasse where “global organization” claims from NLP-based models often contradict “functional localization” claims from controlled experiments, lesion-mapping and neural disorders. In a rare event, we bring together neurolinguists/psychologists/computer-scientists for a general audience to discuss which brain mechanisms we can infer from these vastly different artificial systems, perils of NLP-systems not grounded in linguistic theory vs. pigeonholing brain function into known theories and utility of NLP interpretability tools to isolate distinct brain processes.

**Presentations**

## The Potential and Limitations of Large Language Models for Understanding Predictive Language Processing

Gina Kuperberg[1,2]; [1]Tufts University, [2]Massachusetts General Hospital

By being trained to predict upcoming words, Large Language Models (LLMs) have achieved tremendous success in generating human-like language. Given the brain’s sensitivity to the contextual predictability of incoming words during language comprehension, this is not surprising. I will discuss several ERP/MEG studies that illustrate the use of LLMs to explore where, when, and how the brain processes language in healthy individuals and how this breaks down in schizophrenia. However, I will argue that state-of-the-art transformer LLMs cannot provide complete understanding of the brain's predictive mechanisms because their architecture differs significantly from that of the human cortex. Instead, a more fruitful approach may be to explore more biologically plausible and cognitively interpretable architectures, such as predictive coding. I will present simulations showing that predictive coding not only explains the brain's sensitivity to contextual predictability, but also its neural dynamics and sensitivity to various lexical variables, priming, and their higher-order interactions.

## Testing neurobiology-of-language theories in the wild with NLP

Leila Wehbe[1]; [1]Carnegie Mellon University

Naturalistic experiments, by their use of complex language stimuli, allow us to study language processes in the wild, and to test if theories built on controlled stimuli generalize to the natural setting. To analyze these complex experiments, it is necessary to capture high level meaning in a computational object. NLP offers a broad range of tools that can help with this task. While these tools are imperfect models of the brain, they are still the most expressive instruments we have. The language representations extracted from these tools can be carefully combined to create in vitro, computationally-controlled experiments and test different theories about how language information is represented in the brain. These experiments can be used to disentangle the brain representation of composed meaning from individual word meaning, and semantic information from syntactic information.

## The lacunae of language models in the neuroscience of language

Andrea E. Martin[1,2]; [1]Max Planck Institute for Psycholinguistics, [2]Radbound University

A foundational principle of cognitive science is that the behavior of systems is wildly insufficient to diagnose underlying mechanistic similarity. In the philosophy of science, prediction is insufficient (and unnecessary) for explanatory force in theory (Scheffler, 1957; Shmueli, 2010). Yet in the age of large language models (LLM), we appear to use prediction, rather than explanation, to guide us, at our peril (see Guest & Martin, 2023), towards accounts of brain computation and human language processing. To circumvent explanatory impotence, I suggest we interrogate what would it actually mean if LLM were explanations of behavior, cognition, or neural data. Then I argue that the format of linguistic information in the brain is likely wildly different, not only from LLM, but also from valuable computational- and algorithmic-level descriptions obtained from formal linguistics and psychology. I close by arguing for explanantia that are nonetheless constrained by these disciplines and by neural dynamics.

## How can we use large language models to learn about the brain?

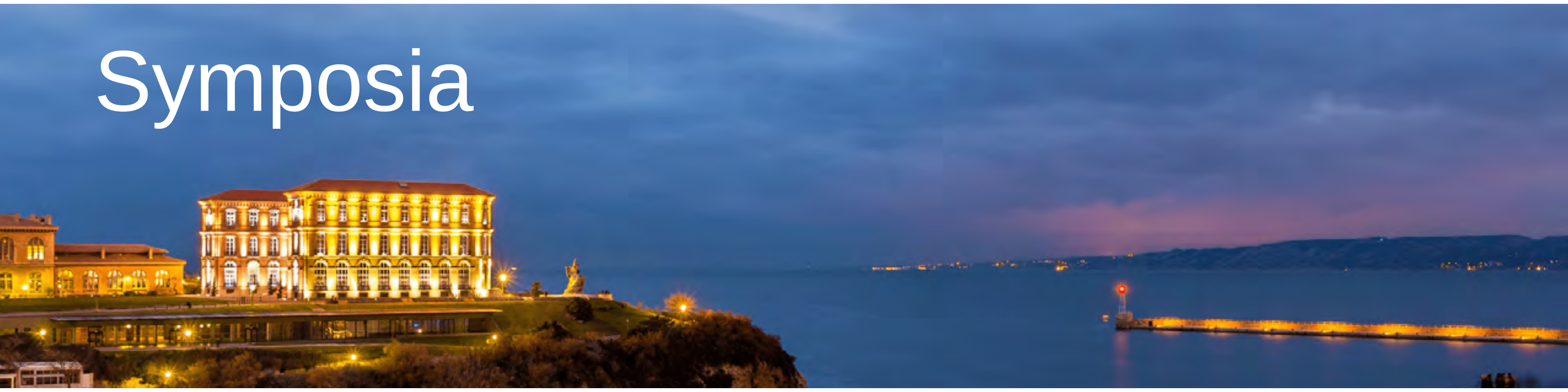
Alexander G. Huth[1]; [1]The University of Texas at Austin

Large language models are extremely effective at predicting how the human brain responds to natural language, but what can they tell us about how the brain works? One approach is to equate the computational goal of the brain with the objective the model is trained on. However, inferences of this type are strongly confounded by "multiple realizability": models trained to solve different problems can develop similar internal representations. Instead, we have pursued two alternative approaches: (1) building language models that are interpretable from the ground up, and (2) applying neural network interpretation techniques to the models that are fit to the brain. I will show how we have used these approaches to study the question of representational timescales across the brain. These results both confirm earlier findings and reveal an exciting new view on how representational timescale and semantic selectivity are related in cortex.

## Traditional and NLP-based approaches for studying syntactic representations in the brain

Christophe Pallier[1]; [1]CEA/SAC/JOLIOT/Neurospin center

Do representations proposed in linguistic theories, such as constituent trees, correspond to actual data structures constructed in real-time in the brain during language comprehension? And if so, what are the brain regions involved? This question was investigated in a series of functional magnetic resonance studies using various experimental paradigms, including repetition priming, syntactic complexity manipulation, and NLP models trained on limited corpora. I will argue that while many questions remain unanswered, progress has been made. For example, the results suggest that full syntactic parsing of sentences may not happen automatically, but that local syntactic operations (merge) do. The use of deep learning models to locate syntactic and semantic information in the brain will also be discussed.






# Origin and function of hemispheric asymmetry for language: insights from neuroscience, animal models and clinical practice.

*Wednesday, October 25, 8:00 - 10:00 am CEST, Auditorium*

**Organizer:** Benjamin Morillon[1,2]; [1]Aix Marseille Université, [2]Inserm

**Presenters**: Adrien Meguerditchian, Yannick Becker, Pascal Belin, Benjamin Morillon, Christian Kell, Agnès Trébuchon

Our interdisciplinary symposium aims to shed light on the origin and function of hemispheric asymmetry for language through fundamental and clinical research, language perception and production research, as well as comparative evolutionary approaches across primates. It offers the latest perspectives on this historic question in cognitive neuroscience, with the comparison of complementary and even incompatible points of view. In particular, the sensory or motor origin of brain asymmetry will be debated, together with the presence or absence of lateralization of specific cognitive processes. The symposium is suitable for students and faculty interested in cognitive neuroscience, linguistics, and communication disorders. Attendees will benefit from gaining knowledge on the latest theories and empirical findings that describe the complex relationship between brain asymmetry and language processing. Overall, this symposium offers a unique opportunity to explore the cutting-edge research on hemispheric specialization in the brain and its implications for language and communication.

**Presentations**

## Gesture and brain asymmetries in baboons: A model of hemispheric specialization for language?

Adrien Meguerditchian[1]; [1]Aix Marseille Université, [2]CNRS

Language is a unique communicative system involving hemispheric lateralization of the brain. Such a lateralization is visible at the structural level, even at birth, in key cortical language areas, such as the perisylvian Planum Temporale, its main connecting fiber track with Broca's area - the arcuate fasciculus and the STS. To discuss the question of language origins, the studies of the communicative gestural system of our primate cousins, including our own research in baboons, have showed similar key intentional and referential properties of language as well as some similar underlying structural hemispheric specialization. In this talk, I will present behavioral and in vivo MRI brain imaging studies in baboons Papio anubis reporting not only human-like structural brain asymmetries of some language-homolog regions in both 93 adults and 30 newborns, but also its correlates with the communicative gestures lateralization.

## New insights about the arcuate fascicle in chimpanzees: lateralization and temporal projections.

Yannick Becker[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig

Many authors have argued that the difference between the linguistic abilities of humans and non-human primates may lie in the differences in neural connectivity between the species. In the human brain, the main connection for language processing is the arcuate fascicle (AF). It arches dorsally around the sylvian fissure and connects frontal and temporal language areas. Although the architecture of language brain regions is highly conserved among primates, it is possible that the AF has undergone a major morphological transformation that accounts for our specificity in language processing. Indeed, only humans are described as having a long and left-lateralized AF terminating in the middle temporal gyrus. Here, using developmental and high-resolution data from the Evolution of Brain Connectivity Project, I will revisit and update the crucial questions about the evolution of the language fiber tract that makes us human. Possible behavioral correlates will be discussed.

## Hemispheric lateralization of the temporal voice areas.

Pascal Belin[1]; [1]Aix Marseille Université, [2]CNRS

The temporal voice areas (TVAs) of primate secondary auditory cortex are important nodes in the cerebral processing of information contained in conspecific vocalizations. While being highly variable in anatomical location between individuals, an analysis of several 100s participants did not reveal any significant asymmetry between the left and right TVAs. The TVAs are thought to reflect an essentially bilateral and symmetric initial stage of template matching, or ‘structural encoding’ restricted to vocal sounds, after which the main types of voice information (speech, identity, affect) are processed in more strongly lateralized functional pathways.

## Auditory hemispheric asymmetry as a specialization for actions and objects.

Benjamin Morillon[1]; [1]Aix Marseille Université, [2]Inserm

What is the function of auditory hemispheric asymmetry? We propose that the identification of sound sources relies on two complementary perceptually relevant acoustic invariants — actions and objects — that are processed asymmetrically and sufficient to model and categorize any sound. We observed that environmental sounds are an independent combination of purely temporal and spectral acoustic modulations. Behaviorally, discrimination of actions relies on temporal modulations, while discrimination of objects relies on spectral modulations. Functional magnetic resonance imaging data showed that actions and objects are respectively decoded in left and right hemispheres, in bilateral superior temporal and left inferior frontal regions. This asymmetry reflects a generic differential processing — through differential neural sensitivity to temporal and spectral modulations present in all environmental sounds — that supports the efficient categorization of actions and objects. These results provide an ecologically valid framework of the functional role of auditory brain asymmetry.

## A perceptual control framework explaining contributions of the dominant and non-dominant cerebral hemisphere to speech production.

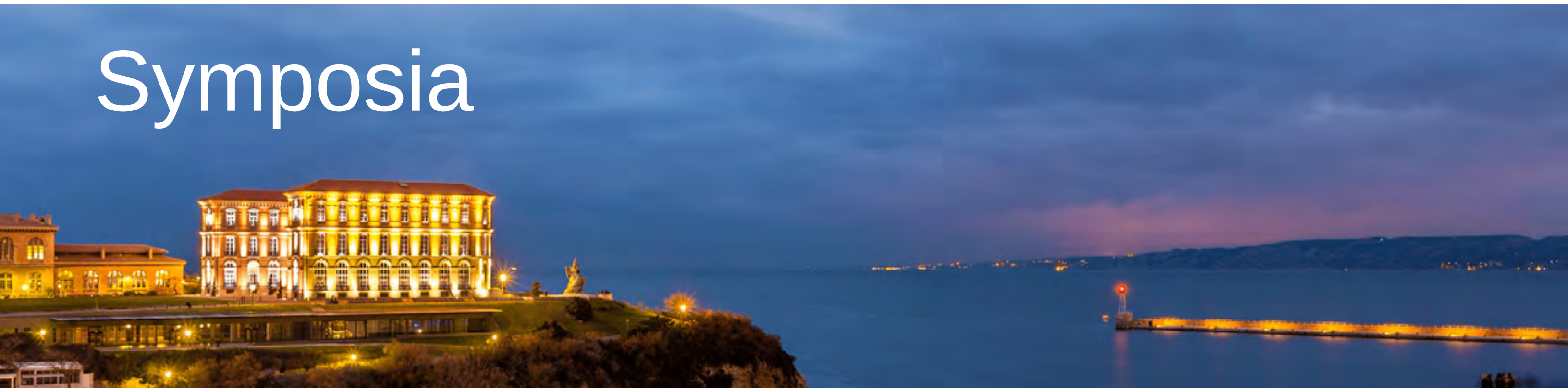
Christian Kell[1]; [1]Goethe University, [2]Department of Neurology of Frankfurt

Hemispheric asymmetries are particularly pronounced for production compared to perception tasks. The best-established speech production model that links computational processes to brain regions, DIVA, proposes a left-hemispheric feedforward and a right-lateralized auditory feedback controller (Tourville and Guenther, 2011). We investigated whether the observed right-lateralization for auditory feedback control arises from a specialization of the right hemisphere for spectral processing (Albouy et al., 2020) or from a right-lateralization for auditory feedback control in general (Tourville and Guenther, 2011). Indeed, both cerebral hemispheres contribute to speech production with the left favouring temporal and the right favouring spectral auditory feedback control (Floegel, Fuchs and Kell, 2020). However, parallel feedback controllers are difficult to reconcile with the idea of unified motor commands controlling a plant that has no intrinsic time, as conceived in DIVA. We therefore propose a dynamic hierarchical perceptual control scheme that incorporates these novel insights (Floegel et al., in press).

## Hemispheric asymmetry of language network: what does it mean in epilepsy surgery?

Agnès Trébuchon[1]; [1]Aix Marseille Université, [2]Inserm, [3]APHM, La Timone hospital

The challenge in epilepsy surgery is to cure patients without causing an additional neurological deficit, which typically requiring determination of language lateralization between hemispheres. The surgical disruption of any component, be it core or peripheral to language functions, have distinct consequences for language processing and performance. Hence, a clinical discussion of lateralization must be framed in terms of specific functional sub-units such as lexical selection, or anatomo-functional subdivisions such as the dorsal pathway of processing. In addition, the lesion underlying drug resistant epilepsy may result in a functional organization different from healthy individuals. As such, neuropsychological data, handedness, intracerebral recordings, electrical cortical stimulation, and electro-video analyses of seizures are used in clinical practices to determine language systems. We highlight why no single modality alone is adequate to identify cortical language systems.






# Unveiling the Neural Substrates of Early Language Development through Precision fMRI

*Thursday, October 26, 1:30 - 3:30 pm CEST, Auditorium*

**Organizers:** Ola Ozernov-Palchik[1], Ev Fedorenko[1]; [1]MIT

**Presenters**: Halie Olson, Zeynep Saygin, Xi Yu, Ola Ozernov-Palchik, Saloni Krishnan

Linguistic skills develop extremely rapidly early in life: by age 3-4, children can already understand and express complex ideas. Furthermore, formal education, including learning to read, fosters the development of vocabulary and the acquisition of complex structures. Despite comprehensive behavioral characterization, the neural substrates of early language learning and processing remain poorly understood. This symposium focuses on the individual-subject (precision) fMRI approach and tackles several open questions in the field: 1) Is the language network already selective and left-lateralized early in life? 2) What role do non-linguistic capacities play in language learning? 3) How does learning to read (or struggling to do so) affect the language system and the brain in general? Jointly, these talks from an all-female panel from different institutions, countries of origin, ethnic backgrounds, and career stages highlight complementary lines of work at the cutting edge of the neurobiology of language development.

**Presentations**

## Language-evoked activation in the brains of awake toddlers

Halie Olson[1]; [1]MIT

Toddlers undergo remarkable changes in their language skills. To study the neural underpinnings of language processing in awake toddlers, we developed an fMRI task using 20-second videos of Sesame Street, in which the audio stream was either played normally (Forward) or reversed by character (Backward), while the characters either spoke to the viewer (Monologue) or to each other (Dialogue). Using the Forward>Backward contrast, we examined (1) group-level activation for the language contrast in the whole brain, (2) individual-level activation within language regions by condition, using individually-defined functional regions of interest for language, iteratively defined and tested in held-out data, and (3) lateralization for language within individual participants. Preliminary results suggest that we can measure language-evoked activation in canonical language regions in this age group, and that this activation may be left lateralized. Though preliminary, these results point to the possibility and promise of studying language network in awake toddlers.

## Specificity of the language network in young children

Zeynep Saygin[1]; [1]Ohio State University

Is language distinct from other cognition? In adults, language cortex is dissociated from adjacent domain-general cortex supporting more general cognitive functions; language is also distinct from nonverbal skills that are also vital for effective communication like face/body perception and theory of mind (ToM; the ability to infer others' mental states). However these skills may share common neural processors especially early in development when these skills are still developing. Does the neural machinery for language emerge from general-purpose neural mechanisms? We localized and tracked the development of selectivity, laterality, and overlap of language, ToM, and domain-general multiple-demand networks in children 3-9 years of age. We find that young children show adult-like, modular organization in both frontal and temporal cortices, with no evidence of a common neural substrate across domains. Future work will explore how continued development of communicative skills can be explained by this distinct neural architecture.

## Characterizing the functional connectivity of the infant language network in relation to school-age reading outcomes

Xi Yu[1]; [1]Beijing Normal University

A critical aspect of successful reading acquisition is oral language skills which start developing in utero. The current study investigated the intrinsic properties of the language neural network in infancy (N=70) and related those properties to 2nd-grade reading outcomes (N=39) in a 7-year longitudinal dataset. Using the LanA probabilistic functional atlas, we first characterized the internal structure of the infant language network using module detection techniques. We identified three modules comprising the inferior frontal (IFG), middle frontal, and temporoparietal regions, respectively. Positive prospective associations were observed between the FC of the infancy IFG module, subsequent kindergarten-age phonological skills, and second-grade reading abilities. Moreover, kindergarten-age phonological skills significantly mediated the relationship between infant FC and subsequent reading outcomes. Our findings suggest that the early-emerging language neural network serves as a neurobiological scaffold important for developing core language/preliteracy skills and laying the foundations for subsequent reading acquisition.

## Examining Selectivity and Lateralization in the Language Network of Children with Dyslexia.

Ola Ozernov-Palchik[1]; [1]MIT

As children learn to read, there is a dynamic interplay between their oral language and reading skills. Using individual-subject fMRI analyses, we investigated differences in selectivity and lateralization of the language network in children with developmental dyslexia (Dys, N=25, ages 7-10 years), age-matched typical readers (Typ; N=47; ages 7-10 years), and reading level-matched younger typical readers (RL, N= 19, 4-7 years).

Comparison to RL allows for disentangling causal and experiential influences on brain development in individuals with dyslexia. Reliable selectivity for language was observed in each left-hemisphere language region across the three groups. While both the Typ and RL groups showed significant left-lateralization across the language network, the Dys group exhibited left-lateralization only in the frontal, but not temporal, regions. This suggests that the reduced left-lateralization in the temporal regions associated with phonological processing is not experientially driven but may have a causal relationship with dyslexia.

## Finding the joy: investigating reward processing during word learning in neurotypical and dyslexic childre

Saloni Krishnan[1]; [1]University of London

While reading, we extract the meaning of words from context, honing our vocabulary in the process. Studies in adults show experiencing reward can fuel memory for words. We are now investigating the link between reward and reading in development. Specifically, what is the contribution of reward-processing systems in the brain to such learning in childhood? How is the experience of reward influenced by reading proficiency? To address this, we have scanned 25 neurotypical children and 25 dyslexic children aged 11-13. In the scanner, children complete a naturalistic reading paradigm involving extracting novel word meanings from sentence context. Our preliminary analyses reveal increased activity in cortical language regions and the ventral striatum during successful learning. Our work sheds light on the link between reading enjoyment and learning, and will show whether boosting enjoyment might be a good strategy to enhance learning in children with dyslexia.

# Slide Sessions



## Slide Session A

*Wednesday, October 25, 1:30 - 2:30 pm CEST, Auditorium*

### Convergent neural signatures of speech prediction error across space, time and frequency

Ediz Sohoglu[1], Loes Beckers[2], Matthew Davis[3]; [1]University of Sussex, [2]Donders Institute for Brain, Cognition and Behaviour, [3]University of Cambridge

### A Corollary Discharge Circuit in Human Speech

Amirhossein Khalilian-Gourtani[1], Ran Wang[1], Xupeng Chen[1], Leyao Yu[1], Patricia Dugan[1], Daniel Friedman[1], Werner Doyle[1], Orrin Devinsky[1], Yao Wang[1], Adeen Flinker[1]; [1]New York University

### How does the nature of a writing system shape the cognitive and neural mechanisms for reading acquisition?

Joanne Taylor[1], Adam Jowett[2], Tibor Auer[3], Angelika Lingnau[4], Kathleen Rastle[2]; [1]University College London, [2]Royal Holloway University of London, [3]University of Surrey, [4]University of Regensburg

### Interruptions of the left posterior occipito-temporal sulcus longitudinally support reading acquisition

Florence Bouhali[1,2], Jessica Dubois[3,4], Kevin Weiner[5], Fumiko Hoeft[1,6]; [1]University of California San Francisco, [2]Aix-Marseille University, [3]Université Paris Cité, [4]Université Paris-Saclay, [5]University of California Berkeley, [6]University of Connecticut

## Slide Session B

*Thursday, October 26, 8:00 - 9:00 am CEST, Auditorium*

### Intracranial EEG Reveals Simultaneous Encoding of Pre-activated and Currently Processed Information During Language Comprehension

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### Deficient cortical tracking of speech in children with developmental language disorder

Anni Nora[1,2], Oona Rinkinen[1,2], Hanna Renvall[1,2,3], Elisabet Service[4,5], Marja Laasonen[5,6], Eva Arkkila[5], Sini Smolander[5,7], Riitta Salmelin[1,2]; [1]Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland, [2]Aalto NeuroImaging (ANI), Aalto University, Espoo, Finland, [3]BioMag Laboratory, HUS Diagnostic Center, Helsinki University Hospital, University of Helsinki and Aalto University, Helsinki, Finland, [4]Centre for Advanced Research in Experimental and Applied Linguistics (ARiEAL), Department of Linguistics and Languages, McMaster University, Hamilton, Canada, [5]Department of Otorhinolaryngology and Phoniatrics, Head and Neck Surgery, Helsinki University Hospital and University of Helsinki, Helsinki, Finland, [6]Department of Logopedics, University of Eastern Finland, Joensuu, Finland, [7]Research Unit of Logopaedics, University of Oulu, Oulu, Finland

### From Temporal to Frontal Cortex and Back: Testing the Dynamics underlying Sentence Comprehension with TMS-EEG

Joëlle A. M. Schroën[1,2], Thomas C. Gunter[1], Leon O. H. Kroczek[3], Gesa Hartwigsen[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain sciences, Leipzig, Germany, [2]International Max Planck Research School on Neuroscience of Communication: Function, Structure and Plasticity (IMPRS NeuroCom), Leipzig, Germany, [3]University of Regensburg, Regensburg, Germany

### MEG evidence that modality-independent conceptual representations encode lexical but not low-level sensory features

Julien Dirani[1], Liina Pylkkänen[1,2]; [1]New York University, [2]New York University Abu Dhabi

# Slide Session C

*Thursday, October 26, 4:30 - 5:30 pm CEST, Auditorium*

### Neural tracking in the visual domain: the role of different articulators in sign language comprehension.

Chiara Luna Rivolta[1], Brendan Costello[1], Mikel Lizarazu[1], Manuel Carreiras[1,2,3]; [1]Basque Center on Cognition, Brain and Language (BCBL), [2]Ikerbasque, Basque Foundation for Science, [3]Universidad del País Vasco (UPV/EHU)

### Convergent cortical network dynamics in word retrieval

Kathryn Snyder[1], Kiefer Forseth[1], Greg Hickok[2], Nitin Tandon[1]; [1]UTHSC, [2]UC Irvine

### Autistic Traits Modulate Discourse Construction: An fNIRS Hyperscanning Study of School-aged Children

Xuancu HONG[1], Patrick C.M. WONG[1], Xin ZHOU[2]; [1]The Chinese University of Hong Kong, [2]National Acoustic Laboratories

## Speaker-listener neural coupling in a shared linguistic embedding space during natural conversations

Zaid Zada[1], Ariel Goldstein[2], Sebastian Michelmann[1], Erez Simony[3], Amy Price[1], Liat Hasenfratz[1], Emily Barham[1], Asieh Zadbood[1], Werner Doyle[4], Daniel Friedman[4], Patricia Dugan[4], Lucia Melloni[4], Sasha Devore[4], Adeen Flinker[4], Orrin Devinsky[4], Samuel Nastase[1], Uri Hasson[1]; [1]Princeton University, [2]Hebrew University of Jerusalem, [3]Holon Institute of Technology, [4]New York University




# Slide Session A

*Wednesday, October 25, 1:30 - 2:30 pm CEST, Auditorium*

## Convergent neural signatures of speech prediction error across space, time and frequency

Ediz Sohoglu[1], Loes Beckers[2], Matthew Davis[3]; [1]University of Sussex, [2]Donders Institute for Brain, Cognition and Behaviour, [3]University of Cambridge

We use MEG and fMRI to determine how predictions are combined with speech input in superior temporal cortex. Previous work suggests that cortical speech representations are best explained by prediction error computations rather than the alternative ‘sharpened signal’ account (Blank and Davis 2016 PloS Biology; Sohoglu and Davis 2020 eLife). However, this previous work used an artificial listening situation in which speech was highly distorted and predictions obtained from external written cues. In the current work we explore a more naturalistic listening situation in which speech is clearly presented and predictions obtained directly from the speech signal itself i.e. based on lexical knowledge of which speech sounds are likely to be heard next for familiar words. In one MEG experiment (N=19) and one fMRI experiment (N=21), we compared neural responses to bisyllabic spoken words (e.g. beta, data, lotus, foetus) in which the first syllable strongly or weakly predicts the form of the second syllable. In addition, we compared neural responses to the same second syllables when heard in a pseudoword context (e.g. beetus, datus, lota, foeta). Pseudowords, by definition, are previously unfamiliar to participants and therefore the second syllable of these items mismatches with listeners’ predictions. Critically, computational simulations show that these experimental manipulations of prediction strength and match/mismatch lead to dissociable outcomes for sharpened signal and prediction error representations of the second syllable, enabling us to adjudicate between these two computational accounts. We measured neural responses using 306-channel MEG and 3T fMRI in separate groups of listeners while they performed an incidental (pause detection) listening task to maintain attention. Across multiple imaging modalities (MEG, fMRI), analysis approaches (univariate, multivariate), and signal domains (phase-locked, evoked activity and induced, time-frequency MEG responses), we show that neural representations of second syllables are suppressed by strong predictions when predictions match sensory input. Neural representations of the same second syllables show the opposite effect (i.e. enhanced

representations following strongly than weakly-predicting syllables) when predictions mismatch with sensory input. In line with our computational simulations, this interaction between prediction strength and congruency is consistent with prediction error but not sharpened signal computations. We further show that the neural signature of prediction error occurs early in processing (beginning 168 ms after the onset of the second syllable), localises to early auditory regions (in fMRI, bilateral Hechl's gyrus and STG) and is expressed as changes in low-frequency (alpha and theta) power. Our study therefore provides convergent neural evidence that speech perception is supported by the computation of prediction error representations in auditory brain regions. Overall, our findings show that neural computations of prediction error play a central role in the identification of familiar spoken words and perception of unfamiliar pseudowords.

## A Corollary Discharge Circuit in Human Speech

Amirhossein Khalilian-Gourtani[1], Ran Wang[1], Xupeng Chen[1], Leyao Yu[1], Patricia Dugan[1], Daniel Friedman[1], Werner Doyle[1], Orrin Devinsky[1], Yao Wang[1], Adeen Flinker[1]; [1]New York University

Introduction: As a direct result of any motor action the relevant sensory system is activated. It is crucial for the brain to distinguish between sensations initiated by oneself and external ones. To address this, a fundamental neural circuit has evolved to inform sensory cortex about forthcoming actions through motor signals, which is referred to as a corollary discharge (CD). Although there is substantial evidence of CD signals in various sensory modalities and animal species, the exact source and dynamics of CD in the human auditory system remains unknown. Methods: To investigate the CD signal in human speech, we utilize the excellent spatiotemporal resolution of electrocorticography (ECoG) and acquire recordings from eight neurosurgical patients while they perform an auditory repetition task (subjects were instructed to listen and then repeat single words freely when ready). We focus our analysis on the neural activity in the high-gamma broadband range (70-150 Hz). Noting that CD, by nature, is a blueprint of the motor commands sent to auditory cortex, we present a novel directed connectivity analysis framework that allows us to study the information flow between different brain regions. We use autoregressive models to probe the Granger-causal relations between all different electrodes sampling cortex. To distill the large neural connectivity patterns into a few dominant patterns we employ unsupervised clustering. This approach elucidates dominant information flow (source and target) as well as prototypical temporal connectivity patterns (tested against permutation at $p<0.05$ for statistical significance). Results: We apply our directed connectivity analysis framework to the neural recordings during auditory word repetition. Our results show three distinct phases during the task likely related to comprehension, pre-articulatory preparation, and speech production. Locked to word articulation we find a distinct component peaking at -107 msec relative to articulation onset with directed influence from speech motor cortex onto auditory cortex (STG). In contrast to connectivity, high-gamma activation reveals pre-articulatory neural activity in multiple cortical regions (including pre- and post-central and inferior frontal gyrus) as well as subsequent STG suppression. However, the directed connectivity approach pin-points a directed information flow originating in ventral precentral gyrus targeting STG happening before articulation onset. The degree of this directed influence on auditory electrodes significantly predicts speech induced suppression in STG (Pearson Correlation, $R=0.43$, $p=1.46e-4$). Further, we replicate this finding across different speech production tasks: naming pictures, reading written words, naming auditory word descriptions, and completing auditory sentences. Analysis of variance of the corollary discharge's connectivity from the dorsal and ventral divisions of sensorimotor cortex and tasks reveals ventral pre-central gyrus as the source (ANOVA region main effect $F(3,369)=12.48$, $p=9.04e-8$; task main effect $F(4,369)=1.02$, $p=0.397$; no interaction $F=0.53$, $p=0.896$). Conclusions: Theoretical frameworks suggest that an auditory corollary discharge signal plays a role in enhancing our sensitivity to our own speech, and its dysfunction can contribute to experiencing auditory hallucinations. Our findings present the first direct evidence for the source and timing of this signal within the human auditory system. These results have significant implications for understanding speech motor control and investigating psychotic symptoms in humans.

## How does the nature of a writing system shape the cognitive and neural mechanisms for reading acquisition?

Joanne Taylor[1], Adam Jowett[2], Tibor Auer[3], Angelika Lingnau[4], Kathleen Rastle[2]; [1]University College London, [2]Royal Holloway University of London, [3]University of Surrey, [4]University of Regensburg

Introduction: Reading is accomplished via two pathways, one based on sub-word information that maps print onto sound and then onto meaning, and one based on whole-word information that maps print directly onto meaning. These processes depend on different neural systems. Dorsal pathway regions, such as left inferior parietal cortex and inferior frontal gyrus, support print-to-sound mapping, whereas ventral pathway regions, such as left middle temporal and anterior fusiform gyri, in addition to left angular gyrus, support print-to-meaning mapping (Carreiras et al., 2014; Price, 2012; Taylor et al., 2013). The ‘division of labour’ (Plaut et al., 1996) between these pathways may depend on the nature of the writing system. Alphabetic writing systems, like Spanish, have systematic print-to-sound relationships and likely rely on sub-word more than whole-word information, at least early in reading acquisition. In contrast, logographic writing systems like Chinese have little systematicity between print and sound and may be more reliant on whole-word information. We tested this hypothesis using behavioural and neural measures in an experiment in which adults learned to read novel words written in two different writing systems. Method: 24 adults learned to read two sets of pseudowords over 10 days. One set was written in an alphabetic writing system, with regular print-to-sound mappings, and the other in a logographic writing system, with arbitrary print-to-sound mappings. Training tasks and post-tests at the end of training focused on print-to-sound or print-to-meaning relationships. At the end of training, neural activity was recorded using fMRI while participants made meaning judgements about trained written stimuli. Results: In post-tests, reading aloud was faster and more accurate in the alphabetic system than in the logographic system. In contrast, saying the meanings of written words was equivalently accurate for the two writing systems, but faster for the logographic system. Univariate analyses of fMRI data showed that activity was greater for the alphabetic than the logographic system in dorsal pathway regions, including left inferior frontal gyrus, inferior parietal cortex, bilateral precentral gyri, and supplementary motor area. In contrast, activity was greater for the logographic than the alphabetic system in ventral pathway regions including bilateral middle temporal gyri and right parahippocampal gyrus, as well as bilateral occipito-parietal cortex, left angular gyrus, and the precuneus. Discussion: Despite engaging in the same training tasks and achieving good performance in both writing systems, participants learned these writing systems differently. Print-to-sound mapping was superior for the alphabetic writing system, which engaged dorsal brain regions. In contrast, print-to-meaning mapping was superior for the logographic writing system, which engaged ventral brain regions and additional areas thought to be involved in meaning processing. These results demonstrate how the writing system shapes the division of labour between print-to-sound and print-to-meaning pathways in reading acquisition.

## Interruptions of the left posterior occipito-temporal sulcus longitudinally support reading acquisition

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Literacy learning builds onto cognitive and neural architectures that are partially in place by the age children start literacy instruction. Many cognitive factors have been reported to predispose a child to acquire adequate reading skills, such as good phonological awareness and rapid naming abilities. At the neural level, previous research showed associations between sulcal interruptions of the left occipito-temporal sulcus (OTS) and reading skills in 10-year-old children and adults (Borst et al., 2016; Cachia et al., 2018), likely reflecting early constraints determined in utero. Here, we studied the relationship between the sulcal morphology of ventral temporal cortex (VTC) and the development of reading skills, to (i) confirm the role of left OTS interruptions as a longitudinal predictor of reading skills, and (ii) evaluate their predictive power relative to benchmark cognitive precursors of reading. We also explored whether (iii) the morphology of the left mid-fusiform sulcus (MFS) would relate to reading skills, as this sulcus is a critical microstructural and functional landmark in VTC (Grill-Spector and Weiner, 2014) and has been functionally implicated in grapheme processing for phonological decoding (Bouhali et al., 2019). To this aim, we identified the OTS and MFS in a cohort of 50 children followed longitudinally from the age of 5, at the onset of literacy instruction, to age 8, when most children have become fluent readers. Structural MRI scans and reading scores were available at both ages, with reading abilities additionally measured at age 7. Sulcal interruptions were stable across timepoints, and better detected with longitudinal processing of structural data. Consistent with previous findings (Borst et al., 2016; Cachia et al., 2018), the presence of an interruption in the posterior section of the left OTS was associated with better reading skills at age 8, but also with early and emerging reading skills at ages 7 and 5. The effect of left pOTS interruptions on reading abilities accumulated over time, as demonstrated by direct and indirect effects of pOTS interruptions on reading skills throughout the three consecutive timepoints in a serial mediation analysis. By accounting for over 22% of variance in reading skills at age 8 over demographic variables, pOTS interruptions were the strongest longitudinal predictor of reading acquisition, well above typical cognitive predictors of reading measured in kindergarten such as phonological awareness, rapid naming, letter knowledge, receptive vocabulary and non-verbal reasoning. In contrast, MFS morphology was not associated with reading. Overall, our results establish left pOTS interruptions as a robust predictor of reading acquisition, with early and accumulating effects independently of known cognitive precursors of reading.




# Slide Session B

*Thursday, October 26, 8:00 - 9:00 am CEST, Auditorium*

## Intracranial EEG Reveals Simultaneous Encoding of Pre-activated and Currently Processed Information During Language Comprehension

Lin Wang[1,2], Benchi Wang[3], Ole Jensen[4], Gina Kuperberg[1,2]; [1]Department of Psychiatry and the Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, Charlestown, MA, USA, [2]Department of Psychology, Tufts University, Medford, MA, USA, [3]South China Normal University, Guangzhou, China, [4]Centre for Human Brain Health, University of Birmingham, Birmingham, UK

Introduction Prediction is thought to play a crucial role in ensuring that language comprehension is both fast and accurate. Indeed, during word-by-word comprehension, item-specific predictions can be decoded from unique temporal patterns of neural activity within the ventromedial temporal lobe, even before new bottom-up input becomes available. This raises two fundamental questions: How does the brain coordinate top-down predictive processing with bottom-up processing? And how does it segregate pre-activated representations from representations that are activated by the perceptual input? To address these questions, we combined intracranial EEG (iEEG) with Representational Similarity Analysis. Methods We collected iEEG data from 16 Chinese participants who had surgically implanted stereo-electrical electrodes as part of their clinical assessment for epilepsy (134 shafts; 2116 electrode contacts, distributed across multiple neuroanatomical regions). Participants silently read 306 sentences, presented word-by-word (300ms, 400ms ISI). These sentences were constructed in triplets, giving rise to two types of sentence pairs within each triplet: (1) Pre-target overlap pairs, which shared the identical pre-target word (e.g. 1a & 1b: “sleeping” - “sleeping”), and (2) Prediction overlap pairs that shared the identical predictable upcoming word (e.g. 1b & 1c: “baby” – “baby”). Across triplets, there was no overlap between pairs of either the pre-target word or the predicted word (No-overlap pairs). 1a. In the picture he saw a sleeping … (?) 1b. In the crib, there is a sleeping … (baby) 1c. In the hospital, there is a newborn … (baby) At each electrode contact, between 300-500ms following the onset of each pre-target word, we extracted the fine-grained temporal patterns produced by each type of pair. We first asked where item-specific representations of the pre-target words were encoded by identifying the regions where Pre-target overlap pairs produced more similar temporal patterns than No-overlap pairs. We then

asked whether, within this same 300-500ms time-window, any of these regions additionally produced temporal patterns that encoded item-specific representations of the predicted targets, i.e. whether and where Predicted overlap pairs produced more similar temporal patterns than No-overlap pairs. Results (1) Between 300-500ms, unique temporal patterns encoding item-specific representations of pre-target words were produced within left ventromedial temporal lobe (left fusiform, inferior temporal and medial temporal), (b) lateral temporal cortex (left middle temporal and bilateral superior temporal), and (c) left inferior parietal cortex. (2) In this 300-500ms time-window, the left ventromedial temporal lobe also produced distinct temporal patterns that encoded item-specific representations of predicted targets. However, the specific electrode contacts that showed the largest predicted target temporal similarity effects showed the smallest pre-target effects, and vice versa. Conclusions Together, these findings point to a tightly coordinated system in which, between 300-500ms, at the same time as new bottom-up input is accessing item-specific representations across left-lateralized temporal-parietal cortices, top-down predictions are pre-activating item-specific representations within the left ventromedial temporal lobe. They further suggest that, within left ventral temporal cortex, distinct neural populations may play a role in segregating information that is pre-activated based on the prior context from information that is activated by the current perceptual input.

## Deficient cortical tracking of speech in children with developmental language disorder

Anni Nora[1,2], Oona Rinkinen[1,2], Hanna Renvall[1,2,3], Elisabet Service[4,5], Marja Laasonen[5,6], Eva Arkkila[5], Sini Smolander[5,7], Riitta Salmelin[1,2]; [1]Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland, [2]Aalto NeuroImaging (ANI), Aalto University, Espoo, Finland, [3]BioMag Laboratory, HUS Diagnostic Center, Helsinki University Hospital, University of Helsinki and Aalto University, Helsinki, Finland, [4]Centre for Advanced Research in Experimental and Applied Linguistics (ARiEAL), Department of Linguistics and Languages, McMaster University, Hamilton, Canada, [5]Department of Otorhinolaryngology and Phoniatrics, Head and Neck Surgery, Helsinki University Hospital and University of Helsinki, Helsinki, Finland, [6]Department of Logopedics, University of Eastern Finland, Joensuu, Finland, [7]Research Unit of Logopaedics, University of Oulu, Oulu, Finland

In developmental language disorder (DLD), learning to understand and use spoken language is disrupted. The reason for this remains unknown, and brain imaging studies in children with DLD are sparse. One hypothesized underlying cause are acoustic-phonetic processing deficits. Using millisecond scale magnetoencephalography (MEG) recordings combined with machine learning models, we set out to investigate whether the cause of this disruption lies in poor cortical tracking of speech. The stimuli were 44 high frequency spoken Finnish words from different semantic categories (e.g. ‘dog’, ‘car’, ‘hammer’) and 44 sounds with corresponding meanings (e.g. dog bark, car engine, hammering), as well as 8 novel (pseudo)words with Finnish phonotactics. Cortical responses to 20 repetitions of each stimulus were measured with MEG in 17 children with DLD and 17 typically developing (TD) children, aged 10-15 years. The sound acoustics were modeled with time-varying (amplitude envelope and spectrogram) and non-time-varying (frequency spectrum, modulation power spectrum) descriptions. A kernel convolution model that models the evoked brain responses as time-locked to the sound was used for decoding the time-varying sound features based on the corresponding cortical responses. In both DLD children and control children, the

cortical activation to spoken words was best modeled as time-locked to the unfolding speech input, whereas the cortical processing of environmental sounds did not show such reliance on time-locked encoding. Both the amplitude envelope (amplitude modulations reflecting e.g. the syllable rhythm) and spectrogram (detailed spectral content) of spoken words were very successfully decoded based on time-locked brain responses in bilateral temporal areas, best at ~100 ms latency between sound and cortical activation. Based on the cortical responses in temporal areas, the models could tell apart, at accuracy of 80-84% (using the amplitude envelope features) and 72-75% (using the spectrogram features), which of two test sounds had been presented. Group differences were found at longer latencies: The cortical representation of the amplitude envelope information was poorer in DLD children compared to TD children at ~200–300 ms lag. This latency range seems to correspond to the latencies between the observed peaks in the amplitude envelope, reflecting the syllable structure of the words. This group difference was especially evident in the right temporal cortex for familiar words and in the left temporal cortex for novel words. Thus, typically developing children seem to display more efficient encoding of the amplitude modulations of speech, reflecting the syllable rhythm. We interpret the poorer encoding at longer latencies in the DLD children as reflecting poorer retention of syllabic-level acoustic-phonetic information in echoic memory and poorer integration of information across syllables. The present results offer an underlying explanation for the impaired word-level comprehension and learning of spoken language in DLD.

## From Temporal to Frontal Cortex and Back: Testing the Dynamics underlying Sentence Comprehension with TMS-EEG

Joëlle A. M. Schroën[1,2], Thomas C. Gunter[1], Leon O. H. Kroczek[3], Gesa Hartwigsen[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain sciences, Leipzig, Germany, [2]International Max Planck Research School on Neuroscience of Communication: Function, Structure and Plasticity (IMPRS NeuroCom), Leipzig, Germany, [3]University of Regensburg, Regensburg, Germany

Introduction. During everyday conversation, the listener's goal is to extract the meaning of the communicated message. This complex process is supported by the interaction within a left-dominant fronto-temporo-parietal network that consists of highly interconnected brain regions such as the left posterior inferior frontal gyrus (pIFG), left posterior superior temporal gyrus and sulcus (pSTG/STS), and left angular gyrus (AG). Currently, causal evidence for the precise timing of the interplay between nodes of this language network (where, what, when) is completely lacking. As a first effort addressing this important outstanding issue, we present a set of three carefully designed experiments that simultaneously combined transcranial magnetic stimulation (TMS) and electroencephalography (EEG) recordings. Methods. To account for the robustness of the language network [1], we adopted a so-called condition-and-perturb design. Offline conditioning by means of 40 seconds of continuous theta burst stimulation [2] was always applied over the left AG, as it is strongly connected with the left pSTG/STS and left pIFG [3]. Across the three experiments, we varied the timing of triple-pulse (10 Hz) online repetitive TMS (rTMS) to test when neural activity in the left pIFG and left pSTG/STS is causally relevant for auditory sentence comprehension. While participants listened to four-word sentences (e.g., He drinks the beer), online rTMS was applied at different latencies relative to verb onset: either early (0-200 ms), middle (150-350 ms) or late rTMS (300-500 ms). Given the presence of extremely large artifacts following TMS over lateral brain regions, we utilized the robust N400 effect [4] at the noun position as a read-

out to draw inferences. Results. Our experiments show evidence for region-specific, time-critical processing windows within the language system: functional relevance was demonstrated first for the left pSTG/STS (0-200 ms), followed by the left pIFG (150-350 ms), and finally again for the left pSTG/STS (300-500 ms). The perturbation outlasted the stimulation duration and impacted the processing of the subsequent noun, indicating their crucial importance in understanding the meaning of a sentence. Conclusion. Our study shows causal, time-specific evidence for a coordinated temporal interplay within the language network during auditory sentence processing, thereby providing an important extension of the insights gained by previous electrophysiological and neuroimaging work on the neurobiology of language. References. [1] Hartwigsen, G. (2018). Flexible redistribution in cognitive networks. Trends in cognitive sciences, 22(8), 687-698. [2] Huang, Y. Z., Edwards, M. J., Rounis, E., Bhatia, K. P., & Rothwell, J. C. (2005). Theta burst stimulation of the human motor cortex. Neuron, 45(2), 201-206. [3] Niu, M., & Palomero-Gallagher, N. (2023). Architecture and connectivity of the human angular gyrus and of its homolog region in the macaque brain. Brain Structure and Function, 228(1), 47-61. [4] Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). Annual review of psychology, 62, 621-647.

## MEG evidence that modality-independent conceptual representations encode lexical but not low-level sensory features

Julien Dirani[1], Liina Pylkkänen[1,2]; [1]New York University, [2]New York University Abu Dhabi

Words convey meaning but in the neurobiology of language, we lack a satisfying account of the interplay between conceptual and lexical representations. Previous research has shown that the brain encodes concepts through both abstract and sensory-motor representations, such as visual shapes, sounds, and motor representations (Ralph et al., 2017). Furthermore, it has been established that different tasks and stimulus modalities (such as pictures vs. words) activate shared representations of concepts, referred to as modality-independent representations (Devereux, Clarke, Marouchos, & Tyler, 2013; Fairhall & Caramazza, 2013; Simanova, Hagoort, Oostenveld, & Van Gerven, 2014). However, the nature of modality-independent representations remains ill-understood. While it is possible that they are equivalent to abstract representations, alternatively, they may possess sensory components that are shared across different contexts and stimuli. Here we use magnetoencephalography (MEG) and a novel representation learning approach to investigate the content of modality-independent concepts and how they evolve over time at the millisecond level. 17 native English speakers participated in an MEG experiment involving an animacy judgment task with randomly presented pictures and words of animals and tools. In the first part of the analysis, we identified the time-points in the MEG data where modality-independent representations of concepts were activated. We used a decoding approach that trained a 3- layer neural network classifier of exemplar-level concepts (e.g. dog, fork) on MEG data from one modality (words) and tested it on MEG data from the other modality (pictures) at each timepoint. This enabled us to extend previous research conducted at the level of semantic categories to the exemplar level (Dirani & Pylkkänen, under review). To investigate the content of modality- independent representations, we extracted the hidden representations learned by the models that demonstrated robust generalization across modalities. The rationale is that models that generalized across modalities learned a representation of the MEG data that supported classification and that is independent of stimulus modality. We conducted a representational similarity analysis (RSA) to unpack the content of these modality-independent representations and to examine their relation to existing models of vision (He et al., 2016), lexical processing (Balota et al., 2007), and conceptual knowledge (McRae et al, 2005). Our results show that pictures activate exemplar-level representations at around 75ms, while for words these representations were activated at ~150ms. Cross-condition decoding was significantly above chance starting around 200ms after stimulus onset, however, the timing of this decoding varied considerably across participants. The RSA revealed significant correlations between modality-independent representations and human-normed semantic features throughout most of the analysis time-window (200-600ms). Crucially, while no significant correlation was observed between modality-independent representations and low-level visual representations, modality-independent representations correlated with representations capturing the lexical statistics of the exemplar names initially at 200ms and later at 400-500ms. Overall, our results suggest that modality-independent conceptual representations do not encode low-level sensory representations but contain representations that capture the lexical statistics associated with their names. These findings contribute to our understanding of how meaning is represented and processed across different modalities, highlighting the connection between language processes and conceptual knowledge.




# Slide Session C

*Thursday, October 26, 4:30 - 5:30 pm CEST, Auditorium*

## Neural tracking in the visual domain: the role of different articulators in sign language comprehension.

Chiara Luna Rivolta[1], Brendan Costello[1], Mikel Lizarazu[1], Manuel Carreiras[1,2,3]; [1]Basque Center on Cognition, Brain and Language (BCBL), [2]Ikerbasque, Basque Foundation for Science, [3]Universidad del País Vasco (UPV/EHU)

In sign languages the linguistic information is transmitted through the simultaneous movement of several bodily and facial articulators, some of which, like the right hand, are more informative than others. This study investigates the relative contribution of each articulator during sign language processing by exploiting the phenomenon of language-brain entrainment. Specifically, we examine the extent to which the brain activity synchronizes with (different parts of) the incoming linguistic visual signal. To measure the temporal periodicity that characterises the visual signal in sign language, we used marker-free motion tracking: a custom-built Kinect system allowed us to record videos of semi-spontaneous sign language narratives (by native deaf signers) while registering the position in three-dimensional space of 21 different body points. These videos served as stimuli for the subsequent experiment. We used magnetoencephalography (MEG) to record the neurophysiological activity of two groups of hearing participants – 15 proficient signers of LSE (Spanish Sign Language) and 15 sign-naive individuals – while they watched 20 videos, 10 in a known (LSE) and 10 in an unknown sign language (Russian Sign Language - RSL). We calculated coherence between the preprocessed MEG data and the visual linguistic signal, and used cluster-based permutation tests to assess statistical differences in coherence between groups and experimental conditions. The motion tracking data made it possible to characterize the visual linguistic signal: for each motion-tracked point, its three-dimensional coordinates were normalised and used to create a speed vector to identify that point's time-frequency profile. As an overall measure of the visual signal, we used PCA to extract the main speed vector for all upper-body points combined (head, neck, shoulders, elbows, wrists, hands, torso); additionally, we selected three linguistically relevant articulators (left hand, right hand and head) to investigate their individual contribution to neural tracking, along with a point with little linguistic import (torso) to provide a sanity check. The results

show that neural activity tracks sign language input, and this tracking is dependent upon sign language knowledge. When comparing entrainment to a known and an unknown sign language, the signers show greater coherence for LSE compared to RSL only when considering the combined visual signal and right hand but not for the left hand, head or torso. Furthermore, proficient signers show stronger synchronisation compared to sign-naive controls when considering the head, left hand, right hand and the combined visual signal, but not the torso. Thus, our findings point to the differential role of the body articulators in sign language processing. Entrainment in sign language occurs in the delta frequency band (0.5 - 2.5 Hz), reflecting the slower periodicity associated with articulators movements, mainly over centro-parietal regions linked with biological motion processing. These findings confirm that language-brain entrainment is a feature of language processing beyond the auditory domain, and depends upon language experience. Furthermore, the neural activity tracks visual articulators that are linguistically most informative, namely, the dominant, right hand. The multilayered sign language signal makes it possible to tease apart those linguistic elements that drive neural tracking of the input.

## Convergent cortical network dynamics in word retrieval

Kathryn Snyder[1], Kiefer Forseth[1], Greg Hickok[2], Nitin Tandon[1]; [1]UTHSC, [2]UC Irvine

Lexical access describes the process involved in the mapping between conceptual representations and phonology and is an integral component of speech production. Furthermore, prominent psycholinguistic models of language propose that lexical access is supported by a network of broadly distributed cortical regions with transient and interactive network dynamics. However, while various brain regions are hypothesized to support separable processes, the language network, its functional mapping to lexical access, and the associated network dynamics remain unclear. Here, we used ECoG to identify brain networks involved in naming using multimodal stimuli with convergent design. Data were obtained from epilepsy patients who underwent invasive electrophysiology (patients=48; electrodes=5,390). Recordings were acquired during cued-naming tasks using auditory (ACN) and orthographic (OCN) descriptions. We identified the lexical-semantic network using a mixed-effects multilevel analysis to estimate group-level broadband gamma power (BGA; 65-115Hz) time-locked to the offset of the last word in the description. In a subset of patients with coverage of these regions (n=5), we characterized the network dynamics using a multivariate autoregressive hidden Markov model (ARHMM). Both tasks engaged an identical lexical access network consisting of the posterior middle temporal gyrus (pMTG; ACN: -176ms, 43.69% BGA, p<0.01; OCN: -193ms, 15.95% BGA, p<0.01), the middle fusiform gyrus (mFus; ACN: -171ms, 16.79% BGA, p<0.01; OCN: 237ms, 22.0% BGA, p<0.01), the intraparietal sulcus (IPS; ACN: 117ms, 24.03% BGA ,p<0.01; OCN: 282ms, 36.15% BGA, p<0.01), and pars triangularis (pTr; ACN: -2ms, 38.78% BGA, p<0.01; OCN: 281ms, 43.55% BGA, p<0.01), and all regions were active immediately following the onset of the last word in the description. ARHMM analyses of ACN isolated 6 distinct cortical states and began with acoustic processing in the superior temporal gyrus (STG) followed by speech processing in the superior temporal sulcus (STS) and pMTG. ARHMM analyses of OCN isolated 7 distinct cortical states and began with orthographic feature processing in visual cortex followed by engagement of the lexical (STS, pMTG) and phonological (STG) routes of reading. Following these initial sensory processing states, ARHMM analyses isolated a conserved lexical semantic processing network consisting of pMTG, mFus, IPS, and pTr. This network state was active following the end of the description in both tasks and correlated with reaction time ($p<0.01$), which is consistent with lexical access. The final three network states in both tasks corresponded broadly to phonological encoding, articulation, and monitoring (subcentral gyrus and STG). These results reveal that pMTG, mFus, IPS, and pTr constitute a core heteromodal lexical access network. Juxtaposing the cortical network dynamics of word retrieval across different conceptual representations better informs our understanding of both specialized and shared cortical language networks, which provides empirical support for theoretical models of speech production. In the future, we believe that this work will contribute important insights that are critical to the development of improved treatment methods, such as neural prosthetics, for speech-related disorders.

## Autistic Traits Modulate Discourse Construction: An fNIRS Hyperscanning Study of School-aged Children

Xuancu HONG[1], Patrick C.M. WONG[1], Xin ZHOU[2]; [1]The Chinese University of Hong Kong, [2]National Acoustic Laboratories

Autism spectrum disorder (ASD) as a neurodevelopmental disorder results in impaired discourse in social contexts (Schaeffer et al., 2023). Little is known about how children with ASD construct discourse with their peer interlocutors in school life. Interpersonal brain coherence (IBC) values between two individuals show how two brains are interconnected and have been shown to be the neural markers of discourse construction in social interaction (e.g., Nguyen et al., 2020). In the present study, we investigate whether and how autistic traits modulate the construction of discourse among school-aged children and the underpinning IBC. We designed three experiments using functional near-infrared spectroscopy (fNIRS) to simultaneously measure the brain activities of dyads of school-age children, some of whom showed elevated autistic traits as measured by the Autism Spectrum Quotient (AQ) questionnaire. We recorded their IBC values from four regions of interest that have been associated with discourse construction (Jacoby & Fedorenko, 2020; Mashashiro & Shinada, 2021), i.e., bilateral temporal-parietal and frontal cortical regions. Altogether, 46 9-to-11-year-old children (23 dyads) participated in this study. Children participated in three experiments. In Experiment 1, they watched a video alone or together with a peer. In Experiment 2, dyads engaged in shared book reading either subvocally or reading aloud together. In Experiment 3, dyads participated in playing Jenga in which they either pretended to play or played for real in turns. To increase ecological validity, the tasks for each experiment are chosen from daily-school-life activities, and we designed the three experiments based on three possible social interactive behaviours in constructing discourse respectively, i.e., implicit interactive behaviour, aligning behaviour and contingent behaviour. The level of interactivity between two individuals is incrementally increased across the experiments. We found that in Experiment 1, the dyad's IBC value is significantly increased when watching together compared to watching alone. In Experiment 2, their IBC value is also significantly improved when they are reading aloud together compared to reading subvocally. In Experiment 3, dyads have significantly higher IBC values in playing for real than pretending to play. Throughout the three experiments, the tasks that involved stronger interactivity consistently showed an increase in IBC values compared to tasks that involved weaker interactivity, including in the temporal-parietal and frontal cortical regions. Importantly, we found that increases in IBC values were modulated by AQ scores across experiments. Specifically, increases in IBC value were negatively correlated with AQ scores in Experiment 2 ($r = -0.63$, $p = .002$), and positively correlated with AQ scores in Experiment 3 ($r = 0.55$, $p = .007$).

These findings indicate that inter-brain coherence is enhanced during discourse construction with interactive behaviours such as co-presence, alignment, and contingency (turn-taking). Moreover, the inter-brain connection is subject to the different levels of interactivity and is moderated by autistic traits in discourse construction. In general, this study illustrates an ecological and quantitative approach to investigating autism-modulated neural mechanisms of discourse construction among school-aged children.

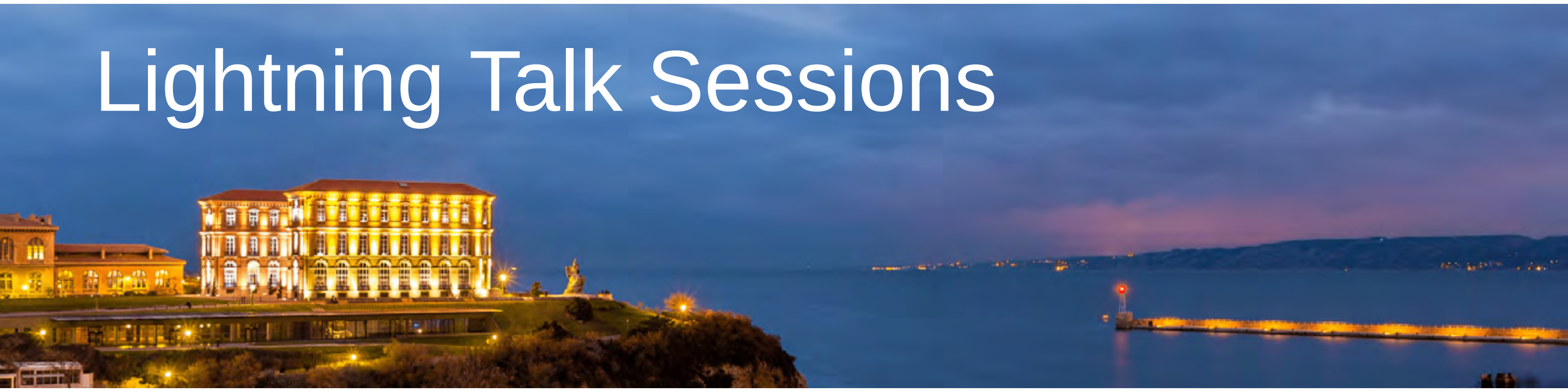
## Speaker-listener neural coupling in a shared linguistic embedding space during natural conversations

Zaid Zada[1], Ariel Goldstein[2], Sebastian Michelmann[1], Erez Simony[3], Amy Price[1], Liat Hasenfratz[1], Emily Barham[1], Asieh Zadbood[1], Werner Doyle[4], Daniel Friedman[4], Patricia Dugan[4], Lucia Melloni[4], Sasha Devore[4], Adeen Flinker[4], Orrin Devinsky[4], Samuel Nastase[1], Uri Hasson[1]; [1]Princeton University, [2]Hebrew University of Jerusalem, [3]Holon Institute of Technology, [4]New York University

Language allows us to express our ideas and feelings to others. Successful communication, however, requires a shared agreement regarding the meaning of words in context—which without, would be impossible for strangers to understand one another. Until recently, we lacked a precise computational framework for modeling how humans use words in context to communicate with each other. To overcome this limitation, previous studies of the neural basis of communication have resorted to measuring direct coupling or alignment between brains by using the neural activity in the speaker's brain to make model-free predictions of the listener's brain activity. Although these analyses can quantify the strength of brain-to-brain coupling, they are content-agnostic and cannot model how we use words in context to convey our thoughts to others. In this study, we positioned large language model (LLM) contextual embeddings as an explicit model of the shared linguistic space by which a speaker communicates their thoughts—i.e. transmits their brain activity—to a listener in natural contexts. We recorded cortical activity using electrocorticography (ECoG) in five dyadic pairs of epilepsy patients during spontaneous, interactive, and unique conversations. Next, we extracted contextual embeddings for every word in the conversation from GPT-2, an established language model. Then, we trained encoding models to predict brain activity during speech production and comprehension in held-out segments of the conversations. To assess linguistic coupling across brains, we used the encoding model trained on the speaker's brain activity to predict the listener's brain activity (and vice versa). This novel intersubject encoding (ISE) analysis quantifies how well the model fit for speech production (or comprehension) generalizes to speech comprehension (or production) in left-out segments of each conversation. We first demonstrate that the contextual embeddings can predict neural activity across the cortical language network during speech comprehension and speech production with high temporal specificity. Consistent with the flow of information during communication, linguistic encoding peaked in the speaker's brain ~300ms prior to word onset ($r=0.192$), while linguistic encoding peaked in the listener's brain ~375ms after each word was articulated ($r=0.223$). During speech production, we found maximal encoding performance in speech articulation areas along somatomotor (SM) cortex, in superior temporal (ST) cortex, and in higher-order language areas in the temporal pole (TP), inferior frontal gyrus, and supramarginal gyrus (SMG). During speech comprehension, the encoding model predicted neural responses in similar brain areas, particularly superior temporal cortex. We then use the intersubject speaker–listener encoding analysis to demonstrate that linguistic content in the speaker's brain ~425ms before word articulation re-emerges, word-by-word, in the listener's brain ~125ms

after each word is spoken (r=0.144). For comparison, we used non-contextual word embeddings that resulted in significantly less coupling. Finally, we applied the same analysis across speaker-listener brain regions to identify connections including both higher-level (TP, TP) and lower-level (SM, ST) speaker-listener language areas. Our findings reveal how speaker and listener neural responses during natural conversations are coupled to a shared linguistic space, and suggest that LLMs provide a novel computational framework for studying how we transmit our thoughts to others.

# Lightning Talk Sessions



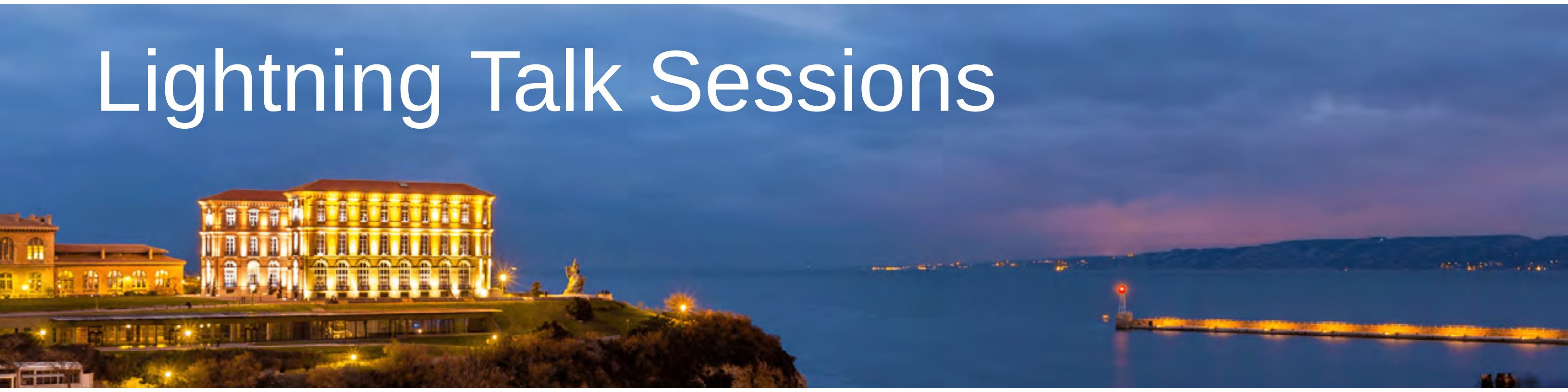


## Lightning Talks A

*Tuesday, October 24, 10:00 - 10:15 am CEST, Auditorium*

| Poster ▲ | Title | First Author | Topic Area |
|---|---|---|---|
| A14 | Using EEG and eye-tracking to investigate the prediction of speech in naturalistic virtual environments | Huizeling, Eleanor | Meaning: Discourse and Pragmatics |
| A50 | Event-related potentials elicited by similarity-based interference during subject-verb dependency resolution | Schoknecht, Pia | Syntax and Combinatorial Semantics |
| A74 | Dendritic non-linearity supports the formation and reactivation of word memories as cell assemblies | Quaresima, Alessio | Speech Perception |
| A84 | Bilateral human laryngeal motor cortex in perceptual decision of lexical tone and voicing of consonant | Du, Yi | Speech Perception |
| A100 | Language Acquisition in Brains and Algorithms: towards a systematic tracking of the evolution of language representations using stereoelectroencephalography recordings in children and deep learning. | Evanson, Linnea | Language Development/Acquisition |
| A126 | Cortical and subcortical mechanisms of orthographic learning | Rapp, Brenda | Reading |

# Lightning Talk Sessions



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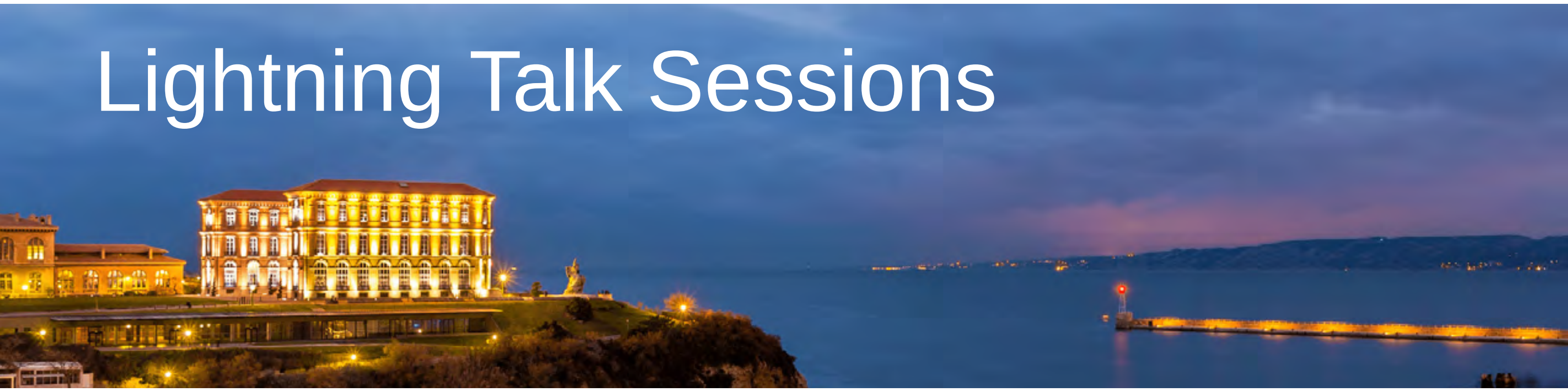
## Lightning Talks C

*Wednesday, October 25, 10:00 - 10:15 am CEST, Auditorium*

| Poster ▲ | Title | First Author | Topic Area |
|---|---|---|---|
| C44 | Neural Encoding of Syntactic Structures during Natural Speech Planning and Production | Morucci, Piermatteo | Syntax and Combinatorial Semantics |
| C54 | Using FLAIR MRI to Account for Hypoperfusion in Examinations of Brain-Behavior Relationships in Acute Stroke | Bunker, Lisa D. | Disorders: Acquired |
| C55 | Mapping the vascular territories in left hemisphere stroke | Halai, Ajay | Disorders: Acquired |
| C70 | A Language-Specific Left-Lateralized Network for Auditory Naming | Yu, Leyao | Speech Perception |
| C123 | Quantification of reading circuits in the ventral occipitotemporal cortex | Lei, Yongning | Reading |
| C126 | How learning to read Braille in visual and tactile domains reorganizes the sighted brain | Gaca, Maciej | Reading |

# Lightning Talk Sessions

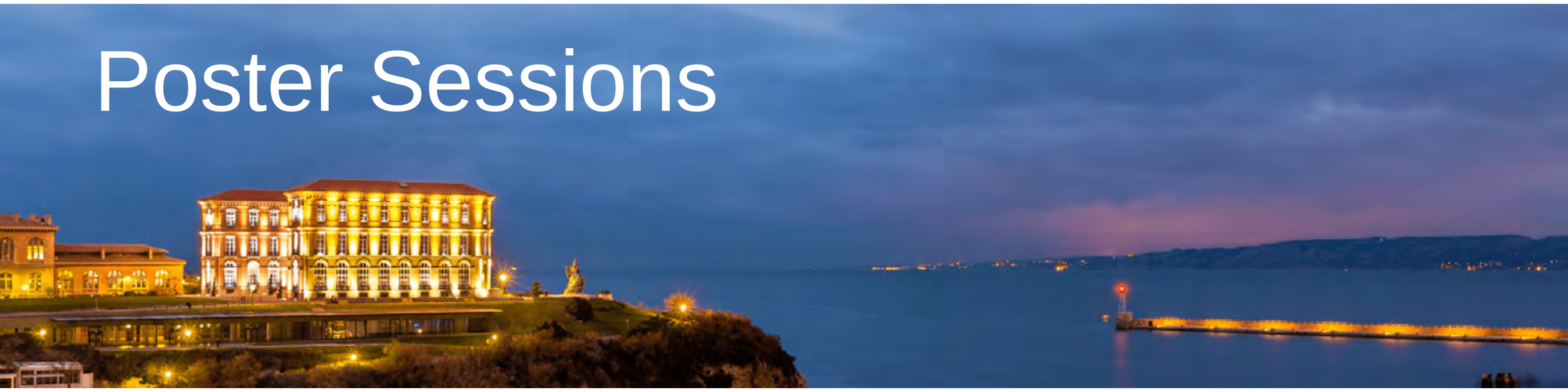




## Lightning Talks E

*Thursday, October 26, 10:00 - 10:15 am CEST, Auditorium*

| Poster ▲ | Title | First Author | Topic Area |
|---|---|---|---|
| E27 | Exploring the representational space of abstract concepts | Persichetti, Andrew | Meaning: Lexical Semantics |
| E51 | The functional connectome and neural tracking of natural speech in post-stroke aphasia | Mehraram, Ramtin | Disorders: Acquired |
| E76 | Language familiarity dependent encoding of natural speech in human temporal lobe | Bhaya-Grossman, Ilina | Speech Perception |
| E100 | Do visual speech cues facilitate infants' neural tracking of speech? | Jordan-Barros, Antonia | Language Development/Acquisition |
| E119 | Cortical Organization of Shared Neural Computations for Reading and Auditory Speech Perception | Scott, Terri L. | Reading |
| E126 | Specific rather than a general neural adaptation deficit in children with dyslexia when processing print | Di Pietro, Sarah | Reading |



# Poster Sessions

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| | |
|---|---|
| **Poster Session A** | *Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port* |
| **Poster Session B** | *Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port* |
| **Poster Session C** | *Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port* |
| **Poster Session D** | *Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port* |
| **Poster Session E** | *Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port* |


# Poster Session A

## Why the GPT task of predicting the next word does not suffice to describe human language production: A conversational fMRI-study

***Poster A1*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Caroline Arvidsson[1], Johanna Sundström[1], Julia Uddén[1]; [1]Stockholm University

Interest is surging around the ”next-word-predictability” task that allowed large language models to reach their current capacity. It is sometimes claimed that prediction is enough to model language production. We set out to study predictability in an interactive setting. The current fMRI study used the information-theoretic measure of surprisal – the negative log-probability of a word occurring given the preceding linguistic context, estimated by a pre-trained language model (GPT-2). Surprisal has been shown to correlate with bottom-up processing located in the bilateral middle and superior temporal gyri (MTG/STG) during narrative comprehension (Willems et al., 2016). Still, surprisal has never been used to investigate conversational comprehension or any kind of language production. We hypothesized that previous results on surprisal in narrative comprehension would be replicated with conversational comprehension and that next-word-predictability would not encompass language production processes. We utilized a publicly available fMRI dataset in which participants (N=24) engaged in unscripted conversations (12 min/participant) via an audio-video link with a confederate outside the scanner. The conversational events Production, Comprehension, and Silence were modeled in a whole-brain analysis. Two parametric modulations of production and comprehension were added: (1) log-transformed context-independent word frequency (control regressor) and (2) surprisal. Production-surprisal and Comprehension-surprisal were respectively contrasted against the implicit baseline. These contrasts were compared with the contrasts Production and Comprehension vs implicit baseline. If surprisal merely indexed part of the activity in the latter, broader contrasts, this provides a handle on production and comprehension processes beyond next-word-predictability. For surprisal in conversational production, we observed statistically significant clusters in the left inferior frontal gyrus (LIFG), the medial frontal gyrus, and the motor cortex. Importantly, Production vs implicit baseline showed bilateral STG activation while STG was not parametrically modulated by surprisal. Moreover, the bilateral MTG/STG were the only clusters active for Comprehension vs implicit baseline and they were also modulated by surprisal. For comprehension, we thus replicated the previous narrative comprehension study (Willems et al., 2016), showing that unpredictable words activate the bilateral MTG/STG also in conversational settings. Next-word-predictability is thus so far a good model for conversational comprehension. For production, however, the next-word-predictability task helped to hone in on what is sometimes considered core production machinery in LIFG. Several functional interpretations of the STG recruitment during production are possible (such as monitoring for speech errors), but the current results point in the direction of two important conclusions: (1) a functional division of the frontal and temporal cortices during production, where the frontal component is prediction-related, and (2) that language processing during production is more than prediction, at least at the word-level. We provide a functional handle on such extra-predictive processes.

Topic Areas: Language Production, Computational Approaches

## Decoding pictures and words with MEG signals: Evidence for shared neural representation of semantic categories

***Poster A2*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Kai Nakajima[1], Jion Tominaga[1], Dmitry Patashov[1], Rieko Osu[1], Hiromu Sakai[1]; [1]Waseda University

Introduction People can recognize semantic categories from objects even though they are presented in different modalities such as images or words. Yet, it is currently unknown as to what extent neural representations of semantic categories are independent of the modalities. Recent studies using Representational Similarity Analysis of fMRI data revealed that semantic category information is represented widely in hetero-modal cortical areas (Fernandino et al, 2022). The time-course of neural representation of semantic object categories are examined using Multivariate Pattern Analysis of MEG data (Carota et al, 2022). However, previous studies do not address the question of whether these representations are shared between objects presented in different modalities (Rybar et al, 2022 for a review). To answer this question, we conducted cross-decoding of semantic categories from MEG signals where participants are presented with picture images and words. Materials and Methods Eight native Japanese speakers participated in the experiment. MEG data were recorded using a whole-head 64-channel MEG system (Sumitomo Heavy Industries, Ltd.) while the participants were performing tasks of looking at picture images or words projected on the screen. In picture condition, participants are asked to name the object orally. In word condition, they were asked to judge the familiarity of objects in 4-points scales. Pictures or words are displayed for 300 ms after 500 ms presentation of a fixation cross. We prepared 8 different objects (Animal, Human, Body part, Vehicle, Food, Inanimate, Manmade place, and Tool artifact). Objects were presented randomly 6 times each, yielding 384 trials in total. The picture condition and the word conditions were counter-balanced among subjects. Recorded data were preprocessed using MNE-python software package (https://mne.tools/stable/index.html). The classification was performed using the support vector machine in scikit-learn (https://scikit-learn.org/stable/) Python machine learning library. The decoding accuracy was calculated using a hold-out method. Training data (80%) and test data (20%) were randomly sampled from the entire sets of data. Magnetic field amplitudes from each sensor channel are averaged within every 50 ms time-window after the stimulus onset. A support vector machine was used for classification. Results As of now, we obtained the result of cross-decoding of eight categories for one subject. The chance level for the eight categories is 12.5%. The cross-decoding accuracy of image dataset using the word dataset for training was 19.1% ~ 28.9%.

Whereas the cross-decoding accuracy of word dataset using image dataset for training was 13.3% ~ 19.4%. The asymmetric results suggest that there are more modality specific information evoked by pictures. We expect to finish analyzing all eight subjects during the summer. We plan to examine the time-course of formation of neural representation of semantic categories by decoding data from different time-windows. We anticipate that the classification accuracy of cross-decoding will reach maximum at around 100 ms ~ 200 ms after stimulus onset based on previous MEG and EEG research of word and image decoding.

Topic Areas: Language Production, Computational Approaches

## Context-driven word production suppresses high-gamma-band activity in the middle temporal cortex

***Poster A3*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Andrey Zyryanov[1,2], Semen Kudryavtsev[1], Irina Makarova[3], Anastasia Matuschak[3], Elizaveta Gordeyeva[4], Nikita Utyashev[4], Alexandra Balatskaya[4], Madina Odeniyazova[4], Nikita Pedyash[4], Alexey Dimertsev[4], Andrey Zuev[4], Oleg Bronov[4], Tommaso Fedele[1], Olga Dragoy[1,5], Svetlana Malyutina[1]; [1]HSE University, Moscow, Russia, [2]University of Tübingen, Germany, [3]HSE University, Nizhniy Novgorod, Russia, [4]National Medical and Surgical Center named after N. I. Pirogov, Moscow, Russia, [5]Institute of Linguistics, Russian Academy of Sciences, Moscow, Russia

Long-standing evidence that semantically related distractors impede object naming (semantic interference) suggests that multiple lexical-semantic representations coactivate during word production. The neural dynamics underlying this coactivation, however, remain obscure. While semantic interference consistently modulates neural activity in the left posterior temporal cortex, it does so in inconsistent directions ranging from suppression (Dirani & Pylkkänen, 2021; Piai et al., 2014; de Zubicaray et al., 2013) to enhancement (Gauvin et al., 2021). Furthermore, it remains unclear how the findings from naming with distractors translate into more naturalistic, context-driven word production. We investigated the spatiotemporal dynamics of context-driven word production using stereotactic EEG recordings in 10 subjects with refractory epilepsy while they performed a sentence completion task. Subjects listened to a sentence with the final word omitted and responded with a single context-appropriate noun. The sentences varied in response agreement (mean 0.48, range 0.07–0.98 in 141 healthy subjects). Lower agreement predicted longer response latencies in correct trials ($t = -13.9$, $p < 0.001$), reflecting semantic interference. Among a total of 720 artifact-free bipolar channels, the task robustly modulated signal amplitude in the high-gamma band (HGA, 70–150 Hz) in 81 channels (as measured using a time-resolved linear regression model of evoked responses, test-set correlation between true and predicted HGA 0.10–0.48, all $p < 0.001$). Hierarchical clustering of these channels based on average HGA in sentence- and response-locked time windows separated them into three spatiotemporal clusters. Two clusters (34 and 17 channels) predominantly spanned bilateral superior temporal, left inferior frontal, and bilateral precentral gyri. They showed well-established auditory and motor HGA enhancement time-locked to sentence comprehension and to response articulation, respectively. The third cluster (30 channels) was located mainly in bilateral middle temporal gyri (MTG) and showed a suppression of HGA around sentence offset. This suppression showed consistent single-trial temporal dynamics: It built up throughout sentence comprehension, ceased immediately before response onset, and

was followed by HGA enhancement at the start of articulation in some channels. Our findings suggest that suppressed MTG activity previously reported by neuroimaging studies of semantic interference in naming also subserves context-driven word production. These findings are best explained by the models of word production where lexical representations interact via inhibitory connections over the course of word selection (e.g., Howard, 2006).

Topic Areas: Language Production, Control, Selection, and Executive Processes

## Examining the brain dynamics of control processes during language production using intracranial electroencephalography

***Poster A5*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Elizabeth Anderson[1,2], Sophie Kajfez[1], Charles Dickey[2], Katherine Andrade[1,2], Burke Rosen[2], Carrie R. McDonald[2], David Lee[2], Leena Kansal[2], June Yoshii-Contreras[2], Jerry J. Shih[2], Sharona Ben-Haim[2], Eric Halgren[2], Stephanie Ries[1]; [1]San Diego State University, [2]University of California San Diego

Although language production is complex, speakers can typically produce 2-3 words per second selected from more than 50,000 words in their mental lexicon (Levelt et al., 1999). Several brain regions have been linked to word retrieval and associated cognitive control processes during language production. In particular, the anterior cingulate cortex (ACC) and lateral and medial prefrontal cortices have been associated with semantic interference resolution in speech production (e.g., Piai et al., 2013; Riès et al., 2017). We used the picture-word interference paradigm to investigate when these different regions may be engaged in semantic interference resolution for word retrieval during language production. While previous work examining word retrieval primarily used non-invasive techniques (e.g., EEG, MEG, fMRI), intracranial EEG recordings are well-suited to determine which brain regions are involved in distinct processes because they combine excellent spatial and temporal resolution and access deeper focal neural activity not accessible using non-invasive techniques. We collected intracranial stereotactic EEG in 11 individuals with intractable epilepsy undergoing invasive monitoring to identify seizure foci (6 M; mean age: 29 years, SD: 8.1 years). Participants named pictures superimposed with to-be-ignored distractor words that were either semantically-related, semantically unrelated, or identical to the picture name. There was a main effect of condition on reaction time ($\chi 2(2, 11) = 105.8$, $p < .001$) and error rate ($\chi 2(2,5) = 11.85$, $p < .01$). There were significantly slower RTs in unrelated compared to identity ($t = -7.02$, $p = <.0001$), and in related compared to unrelated ($t = 2.82$, $p = .012$). Significantly more errors occurred in the unrelated than identity condition (Wald $Z = 3.27$, $p = <.01$). There was no significant difference between unrelated and related (Wald $Z = .006$, $p = .99$). In preliminary intracranial EEG analyses with three patients, we analyzed the effect of condition on bipolar local field potentials (LFP, 0.1-30 Hz) and high frequency band activity (HFB, 70-150 Hz). Principal component analysis (PCA) revealed distinct components in several brain regions across patients during the task including rostral middle and superior frontal, lateral orbitofrontal, and ACC for stimulus-locked HFB data and ACC and superior frontal gyrus for stimulus-locked LFP data. In follow up analyses for HFB we observed greater amplitude in the related versus unrelated conditions in middle frontal regions ($p = .03$) 600-800 ms post-stimulus onset. For LFPs we observed greater amplitude in related versus unrelated conditions in the prefrontal cortex, including the orbitofrontal ($p = .012$) and superior frontal ($p = .014$) regions in the same time-window (600-800 ms post-stimulus onset).

Increased engagement of frontal regions in the related versus unrelated condition is in agreement with a role of these regions in cognitive control processes involved in semantic interference resolution during word retrieval in language production and suggest that these processes are involved later than initial lexical activation processes. Future results from this ongoing study will help shed light on the neural underpinnings of cognitive control in language production.

Topic Areas: Language Production, Control, Selection, and Executive Processes

## Functional connectivity underlying speech monitoring processes as revealed by Graph Signal Processing

***Poster A6*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Yusheng Wang[1,2], Elizabeth Anderson[1,2], Sophie Kajfez[2], Carrie R. McDonald[1], David J. Lee[1], Leena Kansal[1], June Yoshii-Contreras[1], Jerry J. Shih[1], Sharona Ben-Haim[1], Eric Halgren[1], Ashkan Ashrafi[2], Stephanie K. Riès[2]; [1]University of California San Diego, [2]San Diego State University

Speech monitoring has been the subject of extensive research due to its importance for accurate speech production. Several brain regions, including the left posterior temporal gyrus, medial frontal cortex, and inferior frontal gyrus, have been associated with speech monitoring processes. However, how these brain regions interact with one another during speech monitoring has been understudied. Our study examines how these different brain regions are functionally connected to support speech monitoring in individuals with intractable epilepsy undergoing a picture-word interference (PWI) experiment using an innovative Graph Signal Processing (GSP) technique. Whereas traditional functional connectivity analyses use multiple pairwise correlations measurement of the temporal synchrony between the signal recorded in different regions, the GSP approach considers the signal space as a graph which allows for the analysis of signals defined on the entire graph, thereby bypassing the multiple comparison issues. Moreover, GSP considers all of the signal information, including phase, and amplitude, thereby bypassing the need to focus on a restricted part of the signal. Therefore, this novel GSP approach can reveal connectivity patterns that may not be detectable with traditional functional connectivity analysis. Our study utilizes intracranial EEG (iEEG), a brain imaging tool that integrates excellent spatial and temporal resolution, to investigate the brain network supporting speech monitoring in eleven individuals (mean age = 29 years, SD = 7.68 years) with intractable epilepsy as they engaged in a PWI task. Individuals were asked to name pictures while ignoring the overlayed distractor words in three conditions (i.e., semantically related, semantically unrelated, or identical to the picture name). The result shows a main effect of condition on reaction time ($\chi2(1,11) = 105.8$, $p < .001$) and error rate ($\chi2(1,11) = 11.9$, $p =.003$). Post hoc analyses indicated significantly faster RTs in the identity than related ($t = -9.94$, $p < .0001$), or unrelated conditions ($t = -7.02$, $p < .0001$), and significantly faster RTs for the unrelated than related condition ($t = 2.87$, $p = .01$). There are significantly fewer errors in the identity than related ($z = -3.3$, $p = .0031$) or unrelated conditions ($z = -3.3$, $p =.0031$), but no difference between related and unrelated conditions ($z = -0.006$, $p > .05$). Our GSP predictions are as follows based on the above results, we hypothesize that the connection strengths and the number of connected nodes between the different brain regions supporting speech monitoring (i.e., showing larger activity response-locked in error than correct trials and in related than unrelated trials) will be higher in errors than in correct trials and in the related than unrelated condition. This is an ongoing study. We believe that the prospective outcomes of this study will not only shed light on understanding the neural underpinnings of speech monitoring but also could further support the use of GSP for the analysis of functional connectivity in language and cognitive neuroscience more generally.

Topic Areas: Language Production, Control, Selection, and Executive Processes

## Unveiling Accelerated Brain Aging through Discourse Analysis: Leveraging Natural Language Processing and Neuroimaging

***Poster A7*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Identifying non-invasive biomarkers of accelerated brain aging holds significant potential for early detection and intervention in neurodegenerative disorders. Complex cognitive processes, such as discourse, are promising indicators of brain health, often manifesting with subtle deficits years before other neuropsychological impairments become apparent. However, traditional discourse analysis is time-consuming and requires highly trained examiners, posing challenges for larger-scale population studies. Natural Language Processing (NLP) offers a solution to this problem by using machine learning approaches to derive discourse features in a systematic and automated way. In this study, we applied NLP to quantify lexical features generated from verbatim transcriptions of responses to the "Cookie Theft" picture from 210 healthy participants in the Aging Brain Cohort (ABC@USC). Participants underwent 3T brain MRI, including T1-weighted and diffusion tensor imaging (DTI). A machine learning model that trained on a very larger cohort of healthy participants (BrainAgeR, n=3377) was applied to the T1-weighted images to estimate an imaging-derived brain age. The brain age gap (BAG), defined as the difference between brain age and chronological age, was computed as a measure of brain health, with higher BAG values indicating premature brain aging (brain age > chronological age). Additionally, an individualized structural connectome was computed from DTI using the Johns Hopkins University parcellation atlas. Betweenness centrality (BC), a graph theory measure reflecting network hubness, was computed for each brain region and averaged across the left-hemisphere language network as well as the whole brain. Our findings revealed that chronologically older participants exhibited a greater variety of words ($r = 0.42$, $p = 0.04$), higher lexical sophistication ($r = 0.42$, $p < .001$), and increased lexical diversity ($r = 0.1$, $p = 0.01$). However, across all ages, participants with premature brain aging exhibited fewer different words ($r = -0.16$, $p = 0.02$) along with decreased lexical sophistication ($r = -0.19$, $p = 0.007$), more narrow lexical word variation ($r = -0.14$, $p = 0.039$), and diminished lexical diversity ($r = -0.19$, $p = 0.007$). In turn, premature brain aging was associated with increased global average hubness ($r = 0.22$, $p < .001$), but there was a significant decrease in the average hubness of the left-hemisphere language network ($r = -0.15$, $p = 0.03$). In summary, we leveraged NLP to show accelerated brain aging is associated with decreased lexical complexity and diversity in a large cohort of healthy individuals. Premature brain aging was also associated with loss of average hubness specifically in the language network. Understanding how age-related brain structural changes affect discourse may offer a unique opportunity to develop non-invasive biomarkers of advanced brain aging and identify earlier stages of cognitive decline.

Topic Areas: Language Production, Methods

## The eyes don’t really have it

***Poster A8*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The social cue of eye-gaze can convey a range of useful information—including contextual support for referential communication. In the present experiment, we investigated whether eye-gaze direction would facilitate interpretation of sentences exhibiting specific vs. non-specific reference, as in “The kid climbed a/that tree…”. The indefinite determiner “a” biases for a non-specific interpretation of the direct object “tree”, unlike the demonstrative determiner “that”, which conveys a specific meaning for "tree". In the absence of any linguistic context, we hypothesized that sentences with non-specific reference (“a tree”) would be preferred vs. those with specific reference (“that tree”). We asked whether this difference might disappear when sentences with specific reference were supported via the social cue of averted gaze (facilitating referential communication). Finally, given the known lateralization effects for face vs linguistic processing, we also wondered whether differences would be found for more vs. less right/left-handed individuals (i.e., for less vs. more bilateral hemispheric involvement). In an online study, we presented 51 monolingual English speaker participants with emotionally neutral Caucasian faces with direct vs. averted gaze. Each face was followed by a sentence with non-specific or specific reference. Participants made judgments regarding the naturalness of each sentence on a scale of 1-7, and we investigated whether face gaze direction impacted those judgments. Results indicated an overall preference for sentences exhibiting non-specific reference, as well as for sentences following faces with direct gaze vs. averted gaze. No interaction was found between specificity and gaze direction. A negative correlation between handedness and sentence ratings was found. That is, whereas more left-handed/less right-handed (RH-) participants and more right-handed (RH+) participants were strongly sensitive to specificity, only RH- participants were sensitive to eye-gaze direction (showing lower ratings for specific sentences with averted gaze faces). Neither group showed an interaction between specificity and gaze. In sum, our data corroborate intuitive judgments regarding sentences exhibiting non-specific vs. specific reference, as well as other work showing an overall preference for direct gaze. The handedness findings are in line with previous work showing that joint attention is dependent on cortical pathways that are lateralized, such that RH- participants are sensitive to eye gaze/face stimuli, in contrast to RH+ participants.

Topic Areas: Meaning: Discourse and Pragmatics, Animal Communication and Comparative/Evolutionary Studies

## Neural and cognitive predictors of individual variability in speech comprehension

***Poster A9*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Individuals vary in the accuracy and ease with which they understand spoken language. We are identifying and explaining the neural and cognitive sources of this variability, focusing on a common challenge that arises during comprehension – how to interpret intended meaning when there is no one-to-one mapping between spoken words and their meaning (e.g. "BALL" refers to a spherical object and a dance party). Successful comprehension of semantic ambiguity requires a listener to use multiple cues to access and select the appropriate word meaning, and suppress the alternative(s), which sometimes involves reinterpretation (Rodd, 2020). These cognitive operations are supported by inferior frontal and posterior temporal cortical regions (Rodd et al. 2005), although the exact timing of their engagement and specific functional contributions remain underspecified (MacGregor et al., 2020). Moreover, we do not yet understand how comprehension success may be related to functional and anatomical differences in fronto-temporal brain regions within the language-selective and domain-general networks, or to language-selective (e.g. quality of lexical knowledge) and/or domain-general (e.g. flexible selection and inhibition) cognition. In an online behavioural study, we measured semantic ambiguity comprehension ability with a Meaning Definitions Task: volunteers (n=71, 19-59 years) listened to 122 sentences containing an AMBIGUOUS word disambiguated by later context to an unexpected (non-dominant) meaning (Sally worried the BALL would be too crowded). After each sentence, listeners heard the ambiguous word in isolation and defined the word as used in the sentence (mean accuracy = .84, SD = .12, split-half reliability, rs = .82, $p < .001$). Volunteers also completed the Mill Hill Vocabulary Test (mean accuracy = .57, SD = .11), the Spot the Word Task (mean = .79, SD = .10) and the four-part Cattell 2a Culture Fair Test (mean = .72, SD = .14). A PCA on test scores revealed two components explaining 71% of variance ($p < .001$), reflecting vocabulary knowledge (a language-specific ability) and non-verbal IQ (a domain-general ability). Correlational analyses showed that as age increased, factor scores increased for vocabulary-knowledge ($r = 0.26$, $p <.05$) but decreased for non-verbal-IQ ($r = -0.27$, $p < .05$), consistent with previous research (Hartshorne & Germine, 2015). Multiple linear regression showed comprehension success was predicted by vocabulary knowledge and non-verbal IQ, not age. We have revised the Meaning Definitions Task to make a four-alternative forced-choice version, using IRT to reduce the item set (58 sentences). The task is included in the CamCAN Re-Scan Study, a 10-year follow up of several hundred healthy volunteers across the lifespan (see Shafto et al., 2014 for the original study protocol). In this ongoing study we will test whether semantic ambiguity comprehension ability is predicted by behavioural measures of language-specific and/or domain-general function. Making use of structural MRI and resting state MEG data, we will explore how comprehension is predicted by grey matter density, plus anatomical and functional connectivity in fronto-temporal regions. Multivariate statistical models will enable us to relate comprehension ability to variability in neural and cognitive structure and function, to better understand predictors of successful spoken language comprehension.

Topic Areas: Meaning: Discourse and Pragmatics, Control, Selection, and Executive Processes

## Discourse- and lesion-based aphasia severity estimation

***Poster A10*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Measuring aphasia severity, such as with the Western Aphasia Battery (WAB), can be burdensome on patients, their families, and clinicians. There is a need for supplementary measurements that are brief and can be administered remotely or by non-specialists. Such a measurement could be used to triage patients, monitor progress over time, or when patients have limited access to transportation. Discourse analysis, wherein patients produce continuous speech in response to a standardized prompt, provides a promising avenue towards these goals. However, the specific relationships between linguistic elements elicited by discourse and aphasia severity remain understudied. Here, we used machine learning to predict aphasia severity (WAB Aphasia Quotient; AQ) from linguistic features elicited by discourse prompts developed by AphasiaBank. We inspected feature weights from the models to draw conclusions about which linguistic features are most important for predicting AQ. We also supplemented and compared discourse-based models with lesion-based models that use structural neuroimaging features. Methods: 71 survivors of stroke (left hemisphere unilateral, > 6 months post-stroke) were recorded while responding to 3 AphasiaBank discourse prompts: picture-sequence (Broken Window; BW), narrative (Cinderella; 'tell me the story of Cinderella'), and procedural (PBJ; 'tell me how to make a peanut-butter and jelly sandwich). Recordings were transcribed and coded by trained research assistants under the supervision of speech-language pathologists (SLP). Computerized Language Analysis (CLAN) software extracted 45 linguistic discourse features (e.g., # of nouns, mean utterance length, etc.) for each patient and prompt. SLPs administered the WAB to get an observed AQ. Separately, patients underwent structural neuroimaging to collect lesion features (percent of voxels damaged within each region of the Johns Hopkins University atlas). With these features, we used Support Vector Regression (SVR) with Recursive Feature Elimination (RFE) and leave-one-out cross-validation to train a model on data from 70 patients and predict AQ for 1 left-out patient. Briefly, our RFE protocol trained the model to use only the top 10 most informative features for each split of the data, still keeping training and testing sets separate. We did this for each prompt individually, all prompts combined, lesion features only, and prompts+lesion features. We assessed model performance as the Pearson correlation between predicted and observed AQ (PredAQ; ObsAQ). Results: All model PredAQs were significantly correlated with ObsAQ ($p < .05$). Lowest performance was lesion-only (r=.61), highest was all discourse features combined (r=.83). Using discourse only, results for separate prompts were: BW (r=.78), PBJ (r=.7), and Cinderella (r=.74). Including lesion features with discourse did not significantly change model performance, except for Cinderella, which increased to r=.83. Inspecting feature weights revealed that the number of different grammatical types spoken was the most informative feature in multiple discourse-only models. Integrity of the superior longitudinal fasciculus was the most informative lesion feature. Discussion: This work represents an important step towards using discourse features to predict aphasia severity. While all prompts are informative, models trained on picture-sequence description output provide the highest prediction accuracy. Lesion-based models highlighted the importance of superior longitudinal fasciculus integrity for aphasia severity.

Topic Areas: Meaning: Discourse and Pragmatics, Disorders: Acquired

## Social Anxiety in Mentalising: investigating Theory of Mind through fMRI

***Poster A11*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction Recent studies into the mechanisms of social anxiety have indicated differences in the processing of various Theory of Mind tasks. Behavioural studies suggest that mentalising is more consistently and strongly affected by social anxiety disorder in comparison to emotion recognition. Yet, such findings have not been consistently replicated in neuroscientific studies; the findings vary in directionality and strength. Moreover, no study has actively investigated the differences using a task-based fMRI setup. Additionally, a large number of studies used designs with an evident element of performance, by including questions. This convolutes the findings as the effects of performance anxiety and social anxiety cannot be separated. Methods The current study assesses the differences in mentalising abilities during a passive theory of mind task, for 130 participants with autism spectrum disorder (50), social anxiety traits (40) and controls (40). In a 7T MRI, a 6-minute animated video was shown with no other instruction than to watch. The video presents three conditions which are separated into various scenes, including emotion recognition (pain condition), mentalising (mental condition) and control condition. As the participants did not have to answer questions during the task, the element of performance was limited during the fMRI session. Afterwards, the participants were asked to describe the various scenes and subsequently, the number of mental state words in relation to irrelevant words was assessed. Their levels of anxiety were measured by the Liebowitz Social Anxiety Scale. Results Whole-brain analyses suggest significant differences between the Mental, Pain and Control conditions. The Mental condition exhibits higher activities in areas related to Theory of Mind, such as the precuneus, the bilateral superior frontal gyrus, the left middle temporal gyrus and the left parahippocampal gyrus, compared to the pain and the control condition. Almost no differences between groups were found between the conditions; only the control group showed a small but significant cluster in area V3 in comparison to the social anxiety participants in the mental conditions over the pain conditions. However, there was no influence regarding the level of anxiety on the activation, nor were any behavioural differences found in the ratio of mental state words between groups. Conclusions The results of this task suggest that the current task may not be suitable to detect differences between these groups. Moreover, it shows that at a fundamental level, the groups do not differ in their Theory of Mind activation and abilities. As such, tasks with a higher complexity may elicit more variety in responses.

Topic Areas: Meaning: Discourse and Pragmatics, Disorders: Developmental

## Neural response of pragmatic inference in young and older adults: Evidence from ERP data

***Poster A12*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In verbal communication, a speaker often uses utterances with implicit meaning, which requires listeners to interpret via pragmatic inference. As individuals age, their ability to make efficient and accurate pragmatic inferences may decline, leading to communication difficulties and misunderstandings. Considering the fact that the cognitive neural mechanism has not yet been fully revealed, this paper aims to comprehensively employ EEG recording to probe into the cognitive aging phenomenon of pragmatic reasoning and the cognitive neural mechanisms behind it from the perspective of meaning understanding. The current research investigated the effect of age and the contextual relevance in utterances on pragmatic inference. In each set of scenarios, a certain utterance has different meanings regarding the preceding yes-no question. According to its contextual relevance, an utterance served as a direct reply (DR), a moderately indirect reply (MIR), or a highly indirect reply (HIR). During the EEG recording, participants read the scenarios and were asked to make binary judgments as to whether the speaker wanted to say “yes” or “no” to the preceding question in 1/3 of the trials. The behavioral and event-related potentials (ERP) data were collected and analyzed from nineteen elderly participants (14 females, range 57-78 years, mean age 67.4 years) and twenty-three youngsters (19 females, range 18-23 years, mean age 19 years). The behavioral data showed that the task accuracy for the indirect reply conditions by the young group is significantly higher than that of the elderly group. These results showed that elder people have difficulties in comprehending indirect speech. Furthermore, the ERP data showed that, for both the elderly group and the young group, compared with the direct replies, indirect replies elicited an increased late positive component in the middle and later stages of reply presentation. For the young group, however, indirect replies triggered a greater N400 effect than direct answers in the early and middle stages of reply presentation, while the elderly group did not. These findings illustrated that the pragmatic inference ability of elderly individuals is reduced compared with youngsters, because it was difficult for them to enrich the semantic content of the current utterance in real time. It will provide an important psychological theoretical basis for understanding the verbal communication difficulties of the elderly.

Topic Areas: Meaning: Discourse and Pragmatics, Language Development/Acquisition

## The Effectiveness of tDCS associated with Executive Function Training in Functional Communication: Evidence from poststroke aphasia

***Poster A13*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: New approaches in aphasia rehabilitation have recently identified the crucial role of executive functions (EFs) in language recovery, especially for people with severe aphasia (PWSA) (Olsson et al., 2019; 2020; Schumacher et al., 2019). Indeed, EFs include high-order cognitive abilities such as planning and problem-solving, which enable humans to adapt to novel situations and are essential for everyday functional communication (Miyake et al., 2000; Miyake & Friedman, 2012). To date, different studies have already emphasized the role of non-invasive brain stimulation techniques, such as transcranial direct current stimulation (tDCS), in enhancing language improvement in aphasic individuals (Marangolo, 2020). Aim: To investigate whether anodal tDCS over the right dorsolateral prefrontal cortex (DLPFC) combined with different executive function training would enhance the ability to communicate in everyday life in twenty PWSA. Method: In a randomized double-blind crossover design, twenty chronic Italian PWSA underwent ten days of transcranial direct current stimulation (tDCS) (20 min, 2 mA) over the right dorsolateral prefrontal cortex (DLPFC). Two conditions were considered: 1) anodal and 2) sham while performing four types of cognitive training (alertness, selective attention, visuo-spatial working memory, and planning), all of which were related to executive functions. Results: After anodal tDCS, a greater improvement in selective attention, visuospatial working memory, and planning abilities was found compared to the sham condition; this improvement persisted one month after the intervention. Notably, a significant improvement was also observed in functional communication, as measured through the Communication Activities of Daily Living Scale, in noun and verb naming, auditory and written language comprehension tasks, and executive function abilities. Discussion: Our study highlights several important aspects to consider when making treatment decisions for people with severe aphasia. First, it points to the possibility of training cognitive functions other than language. Indeed, from a connectionist perspective which considers the language system as part of a network largely distributed across the brain, this allows planning different cognitive treatments, which, in turn, facilitate aphasia recovery. It also emphasizes the need to assess the person's functional communication skills, whose recovery, even in the most severe patients, ensures the patient to socially interact in everyday life contexts. Finally, it confirms several previous reports which suggest that post-stroke aphasics in the chronic phase can still benefit from combining the treatment with tDCS.

Topic Areas: Meaning: Discourse and Pragmatics, Language Production

## Using EEG and eye-tracking to investigate the prediction of speech in naturalistic virtual environments

***Poster A14*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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EEG and eye-tracking provide complementary information when investigating language comprehension. Evidence that speech processing may be facilitated by speech prediction comes from the observation that a listener's eye gaze moves towards a referent before it is mentioned if the remainder of the spoken sentence is predictable. However, changes to the trajectory of anticipatory fixations could result from a change in prediction or an attention shift. Conversely, N400 amplitudes and concurrent spectral power provide information about the ease of word processing the moment the word is perceived. In a proof-of-principle investigation, we combined EEG and eye-tracking to study linguistic prediction in naturalistic, virtual environments. Participants (n=32) listened to sentences spoken by a virtual agent (pre-recorded by a native Dutch speaker) during a tour of eight virtual scenes (e.g., office, street) while participants' eye-movements and EEG were recorded. Spoken stimuli were 128 subject-verb-object sentences that were either predictable or unpredictable. The verb in the sentence was either related to a single object (predictable) or multiple objects (unpredictable) in the scene. Objects mentioned were either visible or absent in the scene, to confirm or disconfirm participants' predictions, respectively. Increased processing resources, as reflected in increased theta power, were observed either at the verb onset when the verb was predictive of the noun, or at noun onset if the verb was not predictive of the noun. Alpha power was higher in response to the predictive verb and unpredictable nouns. We replicated greater proportions of anticipatory fixations towards the target object in predictable compared to unpredictable sentences and a greater N400 response to the noun when referents were absent compared to visible in the scene. Conversely, no effect of predictability was seen on the N400. Lastly, anticipatory fixations were predictive of spectral power during noun processing and the proportion of anticipatory fixations could be predicted by theta power at verb onset. In conclusion, the rich visual context that accompanied speech partly altered the findings in the EEG data compared to previous reports, where the visual context eased the processing of unpredictable nouns. Our findings provide strong evidence to suggest that the N400 reflects integration rather than prediction. Overall, we show that combining EEG and eye-tracking provides a promising new method to answer novel research questions about the prediction of upcoming linguistic input, for example, to determine whether changes to the trajectory of anticipatory fixations reflect a change in prediction or an attention shift.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

## Gravity matters for the neural representations of action semantics

***Poster A15*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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How plastic are semantic neural representations? Are common word meanings that have been already acquired still constantly updated as a result of our constant experiential streams? Here, we took advantage of an unusual setting that introduces intriguing sensorimotor experience alterations (microgravity training) to address this question. As a ground-based homolog for microgravity, the head-down tilt bed rest (HDBR) procedure asked participants to remain in the 6° head-down tilt position all the time for 15 days, during which the lower-limb actions were practically absent, whereas manual actions were unrestricted. This allows us to examine whether such a pattern of motor experience alteration specifically affects how the brain represents the meanings of lower-limb action verbs. Neural responses on verbs of two upper-limb actions (“to scratch”, “to pinch”) and two lower-limb actions (“to stomp”, “to kick”) were collected via functional magnetic resonance imaging (fMRI) before and after HDBR. Intriguingly, an experience-effector-specific (lower vs. upper limb) modulation was observed in subcortical motor region (peaking at the right subthalamic nuclei) and the left temporal region (peaking at the left dorsal anterior temporal lobe), and not within the canonical effector-specific verb semantic regions (including the left lateral posterior temporal cortex, the left dorsal premotor cortex, the supplementary motor area, and the left posterior intraparietal sulcus) or hand/foot-effector-specific primary sensorimotor regions. The results showed fine separation between neural structures supporting experience-independent knowledge representation and those whose neural semantic representation induced dynamically by sensorimotor experiences, which does not fully align with the effector-specific representation structures. These findings highlight the multidimensional and dynamic nature of semantic neural representations and the intriguing effects of gravity on cognition in a broader way.

Topic Areas: Meaning: Lexical Semantics,

## Semantic Transparency and Chinese Compound Processing: An ERP Analysis

***Poster A16*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Compounding is a morphologically highly productive word formation in languages worldwide. However, its processing is still a debated topic in psycholinguistics. Two major theoretical models have been proposed: the

full decomposition model (Taft, 2003; Taft & Forster, 1975), which posits that all morphologically complex words are initially decomposed into internal morphemes during processing, and the dual route model (Baayen et al., 1997; Bertram et al., 2000), which asserts that 1) both decomposition and whole-word access take place during compound processing, and 2) the route taken depends on the type of compound. One key feature that may affect compound processing is semantic transparency, which refers to the relatedness/association between the internal constituent and the overall meaning of the compounds (Kim et al., 2019). Several neuroimaging studies have investigated the time course of compound processing with millisecond precision via electroencephalography (EEG) – ultimately revealing mixed findings. Some studies found that transparent compounds have a higher probability of being decomposed, and opaque compounds are accessed instead as whole units – supporting the dual route model. MacGregor and Shtyrov (2013) and Tsang et al. (2022) employed a passive-listening oddball paradigm in English and Mandarin respectively and observed an increased Mismatch Negativity (indicating lexical enhancement) for opaque compounds compared to transparent compounds. In addition, Bai et al. (2008) found a larger N400 for opaque than transparent compounds using an auditory lexical decision task Other studies demonstrate that all compounds undergo full decomposition regardless of their semantic transparency. For example, Wei et al. (2023) used a visual lexical decision task and found that both transparent and opaque compounds induced a stronger Left Anterior Negativity (LAN) compared to monomorphemic words, but there was no difference between the two compound types in both LAN and N400. One factor that may contribute to these inconsistent findings is that these studies treat transparency as a binary feature, without considering the presence of partially transparent/opaque compounds. Therefore, this study aims to investigate if and to what extent the degree of transparency in semantics will impact compound processing. In the proposed study, native speakers of Mandarin will complete a visual lexical decision task in Mandarin while their EEG will be recorded. The stimuli will consist of real compound words and pseudo compound words. Critically, the real compound words will further be categorized based on their degree of transparency into 1) transparent-transparent compounds (e.g., 火山 'fire + mountain' volcano), transparent-opaque compounds (e.g., 笨蛋 'stupid + egg' idiot), opaque-transparent compounds (e.g., 海报 'sea + paper' poster) and opaque-opaque compounds (e.g., 东西 'east + west' thing). We hypothesize that real compounds will elicit a smaller N400 compared to pseudo compounds. Furthermore, within the category of real compounds, we expect to observe the smallest N400 amplitude in fully transparent compounds, the largest amplitude in fully opaque compounds, and an intermediate amplitude in partially transparent compounds. Our findings will shed light on the intricate mechanisms involved in compound processing and contribute to a broader understanding of word storage in the mental lexicon.

Topic Areas: Meaning: Lexical Semantics,

## Investigating the extent of error-based adaptation in language using a repetition paradigm: the effect of sentence context and prediction violation

***Poster A17*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Predictive processing theories of language suggest that predictions are continuously updated

(Bornkessel-Schlesewsky & Schlesewsky, 2019, Front Psychol; Fitz & Chang, 2019, Cogn. Psychol.; Kuperberg, 2016, LCN; Rabovsky et al. 2018, NHB). The N400 ERP component, which is sensitive to unexpected input (Kutas & Hillyard, 1980, Science), allows an investigation of these theories. Previous research has demonstrated that N400 amplitudes are reduced when a previously unexpected word is repeated (Rommers & Federmeier, 2018, Cortex), presumably reflecting an implicit memory benefit and adaptation to the unpredicted word (Hodapp & Rabovsky, 2021, Eur. J. Neurosci.). However, most current language models assume that prediction errors are processed in context (e.g., Rabovsky et al., 2018, NHB), which implies an update not only of the repeated word but also of the predictive properties of the corresponding sentence contexts. Here, we experimentally investigate this assumption. Additionally, the violation of strong predictions (i.e., unexpected words in high versus low constraint contexts) could influence possible sentence-level adaptation effects and influence predictions when the sentence is encountered again. While prediction violation does not influence N400 repetition effects to the unexpected words themselves (Lai et al., 2021, Brain. Res.), the change in predictions made from sentence contexts after encountering unexpected information could depend on how certain the language comprehender was about this prediction before the error was encountered. Methods. To investigate these issues, this pre-registered EEG study employed a sentence repetition paradigm that manipulated the repetition of context as well as the violation of predictions. The sentences presented to the participants (n=42) ended with unexpected words. 20 sentences later, this unexpected critical word was repeated either in the same sentence or in a new sentence (context manipulation). Of the repeated sentences, half were highly constraining, and the other half weakly constraining (prediction violation manipulation). We employed Bayesian linear-mixed effect models to be able to investigate possible null effects of the manipulation. Results. Compared to words that were repeated in new contexts, words repeated in the original sentence contexts demonstrated a stronger repetition effect ($\beta$ = 0.65 [0.06, 1.24], BF10 = 3.16). This indicates that the prediction error at the critical word was processed in a sentence context, updating predictive (sentence) cues, and allowing for more precise context-based predictions later in the experiment. Bayesian methods showed evidence against an effect of violated predictions (i.e., high versus low constraint) on downstream predictions made from the same context ($\beta$ = -0.26 [-0.85, 0.33], BF10=0.46). This suggests that the predictive properties of the sentence are updated in proportion to the amount of unpredicted information rather than the certainty of the prediction. Discussion. Together, the results support accounts of the N400 as neural signature of a semantic prediction error that drives adaptation and extend the experimental evidence beyond word-level effects to sentence-level mechanisms. Crucially, this error-driven one-shot adaptation on a sentence level did not depend on the certainty of the predictions, supporting previous findings that prediction violations do not seem to be critical to adaptation in the language system.

Topic Areas: Meaning: Lexical Semantics,

## Object color knowledge representation in the brain of color-blind: Effects of language and sensory experiences

***Poster A18*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Recent studies have identified different neural structures supporting knowledge representation derived from sensory and from language experiences (see review in Bi, 2021). Our previous work showed that object color knowledge is represented in both posterior fusiform gyrus that relies on visual color experiences (observed in only sighted individuals) and dorsal anterior lobe that is independent from visual experience (in both congenitally blind and sighted). However, how these two types of knowledge representation potentially modulate each other is poorly understood. To address this question, the current study investigated the object color knowledge neural representation in dichromats, whose visual-based and language-based color experience are mismatched due to their abnormal color perception (Saysani et al., 2018). We recruited 14 dichromats (DT; red/green color-blind) and 21 trichromats (TC) and tested their color knowledge on 14 color-diagnostic fruits and vegetables in both behavioral and fMRI tasks. Object color representational similarity matrices (RSM) were constructed through multi-arrangement tasks (arranging objects based on color similarity) with scrambled naturally colored object pictures (scrambled-picture color RSM) and object names (object name color RSM). In TC group the two RSMs were highly correlated ($r = 0.81$); In DT group, the correlation ($r = 0.46$) was significantly lower than the TC group ($p < 0.05$), indicating a dissociation between visual-based and language-based object color representation in the DT group. In the fMRI experiment the subjects were presented grayscale picture of these fruit and vegetables and asked to perform one-back real-world color similarity judgement task. In the color perception mask and the language mask, brain regions representing color knowledge matrices based on visual and language experience were similarly identified using representational similarity analysis (Kriegeskorte et al., 2008) in TC group, after controlling for the confounding effect of other object attributes (i.e., shape, touch, taste, semantic, size, texture). In these object color knowledge processing areas identified in the TC group, we tested whether the DT group represent object color based on visual experience (i.e., scrambled-picture color RSM) or based on language experience (object name color RSM) by performing RSA with each of these RSMs with the other one controlled for. In the bilateral fusiform/lingual gyrus (within the color perception mask), DT's neural activity to gray-scale object pictures was significantly, specifically correlated with the object-name-color RSM (i.e., based on language experience; Bayesian one-sample t test: $BF_{10} >= 2.01$), reflecting the dominant role of language on the sensory-derived representation. In the left anterior temporal lobe (within the language mask), effects of both RSMs were significant, reflecting interaction between two systems. Whole brain searchlight RSA examining the interaction effect between behavior matrix (sensory vs language) and group (DT vs TC) further confirmed that the modulating effects of language on the object color knowledge representation in the color perception regions in the DT group. These results supported the neural dual coding of conceptual knowledge, and highlighted the potential interactions between these two types of representations.

Topic Areas: Meaning: Lexical Semantics,

## Tracking word meanings across contexts in MEG with Representational Similarity Analysis

***Poster A19*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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How does context influence the neural representations of lexical items during online processing? Considering the inherent ambiguity and context-dependent nature of most word forms, this study aims to investigate the representational effects of context dependency. While existing neuro-computational models propose three hypotheses (local, distributed, hybrid) regarding the neural instantiation of semantic space, the impact of context dependency on these representations remains unexplored. In this MEG study, we used representational similarity analysis (RSA) to query the representations of three types of noun-verb ambiguous stems: (i) stems whose meanings are unambiguous or at least very consistent across their noun and verb uses (e.g., dream), (ii) stems whose noun and verb meanings are related though different, that is, a relation of polysemy (a fly/to fly) and (iii) homonym stems whose noun and verb meaning are unrelated to each other (a spell/ to spell). Stems were categorized into these semantic types using Wordsmyth and Wordnet, an online sense-norming experiment as well as a computational measure of contextual dispersion. In addition to addressing the effect of syntactic category and meaning consistency, we also manipulated the size of the local syntactic context of each target word, resulting in a 3 (semantic type) x 2 (syntactic category) x 3 (syntactic context) design. Finally, all stimuli were presented after a context sentence that disambiguated the target item: for example, a sentence such as “Gary is a flight attendant” would be used to disambiguate “fly” towards flying as opposed to the insect sense. Our goal was to determine the extent to which evidence for shared representations could be uncovered across the various contextual manipulations and what the effect of the different types of context factors would be. We performed univariate analyses of source-localized MEG signals to provide a basic profile of the effects of our three factors and then correlated theoretical models of dissimilarity with single-trial MEG activity to characterize representational similarity across contexts. Univariate results showed consistent, wide-spread activity increases for larger syntactic contexts, indicating a higher compositional load, as well as higher signals in fronto-temporal cortex for verbs than nouns. In the RSA, a relatedness model grouping unambiguous and polysemous words together and distinguishing them from homonyms was significant in occipital regions starting around 100ms and then evolved into a more temporal cluster. This could reflect repetition priming under the assumption that the unambiguous and polysemous items share a stem morpheme across the noun and verb uses whereas the homonyms do not. Thus the different instances of the shared stem across the different contexts would serve to prime each other for unambiguous and polysemous items, but not for homonyms. We also identified a large frontal cluster at 284-558ms that was sensitive to the semantic distance between the noun and verb senses of target items, as assessed by our sense-norming experiment. Overall, our results suggest an early emerging correlate of shared representations for unambiguous and polysemous items and a later general sensitivity to sense distance in frontal cortex.

Topic Areas: Meaning: Lexical Semantics,

## Auditory associative word learning in adults: the effects of musical experience and stimulus ordering

***Poster A20*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Word learning is imperative to language development. While much of word learning occurs in infancy and childhood, adults still learn new words. Previous experiments of associative word learning in adults have explored the interaction between object modality and temporal congruency of objects and their labels in the visual and auditory domains. Learning was more effective in the visual modality than in the auditory modality for both sequential and simultaneous temporal congruencies. Auditory associative word learning, that is learning the label of a sound, was only successful with simultaneous stimulus presentation, but not with sequential presentation when the label followed a sound. Here we investigate whether and how this difficulty can be overcome by exploring the effects of i) auditory expertise and ii) sequential order modulations between labels and sounds. We tested auditory associative word learning in two experiments with sequential stimulus presentation, while participants were given a congruency-judgement task and their EEG was recorded. The first experiment focused on the role of auditory expertise, testing auditorily trained musicians versus athletes as a high-level control group. The second experiment focused on stimulus ordering, testing for effects of auditory stimulus saliency in sound-label versus label-sound ordering. Participants in the first experiment were presented with environmental sounds followed by pseudoword labels (after a 600 ms-pause) in consistent and inconsistent combinations during a training phase. Testing phases presented matching pairs (consistent pairings of the training) and violated pairs (sounds and labels from the consistent pairings of the training in novel combinations). While no EEG effects of sound-label association (difference in label processing between consistent and inconsistent pairs) emerged in the training phases of either participant group, musicians (n = 23) showed a positive-going EEG effect to violated compared to matching pairs in the testing phases – yet without any above-chance judgement performance. The athlete group (n = 24) replicated previous findings of processing difficulties in adults with auditory-sequential associative word learning, showing no significant behavioral or EEG effects of sound-label association. The second experiment was similar in design as the first experiment, yet participants heard the stimulus pairs either in sound-label ordering or label-sound ordering. The sound-label group (n = 22) showed a negative-going EEG effect for inconsistent versus consistent pairings during training, but no behavioral or EEG effects of association learning at test. In contrast, the label-sound group (n = 23) did not show any effects during training, but a negative-going EEG effect to violated compared to matching pairs in the testing phases, accompanied by an above-chance detection performance. From our results, we propose that adults have an advantage in auditory associative word learning if they are highly auditorily trained and an advantage when they can first focus on the label, before the labelled sound is presented. This underlines that associative word learning is not only influenced by statistical co-occurrence but also by additional factors that are related to the saliency of the labelled objects and modality-specific expertise.

Topic Areas: Meaning: Lexical Semantics,

## Functional dissociations of the default mode network reflect the type of representation and not perceptual engagement

***Poster A21*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The default mode network (DMN) enables us to deploy representations from long-term memory to understand the significance of perceptual inputs like words and pictures (e.g. semantic cognition), but DMN also supports internally directed cognition decoupled from the external environment (e.g. in autobiographical memory and mind-wandering). These processes differ in both the need to interface with perceptible events and in the type of representation to be accessed. A challenge therefore is to understand whether functional subdivisions within DMN reflect the type of representation being accessed or perceptual engagement, since these aspects of tasks are often confounded in the literature. We performed functional magnetic resonance imaging as participants were asked to perform semantic and episodic tasks. For the semantic task, participants were required to either (1) judge whether a currently presented word was semantically related to a previous word (Semantic Coupled) or (2) generate word that was semantically related to a previous word (Semantic Decoupled); for the episodic task, they were required to either (3) recognise a learned word list (i.e., Episodic Coupled) or (4) recall a list of words in the absence of external input (Episodic Decoupled). Distinct DMN regions responded selectively to semantic and episodic task states regardless of whether they were perceptually coupled or not. Dorsomedial DMN was associated with semantic cognition, while core DMN regions in medial parietal regions were recruited in both episodic tasks. Both dorsomedial and core DMN exhibited stronger activation during perceptually coupled states, showing that DMN is not inherently biased towards internal aspects of cognition. In addition, core DMN can change its patterns of functional connectivity with task-relevant regions to support different task states. In conclusion, DMN supports different types of memory-based representations that can be accessed from both sensory inputs and during internal thought.

Topic Areas: Meaning: Lexical Semantics,

## Motor imagery training and verbal semantic processing. A TMS-EEG study

***Poster A22*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In the present preregistered study, we investigated the implication of motor system training in semantic processing. Specifically, we proposed that motor imagery (MI) training activates the motor system similarly to physical execution and recruits higher-order representations of action concepts. MI can be considered as a simulation process that may lead to neuroplastic changes in the motor system and open new avenues for language rehabilitation (Bayram et al., 2023). We proposed a TMS-EEG experiment with two groups of participants: Kinesthetic MI of upper-limb actions (KMI) and Visual Imagery (VI) training group. Each participant performed a semantic categorization task (SC) (abstract vs action verb) in two different stimulation sessions: Verum and realistic Sham. In the Verum session, participants' right-hand motor area was stimulated subthreshold (i.e., without inducing any hand muscle contraction), in four blocks of 70 stimulations delivered at 0 ms, 200 ms (early stages of semantic processing), or 400 ms (post-semantic processing stages) after verb onset in the SC task. Preliminary behavioral results using linear mixed models in terms of response times (RTs) of 10 participants with TMS-0ms stimulation revealed no significant difference in the KMI group between

Sham and Verum stimulation, while shorter RTs were observed in the VI group in the Verum stimulation. The longer RT observed in the KMI compared to VI training in Verum stimulation suggests that motor training before stimulation may have disrupted the stimulation's facilitatory effects on semantic processing. Furthermore, the stimulation condition differentially affected RTs of abstract and action verbs, similarly in KMI and VI: action verbs were processed faster than abstract verbs, in which verum stimulation led to a larger difference in RTs between abstract and action verbs, suggesting that the facilitatory effect of stimulating M1 is more substantial for action verbs. The spatiotemporal patterns analyses of the TMS-Evoked Potentials using EEG data will allow us to identify the neurophysiological mechanisms underlying behavioral effects. We expect EEG results to reveal how and when semantic access and integration will be affected depending on the manipulated variables. Results will be discussed in line with the literature on the interaction between the motor and the language systems.

Topic Areas: Meaning: Lexical Semantics,

## An fMRI Study of Abstract Verb Representation

***Poster A23*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Multiple representation theories propose that word meaning is supported by simulated sensorimotor experience in modality-specific neural regions, as well as linguistic, emotional, and introspective systems. According to the Hub and Spoke Model of Semantic Memory, this distributed system feeds into a primary semantic hub located in the ventrolateral anterior temporal lobe (ATL). Though a substantial amount of research has been conducted to understand the neural correlates of concrete and abstract noun representation, there is less known about the distributed semantic network for verbs, and in particular abstract verbs. In the present study, we set out to examine whether different types of abstract verbs (mental, emotional, nonembodied) and concrete (embodied) verbs differentially recruit a distributed set of cortical regions outside the anterior temporal lobe (consistent with multiple representation theories). Furthermore, we tested whether the ventrolateral ATL is implicated in processing all types of verbs, which would be consistent with the hub-and-spoke model. Finally, we are investigating whether, across the broader ATL region, there are differential patterns of activation associated with different verb types (consistent with a Graded Semantic Hub Hypothesis). We collected data from 30 participants who completed a syntactic classification task (is it a verb? Yes or no) and a numerical judgement task (either is it an even number? or is it an odd number?), which served as a baseline task. We hypothesized that relative to the baseline task and/or the embodied verb conditions 1) abstract mental verbs will be associated with areas involved in introspective experience such as the temporoparietal junction, 2) abstract emotional verbs will be associated with areas involved in emotional processing such as the amygdala, 3) abstract nonembodied verbs will be associated with areas involved in language comprehension such as the middle temporal gyrus, and 4) embodied verbs will be associated with areas involved in sensory and motor function such as processing action and motion. We also hypothesized that patterns of voxel activity across the ATL would be able to classify the different verb types. Dependent on our emerging results, we will discuss implications for semantic models.

Topic Areas: Meaning: Lexical Semantics,

# The neural correlates of metaphor: An fNIRS Study

***Poster A24*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Metaphors are phrases frequently used in daily conversation in which two constructs are compared to highlight how one construct's meaning overlaps with another (e.g., "Her smile was a cat's purr"). The extent to which the left hemisphere (LH) versus the right (RH) hemisphere are necessary for metaphor processing is debated. Between-study inconsistencies in findings may stem from differences in stimulus familiarity and difficulty. Novel metaphor processing is more challenging than processing familiar metaphors, while metaphors are more challenging than literal phrases. Using functional Near-Infrared Spectroscopy (fNIRS) and a paradigm adapted from fMRI from Cardillo et al. (2012), we first tested the hypothesis that compared to literal sentences, metaphors would recruit several core LH language regions—including inferior frontal gyrus (IFG), middle temporal gyrus (MTG), inferior temporal gyrus (ITG), and supramarginal gyrus (SMG), and angular gyrus (AG)—their RH homologues, and regions within the multiple demand network not traditionally associated with language processing (bilateral dorsolateral prefrontal cortex [DLPFC]). We also hypothesized that novel metaphors would recruit bilateral IFG pars triangularis and posterior LMTG more than familiar metaphors. Twenty-eight healthy individuals (n=14 female; mean age=23.1±3.1 years) participated. First, during a familiarization task, participants were presented 50% of all stimuli and asked to make judgments on imageability, figurativeness, comprehensibility for each stimulus. The fNIRS task was split into two runs with three 25s-blocks/run of each of the following four conditions: 1) familiar metaphors (FAM/MET), 2) novel metaphors (NOV/MET), 3) familiar literal phrases (FAM/LIT), and 4) novel literal phrases (NOV/LIT). Data were acquired using two daisy-chained 8x8 NIRx NIRSport2 devices. The montage included 22 measurement channels/hemisphere and 8 short separation channels. Preprocessing in Homer3 (Huppert et al., 2009) included raw data to optical density (OD) transformation, motion detection and correction via splineSG, rejection of stimuli with uncorrected artifacts (t-range: -5–10sec), low-pass filtering at 0.5 Hz, conversion of OD to concentration, and estimation of the HRF (t-range: -2–25sec) via OLS-GLM for the contrasts of MET > LIT and NOV/MET > FAM/MET ($p < 0.01$). Image reconstruction was performed in AtlasViewer (Aasted et al., 2015). For MET>LIT, we found highly left-lateralized activity in most perisylvian language areas, including LIFG, pars opercularis, ventral precentral and postcentral gyri, LSMG, anterior LAG, mid and posterior LSTG, and mid LMTG as well as mid to posterior RMTG. For the contrast NOV/MET>FAM/MET, we found similar patterns of left lateralized activity as the previous contrast but overall weaker effects. In the RH, greater changes in oxyhemoglobin concentrations were noted in RIFG, pars opercularis for novel versus familiar metaphors. Our findings suggest that the right hemisphere and DLPFC do not play a significant role in metaphor processing in healthy, young adults, in contrast with some prior literature (Cardillo et al., 2012). However, metaphors required more core LH language regions than literal sentences, and novel metaphors required more LH resources than familiar metaphors, consistent with our hypotheses. Future directions include extending this research to neurologically healthy older individuals and clinical populations who struggle with metaphor processing (e.g., right hemisphere stroke survivors).

Topic Areas: Meaning: Lexical Semantics,

## Mommy doesn't like it when I curse: an ERP study on taboo word processing and psychosocial characteristics

***Poster A25*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Taboo words are frequent emotional words but they are processed differently from non-taboo frequent emotional words (i.e. negative or positive words). It has been argued that individual psychosocial factors such religiosity and family environment can affect the way one produces and perceives taboo words. In neurolinguistic experiments, taboo words have been known to elicit early and late ERP components associated with their emotional and social load. An effect for taboo words in the Late Positive Complex (LPC) window, especially, has been thought to reflect processing of pragmatic content, commonly described as the reason why taboo words are processed differently from non-taboo emotional words. However, few studies have been carried out in languages other than English. In this study in Brazilian Portuguese (BP), we aimed to examine the difference in processing taboo and non-taboo emotional stimuli priorly normed in a psycholinguistic experiment. Moreover, we examined how self-reported psychosocial characteristics such as religiosity, usage , tolerance in family environment and general tendency to be offended by taboo words interact with lexical processing of taboo words. Twenty seven undergraduates participated in a lexical decision task with 27 taboo words, 27 neutral words, 27 negative words and 81 pseudowords in BP whilst having their neurophysiological responses recorded by EEG. Mean amplitudes were analyzed for word type effect with a linear mixed effect model, in 8 Regions of Interest (ROI), with additional models including religiosity, usage, family tolerance and offendedness as factors. Different from other studies that report P200 responses for taboo words, we unexpectedly found enhanced N1 responses for taboo words in frontal and frontocentral ROIs, which we suggest could be explained as a reflection of the high frequency of taboo words and possibly enhanced attention due to the high arousal attached to taboo stimuli, as well as their unexpectedness in experimental settings. Instead, we found P200 in the central and frontocentral ROIs only for negative words, which we relate to the processing of emotional load. As expected, pseudowords elicited an N400 effect in the occipital, parietal, frontocentral and centroparietal ROIs. Validating findings reported in the literature, in centroparietal, parietal and occipital ROIs, a robust effect in the LPC window was found for taboo words, linked to the cost of processing the social and pragmatic meaning of taboo words. As for the psychosocial characteristics, we found some modulation of N1 amplitudes, suggestive of higher sensitivity for taboo words in correlation to religiosity, less tolerance, infrequent usage and higher offendedness; however, there were no clear tendencies for the influence of these factors on the N400 or LPC effect. We suggest that future studies with a broader sample might be able to assess this possible influence with more statistical power.

Topic Areas: Meaning: Lexical Semantics,

## Spatio-temporal signatures of social verb processing in the human brain: An MEG study

*__Poster A26__ in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Humans have a natural inclination to interact with one another and this is primarily done through language. Our advanced sociolinguistic abilities are thought to stem from our tendency to live in groups, with social verbs possibly playing a central role in shaping human experience. However, no study has yet examined the spatio-temporal dynamics underpinning the comprehension of verbs associated with social behavior, as opposed to those with low social relevance. To address this gap, we recorded MEG activity while participants engaged in a lexical decision task. During this task, participants were presented with social verbs (e.g., “educating”), non-social verbs (e.g., “typing”), and pseudoverbs (e.g., “lyming”), preceded by a grammatical context (“I am”), and instructed to determine whether the target item was a real word or not. All verbs were carefully matched based on critical linguistic variables, including concreteness, frequency, familiarity, AoA, and sensorimotor properties, among others. We performed a time-frequency analysis and compared social vs. non-social verbs in canonical frequency bands associated to linguistic and socio-cognitive processing (i.e., theta [~6 Hz], alpha [~10 Hz], and beta [~20 Hz]) using a cluster-based permutation approach. The brain generators of the sensor-level effects were further estimated using beamformer techniques. Finally, we performed a machine learning decoding analysis to determine the time span at which social and non-social verbs were maximally decoded on a trial-by-trial basis. Our results revealed that social verbs elicited stronger power decreases in the beta band (~20 Hz) compared to non-social verbs in right fronto-temporal sensors. Source localization analysis identified the involvement of the anterior temporal lobe, superior parietal, prefrontal, and motor/premotor cortices in the right hemisphere. Moreover, the decoding analysis demonstrated that trial-by-trial classification between the two conditions emerged between ~450-580ms with an accuracy of ~75%. Our findings suggest that the socialness of human behavior represents a unique dimension of conceptual knowledge, as evidenced by rightward modulations in beta oscillations during a time window associated to semantic processing. These results align with previous studies linking beta to action semantics and highlighting a key role of the right hemisphere in social cognition. Our study provides additional evidence supporting their involvement in processing the meaning of social verbs, offering new insights into the neurocognitive signatures of socialness in the human brain.

Topic Areas: Meaning: Lexical Semantics,

## The role of the super and subordinate hierarchical relationships in word priming

*__Poster A27__ in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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As we read, text we have already read primes semantic networks resulting in predictions of upcoming words, making reading more efficient. This process is so automatic that in garden-path sentences participants experience a surprisal effect when the conclusion of the sentence violates those predictions. Current cognitive theories propose semantic similarity primarily drives priming within the semantic network. However, linguistic theories propose a number of other features that define semantics such as frequency, structure, word type, specificity, and hierarchical relationships. In the current study, we sought to explore the impact of hierarchical relationships on language processing and priming. Utilizing a lexical decisions paradigm, we quantified the asymmetry in priming when the same pair of superordinate and subordinate words reverse which is the prime or probe. On each trial, participants were asked to judge whether a briefly presented (500ms) stimulus was a real or pseudoword. Pseudowords were constructed to precisely match the real words in letter frequency and position. Unbeknownst to the participants, the 144 total trials were arranged into a set of counterbalanced pairs, such that real and pseudowords, and superordinate and subordinate words followed each other equally often. Stimuli were tightly controlled for frequency, string length, and semantic similarity between pairs. If the cognitive science model of spreading activation predicted by semantic similarity is accurate, the Superordinate-Subordinate and Subordinate-Superordinate conditions should be equal as the exact same words occur in both conditions. However, linguistic models would predict that the Subordinate-Superordinate condition should be faster as subordinate category members contain specific features with more information, leading to higher likelihood of priming the superordinate category head. Contrary to both of these theories the strongest priming was observed in the Superordinate-Subordinate condition. Thus, neither theory accurately predicted the outcome, as hierarchy directly affected priming but in the opposite direction from the linguistic prediction. One possible explanation is that the superordinate word led to greater priming by virtue of simultaneously priming a number of near semantic neighbors to the subordinate word, which in turn supported the subordinate word. This explanation combines the influence of both semantic relatedness and hierarchy via a mechanism well situated in the known properties of the neural substrate. In essence, the structure of language itself introduces a hierarchical effect without the need for a specific representation of that hierarchy. Understanding these dynamics has the potential to advance our knowledge of the neural mechanisms underlying language processing and contribute to the development of more comprehensive models.

Topic Areas: Meaning: Lexical Semantics,

## Coordination of statistical and linguistic information during spoken language comprehension

***Poster A28*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In speech comprehension, while it is generally accepted that contextual probability can be bootstrapped for part of speech (POS) identification, the extent to which pre-existing language knowledge shapes how the brain responds to available statistical information is comparatively less explored. To determine how language knowledge may modulate the neural response to natural speech statistics, this study leverages maximum noise entropy (MNE) models (Kaardal et al. 2017) that will assess how statistical and linguistic features interact to explain magnetoencephalography (MEG) data recorded during natural speech listening. MNE models estimate the relationship between the stimulus and neural response as logistic functions of linear combinations of sets of stimulus features. First-order models assert that neural responses arise from the contributions of individual stimulus features (feature variance), and second-order models sum single feature contributions with contributions made by pairs of stimulus features (feature variance and covariance). Thus, by comparing the fits of first- and second-order models, this study will assess the manner in which relationships between statistical and POS features contribute to model goodness-of-fit beyond the contributions of individual features themselves, which has been the typical focus of previous literature. To date, MEG data have been recorded from 37 participants listening to short folktales in Dutch spoken by a native speaker, and these data have been time-aligned and annotated for phone, phone entropy, word, word frequency, word surprisal, and POS. Subsequently, broadband LFP (0.1-170Hz) and functional band power (δ: 2-4Hz, θ: 4-6Hz, α: 8-12Hz, β: 15-30Hz, ɣ: 30-50Hz) will be derived from the recordings. First- and second-order models will be fit for the five functional bands and broadband LFP of each participant for two types of stimulus feature sets: one set containing acoustic and statistical features only, and one set additionally including POS information. Feature-shuffled models will serve as controls. Fit models will be used to generate predicted neural responses for each sensor, and Pearson's r will be calculated and normalized with the Fisher Z-Transformation to assess the correlation of recorded vs. predicted responses across conditions. The bulk of these analyses should be complete by October 2023. We predict a significant interaction between the effect of model order (first vs. second) and the presence of POS information on MNE model prediction quality, driven by second-order models that include POS information. This would suggest that morphological and statistical information jointly account for neural activity that neither feature set does individually. Alternatively, if all second-order models equally outperform first-order models, it suggests that relationships between features are important to the brain but that POS information recapitulates statistical information. If all models perform identically, it suggests that the brain does not make use of covariance information for the feature types included in these models. Thus, regardless of its outcome, this study will add valuable structure to our understanding of how statistical and language-specific knowledge interact during language comprehension. In this way, this study advances knowledge of how speech comprehension emerges from the intricate coordination of statistical information with structured linguistic knowledge.

Topic Areas: Morphology, Computational Approaches

## Neural markers of developmental processing of grammaticality from childhood to adolescence

***Poster A29*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Errors in the acquisition of grammatical morphology characterize developmental stages of children’s acquisition of overt tense and aspect marking. In English, a common developmental error is the use of infinitive verb forms where finite forms are required. For example, omissions of the past tense "-ed," the 3rd person singular "-s," and copula "to be" are typical errors in the course of English language acquisition in early childhood. For example, in the sentence, "Last year, Bob play football," the nonfinite form "play" has been used instead of the correct finite form "played" to indicate the past tense marking. Other kinds of overt tense and aspect marking errors, such as the subject and auxiliary form mismatch seen in the sentence, "We am seeing a movie," are not attested in development. Little is known about the development of the neural bases of grammatical error processing, including whether there is differential sensitivity to the kinds of grammatical errors that children do vs. do not make during development. The present study examined developmental trajectories in the neural processing of grammatical vs. ungrammatical sentences in a cross-sectional sample of N=87 neurotypical children from 5-18 years old. A grammaticality judgment task, modeled after the stimuli in the Test of Early Grammatical Impairment (TEGI; Rice & Wexler, 2001), was used during functional magnetic resonance imaging (fMRI) to compare brain activation for sentences that were grammatically correct vs. those with either developmental or non-developmental tense/aspect agreement errors. In an event-related fMRI task, children heard 108 auditory sentences while making a grammaticality judgment on each trial via button press. We examined fMRI response magnitude to the three types of sentences in select frontal and temporal regions of interest based on a probabilistic atlas of the adult language network (Lipkin et al., 2022). We found that activation in left inferior frontal gyrus (IFG) pars opercularis and pars triangularis decreased with age in response to hearing grammatically correct sentences, but increased in response to ungrammatical sentences (both developmental and non-developmental errors). However, no significant differences in activation were associated with age when contrasting non-developmental versus developmental grammatical errors to each other. In addition, we used multi-voxel pattern analysis (MVPA) to compare how the neural response profiles to developmental vs. non-developmental errors in each parcel changed as a function of age. In left anterior temporal lobe (including superior and middle temporal gyrus), right posterior temporal lobe, and bilateral supplementary motor area, the neural responses to developmental and nondevelopmental errors became less similar as children got older. These results provide new evidence into the neural maturation of grammaticality processing across development. As children get older, left IFG shows greater dissociation of response magnitude to grammatical vs. ungrammatical sentences. Furthermore, the neural patterns that reflect processing of developmental vs. nondevelopmental grammatical errors become more distinct across development, suggesting more mature encoding of nuanced grammatical information.

Topic Areas: Morphology, Language Development/Acquisition

## The grammatical class of verbs that function as the heads of 'N+V' noun phrases in Mandarin: behavioral and ERP evidence

***Poster A30*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Quansheng Xia[1], Zijing Li, Chen Hao, Gaoyan Zhang; [1]Associate Professor

Nouns and verbs are fundamental word classes in languages. In English and other Indo-European languages, verbs are usually changed to derived word form when they are used as nouns (i.e., to promote, promotion). However, such morphological change for verb nominalization is not required in Mandarin. It is thus unclear whether verbs that function as the heads of 'N+V' noun phrases (i.e., '推广' [to promote] in '项目推广' [project promotion]) are converted into nouns or are still verbs. This study aims to figure out this question by using behavior and ERP approaches. We hypothesized that, even without overt morphological change, verbs functioning as the heads of 'N+V' phrases are nominalized. We selected 46 nouns and 46 verbs that can function as the heads of 'N+X' noun phrases in Mandarin. The nouns and verbs do not differ in word frequency, No. of stroke and concreteness (ps > 0.05) but significantly differ in the ratings of word class ($p < 0.05$). In Experiment 1, the stimuli were presented in isolation and participants were instructed to judge whether the words presented are nouns or not. The results showed that nouns were processed faster and more accurately than verbs (ps < 0.05), indicating nouns and verbs are processed differently without context. In Experiment 2, the target nouns and verbs were embedded in the 'N' contexts, which form 'N+X' noun phrases. In the phrases, the nouns and verbs function as the heads and 'N' functions as the modifiers. Based on the results of a large corpus of Mandarin and subjective ratings by Mandarin speakers, the 'N' in 'N+X' phrases were further divided into two types, 'N' as a context that precedes nouns most, and 'N' as a context that precedes verbs most. Twenty-three 'N' contexts that favor nouns and verbs respectively were chosen. The cloze probability of 'N' contexts and targets was controlled for (ps > 0.05). Participants were instructed to judge whether the contexts and upcoming words are acceptable or not. The brain responses to the stimuli were collected from 128 sites placed on the scalp. The behavior and ERP results showed that, when primed by the 'N' contexts favoring nouns, the target nouns and verbs did not show any difference; while when primed by the 'N' contexts favoring verbs, the nouns were responded longer and elicited increased N400 than verbs. The sLORETA analysis showed that this N400 effect locates at the left middle temporal gyrus, indicating nouns require more effort than verbs in the semantic access. This study is the first to investigate the grammatical class of verbs functioning as the heads of 'N+V' noun phrases in Mandarin, providing behavior and ERP evidence that verbs in the phrases are nominalized even without apparent morphological change. The degree of the nominalization of verbs relates to grammatical class anticipation of 'N' contexts, which calls attention to the importance of 'N' contexts in the study of verb nominalization in Mandarin.

Topic Areas: Morphology, Meaning: Lexical Semantics

## Affix semantic typicality facilitates word processing: MEG evidence from Arabic

***Poster A31*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Understanding words involves parsing them into minimally meaningful units. The word bakery has two morphemes, a root bake and a suffix (-e)ry combining to form a place. The fact that we can understand novel words based on their constituents (e.g: 'bagelry') suggests that we rely on associations with other words' meanings and their constituents. One may guess that 'bagelry' refers to a place for bagels, relying on the semantic typicality of -(e)ry words, many of which are place words: bakery, roastery, gallery, etc. There is room for error though, as -ery produces non-place words that are just as frequent. Slavery, savagery are not places for slaves or savages, but concepts. Machinery, jewelry are not places for machines or jewels, but collections. In this neurolinguistic study, we assess the role of affix semantic typicality in word comprehension beyond form-based processing. For this, we use Arabic, where words are minimally composed of a consonantal root and a word-pattern affix, and the phenomenon of affix semantic typicality is widespread and productive. 26 Levantine Arabic speakers participated in an MEG-recorded continuous lexical decision task of 660 stimuli. Within the task, we exploit a double dissociation in the semantic typicality of two affixes. The first pattern's (maCCaCa, where the root consonants fill the open C slots) words typically denote tools, though atypically denote places, and vice versa for the second pattern (maCCaC). The four conditions crossing meaning and pattern were controlled for word frequency. To examine the impact of an affix's semantic typicality on word processing, we compared typical and atypical words for each affix in spatiotemporal regions/times involved in lexeme processing and semantic recombination. We also compared different lexicality conditions for the same affixes, with two types of pseudowords: existing root-affix combinations, and non-root-affix combinations. Regions implicated in form-based processing and in semantic composition were included as ROIs in saptiotemporal cluster analysis. We found early typicality effects of semantic composition at the temporal pole, with more activity for typical words at 153-176 ms (p=0.024). In the superior temporal gyrus/middle temporal gyrus, we found an interaction effect of typicality and category/word-pattern (peak for tools/maCCaCa) at 138-160 ms (p=0.019). In this same area, a reversal of this interaction effect is seen later at 362-398 ms (a peak for maCCaC/typical-place words, p=0.0067)). The early typicality effects are consistent with previous phrase-level semantic composition findings (Bemis & Pylkkanen, 2011). For our lexicality contrasts, we find a significant difference, in decreasing order of activity, among the processing of words, non-root words, and existing-root words early in the STG/MTG (143-215 ms, p=0.022) and later in the ventral temporal lobe (431-521 ms, p=0.0074), a word superiority effect similar to the sentence superiority effect (Snell & Grainger, 2017). This first neurolinguistic study assessing the role of affix semantic typicality finds semantic composition effects not only in semantic composition areas, but critically, in areas previously associated with form-based processing, alongside effects of word lexicality similar to sentence superiority.

Topic Areas: Morphology, Meaning: Lexical Semantics

## Neural signatures of conversion and stress alternation in English noun-verb recognition

***Poster A32*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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INTRODUCTION. Word stress in English is governed in part by word class, with stress predominantly initial on nouns and non-initial on verbs. Further, English has many noun-verb pairs where stress is the only indicator of word class: e.g., cónvert vs. convért (cf. Sherman 1975, Kelly 1988). Previous research has examined how monosyllabic cases of conversion (noun and verb identical in pronunciation) are processed, where no stress alternation is possible (Pliatsikas et al. 2014, Wheeldon et al. 2018). These studies show increases in processing difficulty for words of greater complexity (boating [[[boat]N]Ving]V as compared with [[walk]Ving]V) despite having identical surface forms. The present study aims to fill this gap by examining the interaction between conversion and lexical stress. METHODS. Participants completed a cross-modal priming lexical decision task where they heard complex words over headphones followed by visually presented stems. Prime-target pairs were structured according to four conditions: (A) stress-alternation (constrúcting→cónstruct[N] / constrúct[V]), (B) conversion from noun base with initial stress (píloting→pílot [N/V]), (C) conversion from verb base with final stress (desígning→desígn [N/V]), and (D) verb-only with final stress (fóllowing→fóllow [V-only; no N counterpart]). An equal number of nonword targets were presented following real-word primes so that the lexical status of the prime could not bias the decision to the visual target. Finally, EEG was recorded while participants completed this task and subsequently pre-processed and averaged into ERPs by condition, priming (related vs. control), and participant. RESULTS. Based on preliminary results from 15 participants (32 will be presented at the conference) three of the four conditions showed significant priming as reflected in N400 reduction over the interval of 300-500 ms following stimulus onset. Within this set, the initially stressed noun-base forms (B) showed the greatest priming (~1.4 μV) followed by stress-alternating and finally stressed verb-base conditions (A/C, ~1 μV each), though this interaction was not significant. The verb-only cases (D) showed a smaller N400 reduction (~0.8 μV) which was not significant. These results are distinct from those from response times in a parallel behavioural experiment (N=32) wherein the verb-only condition (4) showed significantly greater priming than the other three, though all conditions primed; however, this priming effect was due primarily to slower baseline reaction times to verb-only words that words that are multiply represented as nouns and verbs. DISCUSSION. This pattern of results indicates a complex interaction between word class, derivational structure, and stress. When the stress on the prime is initial, participants may expect a noun reading, which is available and metrically consistent in B (píloting→pílot), but not in D (fóllowing→fóllow), yielding priming in B but no priming in D. When stress is non-initial, such as in conditions A and C, both prime-target pairs have the same metrical structure and derivational structures (both are verb-basic), and thus their priming effects are equivalent. Finally, when the base stress is held constant (e.g., initially stressed noun in A/B; cónstruct/pílot), there is greater facilitation from primes with consistent stress (B) than when the stress shifts between verb and noun (A).

Topic Areas: Morphology, Prosody

## Frequency attenuation effects in masked repetition priming: a large-scale online study

***Poster A33*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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For the last 40 years, masked priming has been believed to operate at the first stages of lexical access, since it arises with words (but not pseudowords), and with no apparent frequency attenuation effects (e.g., Forster and Davis, 1984). Nonetheless, such effects have been occasionally reported (e.g., Bodner & Masson, 2001). We claim that the contradicting results reported in the literature were due to the substantial low statistical power of previous studies, which were therefore unable to reliably detect medium-to-small interaction effects. To quantify an adequate sample size to detect such effects, we ran a series of simulations taking into account the expected effect size, and the estimates of the standard deviations of the measurements (in this case, RT to related and RT to unrelated) and correlations between the two. This analysis suggested that a sample size of 2,600 subjects would ensure 97% chances to detect a medium-size interaction effect (around 15 ms). To obviate recruitment issues, we capitalized on modern technologies using a novel online stimulus delivery program (Labvanced). Before running the actual experiment, we also ran a pilot experiment with a reduced sample size (N=299) to assess and ensure reliability of the online stimulus presentation program used (Labvanced). In both the pilot and the full experiments, low- and high-frequency words were sampled from SUBTLEX-US frequency database and presented in a typical visual masked repetition priming design. In addition to the highly significant main effects of relatedness and frequency, the result of the full experiment showed a significant interaction between relatedness e frequency, with the low-frequency priming effects being twice as big as the high-frequency priming effects. These results suggest that frequency does impinge on masked priming, and suggests that the mechanisms of masked priming do not operate exclusively at first stages of lexical access. Further implications on the mechanisms of visual word processing will be discussed at venue.

Topic Areas: Morphology, Reading

## Morphophonological alternations modulate early and automatic decomposition mechanisms in the visual word form area: MEG evidence from Tagalog prefixation

***Poster A34*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Dave Kenneth Cayado[1], Samantha Wray[2], Marco Chia-Ho Lai[3], Linnaea Stockall[1]; [1]Queen Mary University of London, [2]Dartmouth College, [3]New York University

Previous cross-linguistic studies have found significant correlation between stem:whole word transition probability (TP, i.e., a measure of morphological complexity) and activity in the left visual word form area (VWFA) around 100-200ms after stimulus presentation, suggesting that morphologically complex words are subject to early, form-based decomposition mechanisms (e.g., Wray et al., 2022 in Tagalog; Stockall et al., 2019 in English; Ohta et al., 2019 in Japanese; Neophytou et al., 2018 in Greek). However, whether this early and automatic decomposition mechanisms is negatively impacted by morpheme boundary opacity due to morphophonological alternations remains an empirical question. The present study investigates if VWFA-based morphological decomposition is modulated by morphophonological alternations in Tagalog. Methods/Design: 19 native Tagalog speakers participated in a visual lexical decision task with concurrent MEG recording. The task had three conditions, all involving the prefixes paN- or maN-: (a) No-Change; words that do not exhibit morphophonological alternations (e.g., paN + halo 'mixer' = panghalo); (b) Nasal-ASSIMilated: the nasal N is pronounced as /m/ or /n/ to match with the place of articulation of the stem-initial obstruent (e.g., paN + pook 'district' = pampook); (c) Nasal-SUBStituted: the prefix-final nasal and the stem-initial obstruent are substituted by a single phoneme that is homorganic to the original obstruent (e.g., maN + palo 'slap' = mamalo). Nasal substitution makes the boundary between the prefix and stem opaque. The VWFA was localized using a task adapted from Gwilliams and Marantz (2016), where participants attended to stimuli from a 4x2 design: (1) a 4-letter Tagalog word, (2) a single letter, (3) a symbol, or (4) a string of symbols. Each were either (1) unmasked, or (2) masked by Gaussian noise. Localizer Results: we conducted a two-stage regression analysis in which regressions were fit at each time point and source point per-subject for factors of String Type (symbols, letters) and Stimulus Type (1-character string, 4-character string). Spatio-temporal cluster-based permutation tests were conducted in the bilateral occipitotemporal region over a 120-170ms time window. With 19 subjects, we found a significant cluster in the ventral occipitotemporal region (p = 0.038), with higher activation for letter/word than symbol, thereby replicating the canonical activation direction previously found in English, Greek, and Finnish. This brain cluster was subsequently used as a functional region of interest in the morphological decomposition analyses. fROI Results: we extracted the dSPM values averaged across space (the VWFA) and time (from 110 to 160ms) and used it as input for a mixed-effects model with TP and Condition as fixed factors. We found a significant interaction between TP and Condition (p=0.041), suggesting that the effects of TP on dSPM was not consistent across different morphophonological alternations. We further found that TP is significantly negatively correlated with dSPM for the No-Change condition, while no significant correlation was found for ASSIM and SUBS conditions. Overall, the present study finds that morphophonological alternations modulate the ease in which prefixed words are decomposed into morphological units in the VWFA by obscuring morpheme boundaries.

Topic Areas: Morphology, Reading

## Rapid morphological changes in gray matter volume (GMV) and cortical thickness (CT) during reading and face processing with structural T1-weighted MRI.

***Poster A35*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction We used T1-weighted magnetic resonance imaging (MRI) to assess rapid changes in macro-level brain morphology in response to reading words and viewing faces. Previous studies have shown that changes in brain morphology can occur after several years or weeks of practicing a skill (e.g., Maguire et al., 2000; Draganski et al., 2004), but recent evidence suggests that morphological changes can occur in less than a few hours (e.g., Tost et al., 2010) or even within minutes in human visual cortex (Mansson et al., 2020) or human motor cortex (Olivo et al., 2022). To investigate whether such rapid plasticity is also evident in higher cognitive processing like reading or face processing, we conducted a randomized balanced within-subject design study in which healthy participants underwent T1-weighted MRI image acquisition while reading or viewing faces. Hypotheses We hypothesized that reading text and viewing faces will change gray matter volume (GMV) and/or cortical thickness (CT) in the visual cortex. Furthermore, we assume that reading will change GMV and/or CT in the visual word form area (VWFA) and that viewing faces will change GMV and/or CT in the fusiform face area (FFA). In addition, we looked into differences in orthographic, phonological and semantic processing in relationship to potentially changes in GMV and CT. Methods We acquired multiple repetitions of structural T1-weighted and functional blood-oxygen level-dependent (BOLD) MRI measurements from 30 subjects performing passive viewing of faces and reading of text passages repeatedly over 30 min. Differences during reading, viewing faces and rest in GMV and CT were analyzed with voxel based and surface based morphometry (VBM/SBM). Results Preliminary results point to a change in GMV in visual cortex (V1, V2) in response to words and faces. Furthermore, compared to rest a trend of a stimulus specific change in GMV for words in the VWFA as well as for faces in the FFA. Conclusion Rapid changes of GMV in response to words and faces in VWFA and FFA suggest that the brain responds with rapid plasticity even in brain areas processing specific visual information in addition to stimulus unspecific GMV changes in early visual cortex (e.g., Mansson et al., 2020; Olivo et al., 2022).

Topic Areas: Morphology, Reading

## The role of morpho-phonological complexity in word recognition: an ERP study of German nouns

***Poster A36*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous research has shown that complex words are decomposed into their morphological constituents during word recognition. Our goal was to study how derivational depth (i.e. the number of steps in the formation of complex words) with or without accompanying phonological processes (e.g., umlauting or vowel fronting) influenced the recognition of German words. We investigated complex nouns with the nominalizing suffix –ung. The experimental conditions were as follows: (1) one-step non-umlauted, where nouns were derived from their verbal bases in one step, e.g., Ladung (N, “load”) < laden (V, “to load”); (2) two-step non-umlauted, where verbs were derived from adjectival or noun bases before being nominalized, e.g., Planung (N, “planning”) < planen (V, “to plan”) < Plan (N, “plan”); (3) two-step umlauted, where verbs got umlaut in the first derivational step, e.g., Schwächung (N, “weakening”) < schwächen (V, “to weaken”) < schwach (A, “weak”). During EEG recordings participants performed a lexical decision task. We hypothesized that morphological complexity operationalized in the number of derivational steps as well as phonological umlaut will impose processing costs reflected in enhanced N400 amplitudes. So far we have analyzed data from 12 participants but we will present data from 30 participants at the conference. The preliminary results suggest that the potential effect of derivational depth can be seen in the N400 latency range, whereas, the effect of umlauting emerges later in the LPC latency range. To be more specific, there was greater negativity between 350 – 450 ms at the central-parietal electrode positions for both two-step conditions (2 and 3) relative to the one-step condition (1) which was interpreted as the depth effect. With respect to umlaut, the initial analysis shows that its effect occurred after 500 ms. For now, we can tentatively conclude that both derivational depth and the accompanying process of umlauting affected the recognition of German complex nouns.

Topic Areas: Morphology, Speech Perception

## Getting to the 'root' of semantic and syntactic processing of morphologically complex words: MEG evidence from Arabic

***Poster A37*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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[Intro] Crosslinguistically, syntactic and semantic processing has been shown to occur across different time spans and using different neural bases. The dissociation is exemplified in single-word reading of nonwords which are ill-formed due to mismatch between an affix and a stem's syntactic category (e.g. resend but *re-soft) and those which are ill-formed due to semantic incompatibility between stem and affix (e.g. *re-smile). The latter has been found to elicit greater activity in orbitofrontal cortex compared to the former during a time window of 350-500ms after word reading (see Stockall et al. (2019) for English and Neophytou et al. (2018) for Greek). Unlike languages such as English which primarily utilize concatenative morphology in which affixes are appended to cohesive, contiguous stems, Arabic and other Semitic languages are characterized by non-concatenative morphology: noncontiguous roots interleave with noncontiguous patterns (e.g. k-t-b 'writing' + ma--a- 'place' = 'office'). Arabic roots are traditionally analyzed as being underspecified; a root may appear in verbs more often than nouns, but does not receive either its category or full semantic information until after interleaving with a pattern. This allows us to investigate if dissociable processing for semantics and syntactics in morphologically complex words is truly attributable to separability of semantics and syntactics, or if these distinct processing stages are consequences of more underspecified distributional properties. [METHOD] N=18 Arabic speakers participated in a visual lexical decision task with concurrent magnetoencephalography. In addition to reading grammatical, attested words, speakers read two types of nonwords: Syntactic Violation, in which roots only attested in tandem with nominal patterns were interleaved with a verbal pattern (e.g. ʕ-q-r-b 'scorpion' + ta-a--a- 'passive/reflexive' = '*scorpioned'); and Semantic Violation, with roots attested in verbs but interleaved with an unattested verbal pattern that indicates a passive or reflexive reading (e.g. z-ɣ-r-d 'trill' + ta-a--a- 'passive/reflexive' = '*was trilled'). [RESULTS] Spatiotemporal cluster-based regressions at 10,000 permutations were performed to determine significant clusters of activity in time and space within a window of 300-500ms after stimulus presentation. Three clusters were identified, all in orbitofrontal cortex: in the left hemisphere, Semantic Violation items elicited significantly more activity than Syntactic Violation items from 426-492ms ($p < 0.01$), and in the right hemisphere, Semantic Violation items elicited more activity than Syntactic Violation items from 421-478ms ($p = 0.11$) and from 479-500 ($p = .15$). These results suggest that the processing stages of morphologically complex words which have previously been claimed to be sensitive to syntactic category (Manouilidou & Stockall 2014; Schreuder & Baayen 1995) may actually be picking up on more distributed statistical properties of morphosyntax, such as which syntactic category is the root/stem likely to emerge in. These results thus not only inform us about how syntactic and semantic information is processed during word recognition but is also compatible with theoretical linguistic accounts that posit distribution of semantic and syntactic properties across the grammar such as Distributed Morphology (Halle & Marantz 1994), as opposed to the bundling of these properties within lexical items.

Topic Areas: Morphology, Syntax and Combinatorial Semantics

## Morphological decomposition in bilateral fusiform areas in Bangla: An MEG

study.

***Poster A38*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Reading morphologically complex words involves identifying the word's constituent morphemes (Rastle & Davis 2008). MEG evidence suggests that these processes occur in the first 200ms of reading, localizing to the left fusiform gyrus (Solomyak & Marantz 2011). However, this work predominantly relies on European languages written in the Roman script. Here, we show evidence of morphological decomposition in bilateral fusiform gyri in Bangla, an understudied language written in an abugida. We develop a functional localizer to identify word-specific brain responses, and demonstrate that stem-to-word transition probability correlates with MEG activity in this region. [METHODS] N=22 Bangla speakers participated in two tasks. The first task involved reading 50 Bangla words and 50 non-linguistic symbols, embedded in two noise levels (Gwilliams, Lewis, & Marantz 2018; Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin 1999). The second was a lexical decision task, involving reading 152 grammatical and 152 ungrammatical morphologically complex words. Brain signals were recorded with a 208 axial gradiometer MEG. [RESULTS] For data from both tasks, we conducted two-stage regression analyses, fitting a regression to each time and source point. We identified significant clusters using spatio-temporal cluster-based permutation tests, computed on t-statistic from one-sided t-tests on regression beta values. Regressions for the Localizer task consisted of String Type (words, symbols) and Noise Level (low, high), spatio-temporal clustering was conducted in left and right occipitotemporal regions, 130-180ms (~"M170" time window) and 150–200ms and 170-220ms (based on visual identification of peaks in sensor data). Marginal effect of Noise was observed 130-153ms in right-posterior fusiform gyrus ($p = 0.10$). Effect of String Type was observed 150–182ms, in the same region ($p < 0.01$). Analyses of MEG data from the lexical decision task included regressions of stem-to-word transition probability, with clustering in bilateral occipitotemporal regions from 150–182ms, i.e., the same time coordinates as the String Type cluster in the localizer task, plus an exploratory 170-220ms time window. A marginally significant cluster of transition probability was identified in right-posterior fusiform gyrus, 150–178ms ($p = 0.09$) in the localizer time window, and 203–220ms in left middle fusiform gyrus in the later time window ($p= 0.025$). Further analyses were conducted for effects of stem frequency and whole-word frequency in 200–500ms time window, in the left temporal lobe. Significant clusters of whole word frequency were identified in left anterior superior temporal regions, 449–500ms ($p = 0.02$). [CONCLUSION] Our results are consistent with Neophytou, Manouilidou, Stockall, & Marantz's (2018) morphological processing model, in which visual form-based morphological decomposition occurs first in fusiform regions, followed by morphological 'recomposition' and whole-word look up in anterior temporal regions. Unlike previous findings in English and Greek, however, the visual word form-responses and morphological decomposition processes initiate in right hemisphere regions, and are subsequently detectable in left-hemisphere. Although other findings show bilateral activity in fusiform gyri for word-form responses (Tarkiainen et al. 1999) and morphological decomposition (Zweig & Pylkkänen 2009), these responses are left-lateralized in European languages. We suggest that hemisphere differences between previous findings and ours may arise from morphological properties of Bangla, or its orthography.

Topic Areas: Morphology,

## Category vs. Semantic Morphological Rule Violations: MEG Comparisons from South Slavic

***Poster A39*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous studies have shown dissociation between stem+affix well-formedness based on category and semantics when processing morphologically complex words. Using pseudoword paradigm with Greek suffixes, Neophytou et al. (2018) showed more activation in left temporal lobe in the 200-300ms time window for the pseudowords violating category-selection rules, and more activation in the orbitofrontal cortex in the 300-500ms window for the pseudowords violating verb argument structure. Comparable pattern of results was obtained in Stockall et al. (2019) with English prefixes. However, with evidence coming from argument structure rule violations only, it's not clear whether the later sub-process relates to semantic information other than argument structure. We created 2 experiments with equivalent designs in two closely related South Slavic languages, Slovenian and BCS, with pseudowords violating prefix attachment rules. Using 3 prefixes that are equivalent in Slovenian and BCS (raz, od, vz/uz), we compared category-selection rules violation (e.g. *razmajka, "raz-mother") to purely semantic (rather than argument structure) rule violations, where the violated dimension was that of state stability/durativity (*razčutiti, "raz-feel"). 16 native speakers of Slovenian and 23 native speakers of BCS performed a lexical decision task in their respective languages, with the concurrent MEG recordings. 1000 Hz sample rate was used on a 208-channel axial gradiometer system. We extracted 600 epochs for each stimulus, and conducted a two-stage regression analysis in which regressions were fit at each time point and source point per subject. We conducted spatio-temporal cluster-based permutation tests on the one-sample t-test values derived from the beta coefficient of the regressions in left temporal lobe and orbitofrontal cortex, in line with Neophytou et al. (2018) and Stockall et al. (2019). The preliminary analyses of the Slovenian data shows a marginally significant cluster for the Condition effect in the orbitofrontal cortex that spans from 334 to 394 ms (p=0.06), with more negative activity for semantic violations. In the BCS data, we found a later significant cluster for the Condition X Prefix interaction spanning from 500 to 515 ms (p=0.03), where more negative activity was found for the semantic violations with the prefix –uz. No significant clusters were found in the left temporal lobe analysis in the 200-300ms time window for either of the languages. These results confirm involvement of the orbitofrontal cortex in the processes related to semantic well-formedness in morphologically complex words, coming from designs that rely on more purely semantic rules, from two closely related South Slavic languages. Further analyses are necessary to test whether these effects hold across prefixes, as well as to understand if the lack of early, category-selection based effects in the left temporal lobe is specific to these languages.

Topic Areas: Morphology,

## Pupillary response of monolinguals and bilinguals in linguistic and nonlinguistic processing

*Poster A40* in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port

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Introduction. Changes in pupillary response is a physiological measure of cognitive processing load (Granholm et al., 1996; Partala et al., 2000). Limited prior research has explored the effects of language background on pupillary response in speech processing. For example, relative to native speakers, greater pupil size was observed in nonnative participants when listening to English as a second language, suggesting increased listening effort (Borghini & Hazan, 2018; 2020). However, few studies have addressed how bilingual experience impacts pupil response when processing speech and nonspeech stimuli in general. The present study was designed to compare pupillary response between monolinguals and bilinguals in linguistic and nonlinguistic auditory processing with different cognitive load. Methods. Based on previous research (e.g., Borghini & Hazan, 2020), 70 English speakers (aged 18-25, controlled for sex and socioeconomic status) will be tested, including 35 monolingual and 35 simultaneous bilingual who spoke another language but learned both before age 3. Participants performed two active listening tasks: linguistic and nonlinguistic, with 18 trials (around 15 minutes) each. In the linguistic task, they listened to short passages (in English or an unfamiliar language) while watching a video on the screen, then answered whether they heard a target word. In the nonlinguistic task, they listened to sequences of musical tones (simple or complex, varied by instrument varieties) while watching the video and were asked whether they heard a target instrument sound. Participants' pupil data were collected using an EyeLink 1000 Plus eye tracker (SR Research, Canada), preprocessed using the PupilPre package (Kyröläinen et al., 2019), and analyzed through generalized additive mixed-effects modeling as it is well designed for time series data analysis (van Rij et al., 2019). Results. Preliminary results reveal different pupillary response in linguistic and nonlinguistic processing. Specifically, in the linguistic task, bilinguals had larger pupil size than monolinguals when listening to English as the familiar language. Further, bilinguals showed similar pupil dilation when attending to familiar and unfamiliar languages, whereas monolinguals did not. In the nonlinguistic task, however, we did not observe group differences. Further discussion will be provided regarding the detailed results. Conclusion. In summary, our findings demonstrate increased pupil dilation in bilinguals than monolinguals when listening to familiar spoken language. This could be attributed to bilinguals' different linguistic experience, as they are generally exposed to more variability in their input than monolinguals, which could lead to more attentional resources required in language processing. Yet, no group differences when listening to musical sounds suggests that bilingual experience affects linguistic and nonlinguistic auditory processing differently. Overall, these findings contribute to building theories of bilingual language and cognition, which are currently lacking in the field (Blanco-Elorrieta & Caramazza, 2021).

Topic Areas: Multilingualism,

## Cortical Generators and Connections Underlying Phoneme Perception: a Mismatch Negativity and P300 Investigation

*Poster A41* in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port

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Background. The Mismatch Negativity and P300 have been widely studied in relation to the perception of pure tone contrasts. Through the administration of linguistic stimuli, these components can also reflect the processes of phoneme discrimination and phoneme categorization, respectively. In relation to pure tone processing, a network encompassing the bilateral superior auditory cortex and right frontal cortex has been described to underly the MMN. The pure tone P300, in turn, is generated by a bilateral fronto-parietal network. At present, it is unclear whether these networks also aid the perception of phoneme contrasts. From this context, the current study aimed to identify the cortical generators and functional cortico-cortical connections governing auditory phoneme perception, through the recording of the MMN and P300 during phonemic oddball tasks. Methods. In 60 healthy adults (30 males, 30 females) aged 20-80 years, electro-encephalography (EEG) was recorded from 128 electrode channels during the administration of an inattentive and attentive auditory oddball paradigm. In these tasks, the standard stimulus [be] and deviant stimulus [ge], contrasting only in terms of articulation place, were presented with an 80/20 probability. The recorded EEG data were preprocessed to extract the event-related potentials (ERPs) for the standard and deviant condition, separately. Source reconstruction of the standard and deviant ERPs was then performed for each participant using eLORETA (Pascual-Marcqui et al., 2011). We applied cluster-based non-parametric permutation testing to identify significant activation differences between both conditions in three component-specific time windows (MMN: 140-190ms, 190-240ms, 240-290ms; P300: 370-420ms, 460-510ms, 590-640ms). Functional connectivity analysis was performed between a total of 68 regions of interest, identified based on the Desikan-Killiany atlas. The maximal cross-correlation function was calculated between each ROI-pair. We applied network-based statistics (Zalesky et al., 2010) to identify significant network differences between the standard and deviant condition. Results. Activation clusters for the MMN were located in the temporal (left and right insula, left superior temporal, right temporal pole), frontal (right rostral middle frontal, pars opercularis) and parietal (left postcentral, supramarginal) cortex. Increased connectivity between the right temporoparietal and left frontal regions was found during inattentive deviant processing. P300 activation clusters were identified in the frontal (left caudal middle frontal, right precentral), parietal (right precuneus) and cingulate (bilateral posterior cingulate, right isthmus cingulate) cortex. Attentive deviant processing relied on increased intra- and interhemispheric connectivity between parietal, cingulate and occipital regions. Discussion. The present results indicate a fronto-temporo-parietal and a fronto-parieto-cingulate network to facilitate passive phoneme discrimination (MMN) and active phoneme categorization (P300), respectively. While this suggests that phoneme perception essentially draws on the same networks as pure tone processing, some activated areas, such as the supramarginal gyrus (MMN) and the insula (P300), might be specific to language processing. Both passive and active processing of phoneme contrasts showed no lateralization to the language-dominant hemisphere. The adopted stimuli, as well as the artificial way of studying phoneme processing in the current study might account for this. Alternatively, both the MMN and P300 might at least partially reflect the activation of domain-general (attention) networks, thus explaining the bilateral activation.

Topic Areas: Phonology, Methods

## Identifying the neural bases of phonological learning

***Poster A42*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Chiara Repetti-Ludlow[1], Adam Buchwald[1]; [1]New York University

Past research has shown that targeting the left motor cortex (M1) with transcranial direct current stimulation (tDCS) during a speech motor learning task can enhance learning of novel speech sound sequences, such as onset consonant clusters (Buchwald et al., 2019). This mirrors similar findings in non-speech motor learning, where targeting M1 can enhance learning in both unimpaired speakers and stroke survivors. However, learning in the speech domain includes both motor learning and phonological (more abstract) learning. Thus, while targeting M1 can enhance motor learning, it remains possible that additional regions are relevant for phonological learning. This sandbox series research project addresses this issue by comparing performance on a phonological learning task while using tDCS to target regions associated with motor (M1) and phonological (pars opercularis) processing. Data collection is beginning, with one group receiving anodal stimulation over M1 (C3 in the 10-20 system), a second group receiving anodal stimulation over LIFG (F5), and a third group receiving sham stimulation. In all cases, the cathode is over the right supraorbital region (Fp2). 20 participants will be recruited for each of the three groups. In order to limit motor effects in this study, we have designed a phonological learning task in an artificial grammar paradigm. Participants learn words in an “alien language” that contains “back vowel harmony,” in which two vowels in the same word assimilate to have the same backness. This process is well-attested in the world’s languages (Rose & Walker, 2011), and previous work has shown that adults who do not speak a language with vowel harmony can still acquire harmony patterns within 20 minutes (Finley, 2017). In the training phase, participants see images with three animals and a circle around one, two, or all three animals. Animal names are phonotactically-legal nonwords. In one version, two animals have a dual suffix “-a,” and three animals have a plural suffix “-u.” Thus, if one animal is called leeg, then two are leega, and three are lugu, with the first vowel moving back and rounding in accordance with the phonological process. After a 20-minute phonological training phase that coincides with the tDCS administration, participants are presented with previously untested images. They hear recordings of two words and then select which they think correctly describes the image. Critical trials will compare items that follow the phonological process with those that don’t (in this example, lugu vs. leegu). Pilot testing done without stimulation indicate that there is not a ceiling effect, thus allowing for different magnitudes of improvement. We hypothesize that the participants in the active tDCS LIFG group will perform significantly better than others at learning the back vowel harmony phonological process. These findings will be compared to our ongoing work on novel consonant cluster learning targeting the same regions. Results from this study will shed new light on our understanding of the neural architecture underlying phonetic and phonological learning processes.

Topic Areas: Phonology, Speech Motor Control

## Learning to map between discrete structure in speech sounds and motor actions

***Poster A43*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Peter Donhauser[1], Yue Sun[1], David Poeppel[1,2]; [1]Ernst Strüngmann Institute, [2]New York University

Listeners arguably transform acoustic speech signals into discrete phonological representations and can use these for lexical access or repetition. While different representational formats (phonemes, syllables, distinctive features) might be employed at different computational stages of speech processing, the degree to which they are accessible to other computations might differ. For example, when learning to write, a specific representational format of speech (phonemes, for some writing systems) has to be made accessible to a new output domain. Here we developed an experimental paradigm that aimed to test the accessibility of speech representations, specifically the distinctive feature level, using an auditory-motor learning task. Both speech sounds and motor acts, although continuous at the surface level, can be described by discrete features in a given context. For example, the onset of the syllable /ba/ can be uniquely described by the features {labial, plosive, voiced} within the sound inventory of German, and a button press with the left index finger could be uniquely described by the features {left, index} among the response options in an experimental task. When participants have to learn a new mapping between sets of syllables and motor acts, the mapping should be easier to learn if features of both sets map onto each other. Eight participants learned auditory-motor associations between 1) four syllables whose onsets differed in manner and place of articulation: plosives (labial /ba/ or coronal /da/) and nasals (labial /ma/ or coronal /na/) and 2) four buttons that were pressed with index or middle finger of the left or right hand. Participants learned multiple different mappings with either a consistent or an inconsistent mapping between syllables and buttons, counterbalanced across participants. We used an auditory feedback procedure in which participants heard syllables from two speakers in rhythmic alternation: the target syllable is uttered by the first speaker and participants press a button to control the syllable that will be uttered by the second speaker. Participants have to learn the correct auditory-motor mapping to match the target syllable. Reaction times averaged within different mappings exhibit effects for order and consistency: while participants' reaction times were influenced by the temporal order of mappings, they were faster for consistent mappings, as predicted. We then split errors into double-feature (wrong hand and finger) and single-feature (wrong hand or finger) errors and found an interaction between consistency and error type: while different error types were equally probable for inconsistent mappings, single feature errors were more frequent for consistent mappings, suggesting that participants did learn direct mappings at the feature level when this was possible. We thus found preliminary evidence that listeners can access speech representations at the distinctive feature level and map them to an arbitrary but analogously structured motor output. We argue that the problem of representational formats and their accessibility is important not only for language science but also applications, whether old or new (reading, writing, brain computer interfaces).

Topic Areas: Phonology,

## Syllables and their beginnings have a special role in the mental lexicon

***Poster A44*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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How spoken words are stored in the brain is a fascinating question for the understanding of human language. Since words are built as temporal sequences of speech sounds, a relevant but not yet clearly answered question is whether individual speech sounds within these sequences contribute equally to the encoding of words. One widely shared intuition suggests that lexical informativeness decays gradually from the beginning to the end of words, due to the directional nature of time. Meanwhile, ample evidence from psycholinguistic and neurolinguistic research demonstrated that perception and production of continuous speech is governed by a critical computational unit: the syllable. This body of work revealed that speech sounds at syllable beginnings (onsets) are more reliably processed than those at syllable endings (codas). Based on the assumption of a functional interplay between speech processing and lexical storage, our study investigates whether the distribution of lexical information among different speech sounds of words is also regulated by the syllable unit. By analyzing lexical databases of 12 typological different languages, we demonstrate that there is a compelling asymmetry between syllable onset and syllable coda in their involvement in distinguishing words stored in the lexicon. In particular, we show that the functional advantage of syllable onset over syllable coda reflects an asymmetrical distribution of lexical informativeness within the syllable unit, but not an effect of a global decay of informativeness from the beginning to the end of a word. Furthermore, employing 3 series of lexicon simulations, we demonstrated that the greater involvement of syllable onset in contrasting words is jointly determined by various streams of phonological and phonotactic regularities that shape the probabilistic distribution of speech sounds across different positions within words. These regularities reflect computational constraints from both the transformations between lexical representations and their corresponding articulatory/acoustic correlates and the mapping between lexical representations to semantic units. Our findings highlight the intricate relationship between the computations in speech operations and the organization of words in the mental lexicon. The converging evidence across languages from a range of typological families supports the conjecture that the syllable unit, while being a critical primitive for both speech perception and production, is also a key organizational constraint for lexical storage.

Topic Areas: Phonology,

## Neural source dynamics of predictive and integratory structure building during natural story listening

***Poster A45** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Neuro-computational language models have gained popularity as linguistically interpretable tools for studying language comprehension in naturalistic contexts. Here, we use this method to investigate to what extent three commonly used parsing strategies can account for neural activity related to Dutch sentence comprehension. In particular, we test how well the brain activity of people listening to Dutch audiobook stories is predicted by an integratory bottom-up parser, a predictive top-down parser, and a mildly predictive left-corner parser. Dutch syntax exhibits mixed headedness, which makes it more amenable to comparing

different parsing strategies than English, because English phrases are strictly head-initial and therefore particularly well-suited for the left-corner parsing strategy. By comparing these parsers in terms of how well they reconstruct brain activity during natural story listening, we intend to uncover possible mechanisms underlying high-level language comprehension. Twenty-four Dutch participants listened to 49 minutes of Dutch audiobook stories while their brain activity was measured with magnetoencephalography. Each word in the audiobook was assigned a complexity metric corresponding to the number of nodes that would be visited by the three parsers when incrementally integrating the word into the hierarchical structure of the sentence. These syntactic complexity metrics were then mapped onto delta-band source activity using multivariate temporal response functions (TRFs). TRFs are linear kernels that describe how the brain responds to a representation of a (linguistic) feature. By additionally including lower-level features as predictors in our TRF models, we explicitly modeled the acoustic (i.e., acoustic spectrogram, acoustic onsets) and statistical (i.e., word frequency, entropy, surprisal) properties of the auditory stimuli. The results show that all three syntactic predictors explain variance in the left-hemispheric language network on top of the variance accounted for by lower-level predictors. Strikingly, activity in left inferior frontal and superior temporal regions most strongly reflects node counts derived by the top-down method, showing that predictive structure building is an important component of Dutch sentence comprehension. The effects of node count derived from bottom-up and left-corner parsing models, while significant, were considerably weaker. The weak effects of bottom-up node count in the presence of strong top-down effect suggests that predictive sentence comprehension (captured by strong effects of top-down node count) is accompanied by reduced demands on integratory processing (reflected in weak effects of bottom-up node count). Moreover, the absence of strong effects of left-corner node counts suggests that its mildly predictive strategy does not capture Dutch sentence comprehension well, in contrast to what has been found for English. This might be related to the fact that Dutch contains head-final phrases, whose left corner often contains multiple words, making the left-corner parsing strategy insufficiently incremental. In sum, using neuro-computational language models, we find that Dutch sentence comprehension is best modeled via a predictive parsing strategy, contrasting previous naturalistic studies conducted in English. These findings, though still from related languages, therefore underscore the need for more work on typologically diverse languages, whose structural properties are different from those of English and therefore invite different parsing strategies within the fronto-temporal language network.

Topic Areas: Syntax and Combinatorial Semantics, Computational Approaches

## Modeling memory retrieval during naturalistic comprehension

***Poster A46*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Tzu-Yun Tung[1], Jonathan R. Brennan[1]; [1]University of Michigan

INTRODUCTION: Retrieval interference effects during agreement processing have been explained by cue-based retrieval theories under Adaptive Control of Thought-Rational (ACT-R) [3]. However, previous studies rely primarily on artificially-constructed sentences, which differ from every-day language. How similarity-based interference and decay may modulate naturalistic comprehension [1] remains unknown. We test for interference and decay effects during the resolution of subject-verb agreement during Chinese audiobook naturalistic listening. Extending [6]'s characterisation of pronoun reference in natural stories with ACT-R, we fit electroencephalography (EEG) signals against two ACT-R variants [4] and word-predictability measure from Chinese GPT2 [2, 9]. Variants differ in cue-combinatorics [8, 10]: structural cues may be weighted (i) equally [3] or (ii) preferably [8] over nonstructural cues in ACT-R. We find that interference effects, indexed by sustained negativity Event-Related Potential (ERP) component, surface in naturalistic comprehension, and are captured by both ACT-R models. METHODS: We extracted all subject-verb dependencies and intervening distractor nouns from audiobook text and annotated animacy features of the target and distractor nouns to determine interference effects (formalized as weighted associative strength in ACT-R); the time-interval between subject and verb was noted to model activation decay. Interference was higher where the animacy feature matched between target and distractor nouns. We then derived the ACT-R metrics reflecting activation of subject noun-phrase and GPT2 surprisal at the critical verb. 19 Chinese native speakers (12 female; aged 20–38) listened to Chinese "The Little Prince" audiobook [5] during EEG recordings (sampling 500 Hz, online filter 0.1–200 Hz). Data was segmented around critical verb onset (-300–1000 ms); artifacts removed (0%-4.9%) using ICA and visual inspection. Single-trial mean amplitude was computed per trial for central channels (Fz, FC1, FC2, Cz, CP1, CP2, Pz) during 100–300, 300–500 and 500–800 ms [7, 11]. EEG amplitude was the dependent variable in separate Bayesian statistical models with different ACT-R and GPT2 metrics as fixed effect and random slope of each metric by participant. 223 trials were analyzed per participant. RESULTS & CONCLUSION: Results show interference effects during naturalistic comprehension: Higher subject activation and weighted associative strength, estimated via both ACT-R models, leads to less negativity in all three time-windows. Regression coefficients b (posterior mean and 95% CI) are: ACT-R-1: 0.06 ([0.01, 0.10]), 0.04 ([0.007, 0.08]), 0.04 ([0.006, 0.07]). ACT-R-2: 0.06 ([0.01, 0.10]), 0.04 ([0.007, 0.08]), 0.04 ([0.008, 0.07]). Compared to GPT2 surprisal, ACT-R metrics receive stronger evidence for successfully predicting single-trial EEG amplitude of the sustained negativity: ACT-R-1: $\Delta$ELPD = −2.7 SE = 2.6, $\Delta$ELPD = −3.7 SE = 3.6, $\Delta$ELPD = −2.7 SE = 3.0. ACT-R-2: $\Delta$ELPD = −2.7 SE = 2.6, $\Delta$ELPD = −3.8 SE = 3.7, $\Delta$ELPD = −2.6 SE = 3.0. We thus report one of the first cortical electrophysiological evidence of the memory interference effects during naturalistic language processing. Supplement: https://shorturl.at/MPSWZ

Topic Areas: Syntax and Combinatorial Semantics, Computational Approaches

## Tracking the representational dynamics of linguistic composition during sentence comprehension: A proposed neural decoding study

***Poster A47*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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[Introduction] The spatial and temporal correlates of linguistic composition have received much attention in the field (Brennan et al., 2020; Ding et al., 2016; Pylkkänen, 2020; Zaccarella & Friederici, 2015). However, the representational details of composition remained underspecified in neuroscientific terms: What is the relationship between inputs and outputs of this computation (c.f. Fyshe et al., 2019)? In this proposed study, we probe how linguistic representations evolve during phrasal composition using neural decoding (King et al., 2018). Specifically, we test the hypothesis that syntactic information of a verb head is re-activated when it is "merged" into a Verb-Adverb phrase (e.g., at the right bracket in [eat slowly]). [Design] The current study involves (1) training a decoder that exclusively targets syntactic category information and (2) using it to probe how category information is activated across a phrase. First, we train a V-Adv part-of-speech (PoS) temporal decoder on EEG data recorded during rapid serial visual presentation of sentences. Then, the decoder is used to predict PoS on data from a separate testing region of those sentences where we manipulate compositional context. Activation dynamics of the grammatical head (the verb) is quantified as the probability that a V-Adv decoder assigns the corresponding label ("V"). To illustrate, for the word-wise translated Chinese sentence "[run DE quickly] DE team [arrived early]" ("The team that ran fast arrived early"; the DE morpheme either introduces a modifier or a head), a V-Adv decoder will be trained on the sentence-final region and is then applied to predict PoS tags at the critical Adv ("quickly") in the sentence-initial region. We manipulate two factors in the critical region: Bracket Closing (present: "run quickly"; absent: "run quick") and Conceptual Association (high: "run quickly"; low: "run profoundly"), resulting in four conditions of 60 experimental sentences each. If PoS information is reactivated phrase-finally, we expect higher verb activation at the critical Adv when there is bracket closing, independent of conceptual association. To evaluate generalizability, we also train a separate decoder on epochs from a phrase plausibility judgment experiment (thus "between-task"). [Analysis] EEG epochs (train and test) will be baseline corrected and then augmented with a 3-epoch averaging technique (Murphy et al., 2022). Augmented epochs enter the temporal decoding pipeline based on a sliding logistic regression classifier over all sensors, yielding a time-series of P(Verb) across the critical region. Cluster-based permutation tests will be performed to identify significant clusters between conditions. [Results and Directions] Pilot analysis (N=2) yielded PoS decoding accuracy of above 70% within the training epochs using cross-validation, and above-chance accuracy (52%) in test epochs. ERP analyses showed a composition-induced negativity at Fz in the 250-300ms time window, which is modulated by Bracket Closing and Conceptual Association (consistent with Neufeld et al., 2016; Parrish & Pylkkänen, 2022). Statistical comparisons will be performed once we reach a target N of 30.

Topic Areas: Syntax and Combinatorial Semantics, Computational Approaches

## Memory-based processing models predict neural tracking during comprehension of complex sentences

***Poster A48*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction Models of sentence processing seek to explain the relationship between linguistic complexity and processing difficulty. Towards this end, many studies have investigated the processing asymmetry that arises between (simpler) subject-relative clauses (SRCs) and (more complex) object-relative clauses (ORCs). Memory-based models—such as Dependency Locality Theory (DLT; Gibson, 2000) and Cue-Based Parsing Theories (CBP; Lewis & Vasishth, 2005)—make distinct predictions as to the locus of difficulty in ORCs. This has been investigated extensively, using online behavioral measures, eye-tracking, computational modeling, and functional neuroimaging. The current study evaluates whether the predictions of DLT or CBP are borne out in electrophysiological responses as individuals listen to sentences with SRCs and ORCs. Methods We recorded EEG as participants (n = 13) listened to sentences with embedded ORCs and SRCs and completed a sentence-picture matching task. For each sentence, we constructed linear kernels depicting the predicted moment-by-moment processing costs for each model in its base form, as well as for several alternative implementations(for a similar approach using fMRI, see Shain et al., 2022). We additionally coded models for constituent closure and bracket count (Nelson et al., 2017; Brennan & Hale, 2016). We then separately convolved each kernel with the narrow-band filtered, Hilbert-transformed EEG data over an integration window of -100 to 400ms in time-steps of 10ms (Brodbeck, 2018). We quantified the strength of the dependency between the two signals at each step using Mutual Information (MI; Ince et al., 2017). Following this we assessed each model using linear mixed-effects models with fixed effects for construction and model-type, the interaction between construction and model-type, and by-subject random intercepts. Pairwise comparisons were conducted using estimated marginal means. Results Results revealed significant main effects for model ($F(6) = 35.62$, $p < .001$; Eta2 (partial) = 0.58, 95% CI [0.49, 1.00]) , construction, ($F(1) = 20.74$, $p < .001$; Eta2 (partial) = 0.12, 95% CI [0.05, 1.00]), and a significant interaction between model and construction ($F(6) = 24.30$, $p < .001$; Eta2(partial) = 0.48, 95% CI [0.38, 1.00]). The best fitting model was a modified DLT model that calculates processing costs as instances of memory retrieval and instances of integration over long-distance dependencies based on the number of intervening nouns and verbs, with additional weight given to intervening verbs (Shain et al., 2016). Conclusion These results are consistent with recent findings from functional imaging studies suggesting that processes related to memory encoding and retrieval are central to language comprehension in the human cortex (Shain et al., 2022). However, future work seeking to co-localize hemodynamic and electrophysiological responses to memory cost would be necessary to fully evaluate the relationship between these two effects.

Topic Areas: Syntax and Combinatorial Semantics, Computational Approaches

## Mental compression of sequences in human working memory

***Poster A49*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The human species seems to be endowed with the ability to rapidly discover the complex embedded structures present in the environment. This ability may be at the origin of the species-specific capacities for music, mathematics and natural language. We here study how the human brain stores sequences of events that exhibit varying levels of regularity and sequence information. I will present the results from the behavioural and brain imaging studies we ran to determine how visual sequences of spatial positions and auditory sequences made of two sounds are encoded. Results suggest that the sequences are internally compressed using an abstract, language-like code that captures their regularities. For visual sequences, behavior suggests that participants quickly discover the most compact description of each sequence provided by the postulated language, and that they use elementary geometrical rules to predict the next items. fMRI results show that brain activity in dorsal inferior prefrontal cortex correlates with the complexity provided by

the language, namely the sequences' minimal description length (MDL), while the right dorsolateral prefrontal cortex encodes the presence of embedded structures. To access the temporal unfolding of the successive brain representations involved in sequence encoding, we performed a MEG study. Using multivariate decoders, each successive location could be decoded from brain signals, and upcoming locations were anticipated prior to their actual onset. Crucially, sequences with lower MDL led to lower error rates and to increased anticipations. Furthermore, neural codes specific to the numerical and geometrical primitives of the postulated language could be detected, both in isolation and within the sequences. Does the postulated Language-of-Thought generalise to other types of sequences? To answer this question, we exposed participants to a hierarchy of binary sound sequences of variable complexity, whose minimal description required transition probabilities, chunking, or nested structures. Occasional deviant sounds probed the participants' knowledge of the sequence. We predicted that task difficulty and brain activity would be proportional to the MDL in our formal language. Furthermore, activity should increase with MDL for learned sequences, and decrease with MDL for deviants. These predictions were upheld in both fMRI and MEG, indicating that sequence predictions are highly dependent on sequence structure and become weaker and delayed as complexity increases. The proposed language recruited bilateral superior temporal, precentral, anterior intraparietal and cerebellar cortices. We propose that these areas collectively encode regular sequences as repetitions with variations and their recursive composition into nested structures. In conclusion, we note that for both visual spatial and binary auditory sequences, the regions that were involved in sequence encoding overlapped extensively with a localizer for mathematical calculation, and much less with spoken or written language processing.

Topic Areas: Syntax and Combinatorial Semantics, Computational Approaches

## Event-related potentials elicited by similarity-based interference during subject-verb dependency resolution

***Poster A50*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Pia Schoknecht[1], Shravan Vasishth[1]; [1]University of Potsdam

Similarity-based interference during cue-based retrieval has been examined in a large number of behavioral studies (see Jäger et al., 2017), but the electrophysiological correlates of interference have not received as much attention. While no link between any event-related potential (ERP) component and similarity-based interference has been established so far, some studies have found negativities for high vs. low interference conditions (Lee and Garnsey, 2015; Martin et al., 2014; Schoknecht et al., 2022; Vasishth and Drenhaus, 2011). Here, we present an ERP study on interference during subject-verb dependency resolution in German based on the design of Van Dyke (2007), a landmark behavioral study. Cue-based retrieval theories propose that the verb in a long-distance subject-verb dependency initiates retrieval of its subject. The retrieval is mediated by retrieval cues generated at the verb. In the design employed here, a syntactic and/or a semantic cue triggers a retrieval at a verb. The syntactic cue triggers a search for a noun with subject marking and the semantic cue for an animate noun. A distractor noun intervening between the subject and verb is manipulated to match/mismatch the subject and animacy retrieval cues. Conditions where the distractor matched the subject or animacy cues (or both) were expected under cue-based retrieval theory to induce high interference during retrieval. In two EEG sessions separated by 1-8 weeks, 100 monolingual, right-handed, native speakers of German with no history of neurological disease read 120 item quadruplets, presented word-by-word in a standard Latin-Square design. The dependent variable for Bayesian mixed model analyses was the mean amplitude 350 – 450 ms post verb onset at 16 electrodes (FC1/z/2, F3/z/4, C3/z/4, CP1/z/2, P3/z/4, Pz, POz). Here, we report the Bayes factors using a truncated normal prior with a standard deviation of 0.5 for the effects of interest, which corresponds to effect sizes up to approx. 1.5 μV. In line with the literature, this prior assumes a more negative response for high vs. low interference conditions. Bayes factors provided strong evidence for the semantic interference effect, i.e., a more negative response to conditions with high semantic interference compared to conditions with low semantic interference (BF10=21.2, β=-0.29, CrI=[-0.48, -0.09]). In contrast, no evidence for a syntactic interference effect (BF10=0.3, β=-0.1, CrI=[-0.26, -0.01]) or the interaction of syntactic and semantic interference (BF10=0.6, β=-0.19, CrI=[-0.49, -0.01]) was found. This large-scale ERP study found strong evidence for a semantic interference effect in a broadly distributed negativity in a time window 350 – 450 ms post critical word onset and no evidence for syntactic interference or an interaction. The decisive importance of the semantic cue (here: animacy) to retrieve a subject is in line with the notion that animate entities are proto-typical agents (Dowty, 1991). Furthermore, the data supports the possibility that language processing relies predominantly on semantic associations to form (probabilistic) representations of event structures (Rabovsky et al., 2018) and speaks against a dominant role for syntactic constraints. A semantic-association view is also consistent with underspecification and good-enough processing accounts of sentence processing (Ferreira and Patson, 2007).

Topic Areas: Syntax and Combinatorial Semantics, Control, Selection, and Executive Processes

## Exploring Structural Connectivity Networks for Classification of Post-Stroke Aphasia Patients and Healthy Controls using Graph Neural Networks

***Poster A51*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background: Structural connectivity, which is derived from anatomical connections (white matter fiber tracts) connecting cortical and subcortical brain regions, provides a way to construct brain graphs and investigate the organization of brain networks in patients with post-stroke aphasia (PSA). Graph-based features, derived from these structural connectivity matrices, can be used to train machine learning classifiers, and automatically diagnose brain disorders. Graph neural networks (GNNs) are an extension of traditional convolutional neural networks that are designed to operate on graph-structured data. It leverages the structural information present in the graph to perform tasks such as node classification, link prediction, and graph classification. Method: In this study, the deep graph library (DGL) was used to implement and apply GNNs for classifying patients with chronic post-stroke aphasia (N=50) compared to age-matched healthy controls (HC, N=40). The input to GNN model was the adjacency matrices (created based on structural connectivity) and a feature matrix, which represents the features associated with each node (brain regions). Nodes of the adjacency matrix of each individual were defined by parcellating the brain using the JHU atlas. Edges of the adjacency matrix were defined by calculating the structural coupling between each pair of nodes. To define the feature matrix, we used time-series recorded during resting-state functional magnetic resonance imaging (rsfMRI) scans. The data were structured similarly for both healthy and PSA groups. GNN was developed using DGL toolbox (developed in Python). The architecture includes six consecutive Graph Convolutional layers followed by Batch Norm and ReLU activation functions. At the end of feature decoding path, a linear function maps the resulting features into number of classes defined in this study. Using such a model architecture, in each layer, a node's representation is updated by considering both its own features and the features of its neighbors. By stacking multiple layers, the network can capture increasingly complex patterns and dependencies in the graph structure. Results: The model was validated using three performance metrics: precision, recall, and F1 score. Preliminary results showed that classifying PSA and healthy controls using GNN provides 0.85, 0.77, 0.76 for precision, recall, and F1 score, respectively. Conclusion: GNNs can learn patterns and relationships within the brain networks and make predictions about the presence or absence of PSA. In the next step, we will use this trained model to explore structural brain connections supporting behavioral performance of patients with PSA in language-related tasks.

Topic Areas: Disorders: Acquired, Computational Approaches

## Language network dysfunction with preserved temporal variability of dynamic functional connectivity in individuals with post-stroke aphasia

***Poster A52** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Variation in post-stroke aphasia (PSA) recovery and underlying neurobiological mechanisms remain poorly understood. Functional MRI studies have revealed treatment-induced changes in resting state functional connectivity that may represent functional reorganization supporting language recovery. Dynamic functional connectivity (dFC), which remains largely unstudied in the context of PSA, can shed more light on this functional reorganization. We have previously found that greater temporal variability (TV) of language network (LN) dFC (i.e., the magnitude of second to minute timescale variations in inter-regional synchronizations) is associated with (1) greater response to aphasia therapy aimed at improving word-finding and (2) greater treatment-induced increases in LN small-worldness, a graph metric that measures both the efficiency of communication across a network and the tendency of nodes to cluster together. Even though TV appears to be promising towards clinically focused prognosis, it is still not clear if, and to what extent, TV is affected by stroke and how dFC is altered in patients with PSA. The answer to these questions will provide important context for studies relating dFC to PSA recovery and functional reorganization. Methods: We compared dFC in 19 patients with chronic PSA (>6 months post-stroke) to that of 42 healthy controls (HC). Resting state functional MRI scans and T1-weighted structural scans were collected using Siemens Prisma 3T scanners. Lesion maps were generated using the semi-automated segmentation tool ITK-Snap and were used to mask lesioned voxels from functional volumes. All MRI data was preprocessed using SPM12 and the CONN Evlab module. Mean time series per region of interest (ROI) were generated using the CONN toolbox and the Automated Anatomical Labeling (AAL3) atlas and sliding window dFC and TV were computed for 34 bilateral language ROIs using custom MATLAB scripts. K-means clustering was used to identify connectivity states. Fractional occupancy (FO, i.e., the fraction of windows clustered into a state) was computed for each state and each participant. Finally, two-sample t-tests were used to compare TV and FO in the PSA and HC groups. Results: No significant difference in TV was found between PSA and HC groups (PSA: mean=0.56, HC: mean=0.55, p=0.80) indicating that TV is not significantly altered in individuals with PSA. However, the clustering analysis did reveal group differences. Four connectivity states were identified, two of which showed significantly different FO between PSA and HC groups. Individuals with PSA spent more time in a state characterized by relatively low small-worldness (1.27) and global efficiency (3.72e-4) (PSA mean FO=0.39, HC mean FO=0.093, p<0.001). HC spent significantly more time in a state with higher small-worldness (2.0) and global efficiency (5.2e-4) (PSA mean FO=0.15, HC mean FO=0.29, p<0.05). Conclusion: Individuals with PSA were found to have similar TV to healthy controls suggesting that the relationship with treatment response is reflective of potentially modifiable interindividual differences in the capacity for functional reorganization and recovery, rather than stroke-related effects. Individuals with PSA were, however, found to spend more time in a state with less efficient communication and less clustering of sub-networks, likely representing dysfunction in LN due the stroke lesion.

Topic Areas: Disorders: Acquired, Computational Approaches

## Classification between PPA, MCI and Healthy Controls using EEG and Artificial Intelligence

***Poster A53*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Primary progressive aphasia (PPA) is a rare neurodegenerative disorder in which language impairments are the primary symptom. Diagnosis is very challenging and requires an expert physician and a combination of methods often involving expensive imaging modalities such as MRI or PET scans. Previous research has shown the importance of connected speech in PPA subtyping[1] and we have recently employed Natural Language Processing and Machine Learning methodologies for subvariant diagnosis[2]. However, early differential diagnosis between PPA and other neurodegenerative disorders[3], e.g., mild cognitive impairment (MCI), is even more challenging due to similar clinical profiles initially. Therefore, it would be beneficial if diagnosis could be assisted with alternative methods such as low-density EEG and suitable functional connectivity metrics, which would sufficiently differentiate between healthy individuals and individuals with MCI and PPA. To achieve accurate healthy, MCI and PPA patient classification, we used 3-minute recordings of 8-channel (F7, F8, T7, T8, CP3, CP4, P5 and P6) EEG signals recorded during an eyes-closed resting state session. The data were collected from 8 healthy elderly control participants (HC), 8 MCI and 14 PPA patients (9 lvPPA, 5 nfvPPA).

The recorded data were re-referenced using the common average method, and subsequently preprocessed to remove noise using a set of second order Butterworth filters. (Non-)Linear were removed using least-squares fit method. The data were separated into 4096 sample epochs resulting in a total of 974 epochs (361 healthy, 319 MCI, 294 PPA). The Relative Wavelet Entropy (RWE) method was used to calculate the functional connectivity matrix, based on the Orthogonal Wavelet Transform using Morlet wavelets and the Shannon entropy. Classification was conducted using the k-Nearest Neighbor (kNN) and Support Vector Machine (SVM) classifiers. The training set contained 705 epochs (270 healthy, 225 MCI, 210 PPA) and the test set 269 epochs (91 HC, 94 MCI, 84 PPA). Classification was evaluated on a participant level (epoch voting). Three classification experiments were conducted using various classifier parameters. The highest accuracy rates on the test set reported are: (a) for HC-MCI 100.00% using the kNN classifier with Cityblock distance and, k=1, (b) for HC-PPA 100.00% using an SVM with an RBF kernel and $\sigma=0.7$, and, (c) for HC-MCI-PPA 77.78% using an SVM with an RBF kernel and $\sigma=1.38$. Three minutes of low-density EEG using functional connectivity metrics can provide adequate accuracy classification between the healthy, MCI and PPA. We are in the process of automating this analysis now. These results indicate that this low-cost, easy method can be used by clinicians to assist the differential diagnosis of PPA vs. other neurodegenerative disorders. [1]Wilson, Stephen M., et al. "Connected speech production in three variants of primary progressive aphasia." Brain 133.7 (2010): 2069-2088. [2]Themistocleous, Charalambos, et al. "Automatic subtyping of individuals with Primary Progressive Aphasia." Journal of Alzheimer's Disease 79.3 (2021): 1185-1194. [3]Frantzidis, Christos A., et al. "Cognitive and physical training for the elderly: Evaluating outcome efficacy by means of neurophysiological synchronization." International Journal of Psychophysiology 93.1 (2014): 1-11.

Topic Areas: Disorders: Acquired, Computational Approaches

## Cluster-based delineations of aphasia profiles using EEG measures of acoustic and linguistic speech encoding

***Poster A54*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Unsupervised machine learning methods can help us develop the diagnostic tools of tomorrow by analyzing clinical data patterns and grouping patients based on their clinical profiles (Alashwal et al., 2019). This data-driven approach may complement already existing diagnostic categories that have previously been established based on case studies. Such is the case for aphasia, a language disorder for which categorization of subtypes goes back to the days of Broca and Wernicke. Although there is a shift towards using more data-driven methods to find patterns of aphasia subtypes (Wilson & Hula, 2019), the classical aphasia typology is still used in the clinic to date. Nonetheless, accumulating evidence shows that a neurobiologically informed diagnosis - as opposed to a diagnosis based on behavioral language tests - may represent the large heterogeneity in aphasia phenotypes more accurately (Pasley & Knight, 2013; Tremblay & Dick, 2016). Here we clustered 41 individuals with aphasia (IWA) in the chronic phase after stroke based on their outcomes on a natural speech listening paradigm while EEG data was recorded. Specifically, the relationship between speech features and the EEG signal was studied by means of encoding models. We combined several speech features in 4 encoding models to achieve outcome measures that represent (1) acoustic processing, (2) speech segmentation-related processing, (3) linguistic processing at phoneme level and (4) linguistic processing at word level (see Kries et al., biorxiv, https://doi.org/10.1101/2023.03.01.530707 for details). Before clustering, we scaled the data using the RobustScaler from Scikit-learn and conducted principal component analysis to reduce dimensions from 4 speech encoding models to 2 principal components (n=2 was pre-defined). The cluster analysis was performed using Scikit-learn's k-means clustering. To choose the optimal number of clusters, we looked at silhouette scores (i.e., reflecting how close a score is to its own cluster and how far it is from another cluster) and at within-cluster sum of squared errors (via the elbow method). Together, the conclusions from both methods showed that a division of IWA into 3 clusters and into 7 clusters would be optimal. Hence, we conducted a feature analysis for both options. When dividing IWA into 3 clusters, we observed, via visual inspection, that the 3 clusters are distinguishable in amplitude of speech encoding across dimensions, but also that there are differences between dimensions. For example, IWA in 'cluster0' seem to have relatively higher encoding of phoneme-level linguistics (surprisal and entropy), while IWA in 'cluster2' seem to have relatively lower encoding of phoneme-level linguistics and segmentation cues (phoneme and word onsets), but relatively higher encoding of acoustic cues (envelope and envelope onsets). Similar, but more complex patterns within and across speech encoding dimensions were observed when IWA were delineated into 7 clusters. This preliminary analysis, which will be further optimized in the coming months, shows that machine learning algorithms may be a valuable asset to delineate data-driven profiles of aphasia. However, a larger dataset in the future would certainly yield more robust outcomes. This study presents a first step towards a neurobiologically informed, data-driven diagnostic tool for aphasia.

Topic Areas: Disorders: Acquired, Computational Approaches

## The role of domain-general abilities in language recovery following acute stroke

***Poster A55** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Karen Arellano-Garcia[1,2], Nerea Gorostiola-Oyarzabal[1,2], Maria del Mar Freijo[3,4], David Soto[1], Simona Mancini[1]; [1]Basque Center on Cognition, Brain and Language, [2]Universidad del Pais Vasco, Spain, [3]Cruces University Hospital, Bilbao, [4]Biocruces-Bizkaia Health Research Institute

Current research has suggested that during the main phases of recovery after stroke, the network that supports domain-general abilities might play a role in recovery by compensating for disruptions in the language network. However, behavioral studies evaluating language-specific and domain-general skills after stroke have reported mixed evidence of a significant correlation between domain-general and language functions. The purpose of this study is to analyze the recovery of linguistic and domain-general abilities after stroke with a longitudinal approach, to assess whether the latter are part of the regular machinery supporting linguistic functions and their recovery, or if their implication changes over time. 70 native speakers of Spanish (24 female) with age range 42-89 years old (M=67.75, sd=10.47) that suffered from a first ischemic stroke either in the left (LH: n=33) or right hemisphere (RH: n=37), no more than one week prior (M=2.37 days post-stroke, sd=1.78), accepted to participate. Two batteries are administered: a linguistic (LNG) one to assess production and comprehension of phonology, syntax, and semantics and one to evaluate domain-general mechanisms (DG): attention (alerting, orienting and conflict) is measured with the Attention Network Test; visual memory (short-term: STM and working memory: WM) is assessed with backward and forward visual spans, and abstract visual reasoning abilities with the Raven's Colored Progressive Matrices. Participants are assessed at four time points (TPs): within the first week after stroke (TP1), three to four weeks post-stroke (TP2), three months after stroke (TP3), and six months after stroke (TP4). Here, we present the associations between language skills and DG abilities in TP1. We fit linear models for each linguistic level as a function of each DG ability separately. Statistical significance is assessed with likelihood ratio tests. In the models of attention, only alerting abilities yielded a significant interaction with group in syntax processing ($\chi2(1)= 4.56$, $p=.03$): lower alerting scores predicted lower scores in syntax for RH- compared to LH-lesioned participants. Abstract visual reasoning predicted phonology ($p<.001$), syntax ($p=0.002$) and semantics ($p<.001$) independent of group. STM predicted phonology ($p=.015$) and semantics ($p=.018$) independent of group. WM predicted phonology ($p<.001$) and syntax ($p=0.003$) also independent of group. Data from the first week after stroke suggest that DG abilities support language skills levels differentially. Better performance in individual DG skills is associated with better performance in specific language levels. This suggests that DG processing plays a dynamic role in linguistic abilities in the acute phase post-stroke. Ongoing work involves the acquisition of data at subsequent TPs, and analysis of behavioral profiles relative to lesion localization, to provide an in-depth analysis of how stable or dynamic is the relation between language and DG functions during post-stroke recovery.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

## Lesions and language activity in post-stroke aphasia too mild to detect on the Western Aphasia Battery-Revised

***Poster A56** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Some left hemisphere (LH) stroke survivors are identified as not having aphasia on the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2007), despite self or caregiver reports of communication deficits (Cavanaugh & Haley, 2020). While research on this "not aphasic by WAB" (NABW) group is limited, prior studies have found differences between this group and healthy controls on behavioral testing (Armstrong et al., 2013, Dalton & Richardson, 2015; Fromm et al., 2017). Fromm et al. (2017) also compared the NABW group to the top anomic (TA) group with the same WAB Aphasia Quotient (AQ) range of 6.2 (NABW AQ=93.8-100; TA=87.5-93.7) and found group differences in discourse measures. The limited research on the NABW group leaves open questions about the nature of their impairments and stroke lesions compared to people identified as having aphasia on the WAB. Here we analyzed group data to identify differences between the NABW and TA groups on behavioral testing, lesion size and location, and fMRI language activation. Methods:

Participants were 38 LH stroke survivors (18TA, 20NABW; Age=63.2y (11.8); Gender=19F, 19M; Race=14 Black, 24 White; Education=16.9y (2.6); Chronicity=51.1m (68.7)). NABW participants had self or caregiver reported aphasia. All participants completed an MRI and language battery. We performed Independent Samples T-Tests and Chi-squared tests to determine group differences on behavioral testing scores and demographics variables. Lesions were manually traced from FLAIR and T1-weighted scans and warped to MNI space. Support Vector Regression Lesion-Symptom Mapping (SVR-LSM) was applied to determine differences in lesion location between groups (DeMarco and Turkeltaub, 2018). Lesion volume was regressed out of lesion data and 10,000 permutations were used to control the cluster-level family-wise error rate. Participants performed an adaptive semantic decision fMRI task (Wilson, 2018) to localize active language regions. We then performed a mass-univariate t-test comparing activation magnitude (SEM>VIS) between the NABW and TA groups. The results were thresholded voxelwise $p<.005$ and corrected for cluster size $p<.05$ based on 5000 permutations. Results: There were no significant group differences in demographic variables or lesion volume ($p=.17$). There were significant group differences in WAB subtest performance on Spontaneous Speech ($p<.001$), Repetition ($p<.001$), and Word Finding ($p<.001$), but not Auditory Verbal Comprehension ($p=.55$). Eight of 14 behavioral tasks had group differences, including measures of semantics, phonology, and reading. There were no significant findings in the lesion-symptom map, but there was a gradient effect with superior frontal lesions associated with NABW and posterior superior temporal lesions associated with TA. In the fMRI data, we found greater activation in the ventral IFG for the NABW group compared to the TA group at the voxelwise cutoff, though the difference did not survive statistical correction at the cluster level. Conclusion: These results indicate that there are behavioral differences between the NABW and TA groups beyond what can be captured with the WAB. While no statistically significant differences were found in lesion volume, location, or language activation to explain the differences on behavioral testing, there were trending differences that might require a larger sample size to confirm statistically.

Topic Areas: Disorders: Acquired,

## Regional brain aging: premature aging of the domain general system and aphasia severity

***Poster A57*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Brain age is becoming increasingly recognized as a marker for cognition and cognitive reserve. It is estimated by comparing regional gray matter tissue volumes from one individual against a normative database of healthy individuals. The difference between chronological age and estimated brain age (BrainGAP) provides information about the health of the brain tissue relative to typical brain aging. Advanced brain aging (increased BrainGAP) is associated with poorer cognitive reserve and lower resilience to injury. However, brain aging is a concept that has been largely defined based on healthy individuals without focal brain lesions. It is possible that focal brain lesions (e.g., strokes) are associated with differential levels of brain aging within the same person (i.e., some brain regions may age faster than others). Therefore, we hypothesize that atrophy within specific brain systems commonly associated with language recovery may be important determinants of variance in long-term aphasia severity. Methods: Eighty-nine participants with stroke aphasia (PWA) and 232 healthy control participants underwent T1-weighted MRI scanning. The BrainAgeR pipeline was used to estimate brain age for controls. Those with an estimated brain age within 5% of their chronological age were used to create future linear models (n=126). Gray matter volume of each region of interest (ROI) in the Johns Hopkins University (JHU) atlas was calculated for all PWA and controls. ROIs from the JHU atlas were grouped into brain regions, including left hemisphere, right hemisphere, domain-general, and language-specific. For each PWA, non-lesioned ROIs were identified in each region (e.g., domain-general ROIs). In controls, the gray matter volume of the identified ROIs were used to generate a model to estimate brain age (from BrainAgeR). Then, by entering the gray matter volume of these ROIs in PWA into the model, it was possible to estimate the regional brain age of each PWA (i.e., the combined brain age of domain general regions). We then evaluated the relationship between regional brain age and aphasia severity (WAB-R AQ) using multiple linear regression models in which the WAB-R AQ was the dependent variable, and the following were independent variables: regional BrainGAP, atrophy (average gray matter volume), lesion volume, participant age, and number of ROIs used in the regression model. We focus on the domain-general region as participants had large lesions encompassing most of the language-specific ROIs. Results: PWA had an increased BrainGAP compared to controls, specifically to the left hemisphere. Multiple linear regression analysis between left domain-general regions and WAB-AQ revealed that BrainGAP ($p=0.008$), atrophy ($p=0.009$), lesion volume ($p<0.001$), and age ($p<0.001$) were significant predictors of aphasia severity (WAB-R AQ). Discussion: The results corroborate previous research suggesting that individuals have increased brain age following a stroke, but also extends this notion by demonstrating that it is the lesioned hemisphere driving the increased BrainGAP in PWA. These results suggest that isolated aging matters for behavior, and degradation to specific brain regions may be associated with behavioral outcomes.

Topic Areas: Disorders: Acquired,

## Motivation and design of a study on the neural correlates of verb production in chronic post-stroke aphasia

***Poster A58*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Spoken language production is a rapid and integrative system, where concepts are activated (semantic processing) and mapped to a word form (lexical processing) with its associated grammatical markers (morphosyntactic processing) and sound representations (phonological processing)[1]. However, there remains substantial debate as to whether lexical and morphosyntactic systems rely on distinct regions within the language network. Lesion-based research in aphasia shows left temporal regions are necessary for lexical processing and left frontal regions are critical for morphosyntactic processing[2], yet functional neuroimaging studies of healthy speakers suggests that processing is distributed throughout the network regardless of lexical or morphosyntactic demands[3]. Verb production tasks may shed light on this debate because verbs are thought to exist at the nexus of lexical and morphosyntactic processing[4]. However, most verb production tasks have not undergone rigorous psychometric validation, thereby limiting the degree to which robust inferences can be made regarding the cognitive constructs underlying the response to items. We recently applied item response theory (IRT), an advanced psychometric framework, to a commonly used verb production task (Verb Naming Test [VNT])[5] in 107 participants with chronic post-stroke aphasia and found the VNT displayed adequate fit and strong reliability to a unidimensional construct[6] that was predominantly aligned with lexical processing[7]. This study in-progress aims to leverage our IRT modeling framework to evaluate the neural correlates of verb production using the VNT. To date, we have enrolled 41 participants with chronic post-stroke aphasia across two recruitment sites (VA Pittsburgh Healthcare System, Portland State University) as part of a larger, ongoing research study. Participants were administered the VNT, among numerous other behavioral tasks, by a speech-language pathologist who also scored the responses. Structural neuroimaging has been acquired for 21 of the enrolled participants, and lesion delineation, completed following previously published methods[8], is in progress. By the time of our sandbox series poster, we project to have recruited ~60 participants, ~30 of which we anticipate will have lesion-delineated structural neuroimaging. For our presentation, we will present our interim findings descriptively and, if adequately powered, will discuss preliminary results from our planned main analysis, voxel-based lesion-symptom mapping[9]. Here, IRT-based VNT scores will serve as the dependent variable. Controlling covariates will include lesion volume, presence of a concomitant motor speech disorder, and performance on a nonlinguistic semantic memory measure, the latter two of which are potential confounders of naming performance[10,11]. In line with our prior work[7] and lesion studies of word production[12], we predict that scores on the VNT will correlate predominantly with left temporal regions, lending further support to the view that verb production is most associated with lexical processing. [1]Levelt et al. Behav Brain Sci. 1999;22(1):1-38. [2]Matchin et al. Brain. 2022;145(11):3916-3930. [3]Hu et al. Cereb Cortex. 2022:bhac350.[4]Gordon, Dell. Cogn. Sci. 2003;27(1):1-40. [5]Cho-Reyes, Thompson. Aphasiology. 2012;26(10):1250-1277. [6]Fergadiotis et al. JSLHR. 2023;0:1-22. [7]Casilio et al. Clinical Aphasiology Conference. 2023. [8]Wilson et al. Brain. 2023;146:1021-39. [9]Bates et al. Nat Neurosci. 2003;6(5):448-450. [10]Schwartz et al. Brain. 2012;135(12):3799-3814. [11]Bird et al. Brain Lang. 2000;72(3):246-309. [12]Alyahya et al. NeuroImage Clin. 2018;18:215-30.

Topic Areas: Disorders: Acquired, Language Production

## Distinct functional connectivity patterns in stuttering and non-stuttering children: A confirmatory network analysis using CS-GIMME

***Poster A60*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Soo-Eun Chang[1], Yanni Liu[1], Valeria Caruso[1], Fiona Hobler[1], Hannah Becker[1], Mike Angstadt[1]; [1]University of Michigan

Network-based analyses examining the functional architecture of brain connectivity have increased our understanding of complex neurodevelopmental and psychiatric disorders. Stuttering is a childhood-onset speech disorder that has been linked to deficits in major neural circuits including the basal ganglia thalamocortical network. One influential theoretical model (DIVA) posits that stuttering may arise due to deficits in the initiation circuit of the feedforward control system, leading stutterers to rely on a less efficient feedback control system that monitors sensory feedback for error-based processing - coordinated by the right ventral premotor cortex (RvPMC). Here we used a recent extension of a network-based analysis - Group Iterative Multiple Model Estimation (GIMME), with confirmatory subgrouping (CS-GIMME), to estimate subgroup-level connections for priori known groups (stuttering, control). Connectivity results are derived at the group as well as at the individual level, which allows for examining subject-specific heterogeneity in connectivity. CS-GIMME can detect paths between nodes ("edges") that are consistently present for individuals within stuttering and control groups, thus facilitating our interpretation of the heterogeneous connectivity maps and allowing for subgroup-specific inferences. We hypothesized that the stuttering group would show increased connections involving the RvPMC while showing reduced connections in subcortical regions involved in initiating motor sequences. Resting-state fMRI (rsfMRI) data were acquired from 73 children who stutter (CWS) and 76 age- and gender-matched children who do not stutter (CNS) (mean age=72 ± 22 months, age range from 38-129 months, 34 CWS girls, 40 CNS girls). Stuttering severity (SSI) range was 2-37 (17.8±6.3) (very mild~very severe). Data were processed using standard methods in SPM12. Subjects were eligible to be included if they had at least 4 minutes of useable data (after motion censoring at FD>0.5mm) and a usable T1 image. Participant-specific time series (164 functional volumes) from 17 regions of interest (ROIs) were extracted. The ROIs and their locations were selected according to regions defined in the DIVA model (Tourville & Guenther, 2011). CS-GIMME was run using a 75% threshold for both group and sub-group level edges. Results showed that for both groups, there were significant connections involving homologous regions in the two hemispheres as well as connections within subcortical regions (thalamus, globus pallidus (GP), putamen). Group-specific connectivity results showed that in the control group only, there were connections between the left thalamus and left GP and between the right SMA (initiation) and right M1 (larynx), whereas in the stuttering group only there were connections between the right SMA (initiation) and the left somatosensory cortex (larynx). Compared to controls, CWS showed heightened node degree involving the right vPMC and reduced density (number of connections) within left initiation-related regions (SMA, putamen, GP and Thalamus). These results show that CS-GIMME can derive functional connectivity results that differentiate stuttering from non-stuttering groups in pathways predicted by the DIVA model. In future research, we will further apply GIMME to derive data-driven subgroups within the group of children who stutter to examine whether this method can help predict specific subtypes, or eventual persistence and recovery in developmental stuttering.

Topic Areas: Disorders: Developmental, Computational Approaches

## Role of Glial Cells in the Pathophysiology of Stuttering: A Focus on Synaptic Refinement

***Poster A61*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Synaptic refinement is essential to brain development, orchestrating the elimination and preservation of specific synapses in response to neural activity fluctuations. Disruptions in this process have been linked to neurodevelopmental disorders such as autism spectrum disorder (ASD) and Tourette Syndrome. Despite indications from imaging data suggesting that a similar deficit may be present in individuals who stutter, supporting direct experimental data has been limited. In this study, we utilized viral-vector-assisted circuit mapping, advanced electron and light microscopy, and 3D computer-assisted cellular reconstruction techniques to study synaptic pruning in a mouse model of stuttering. Our findings indicate a significant deficit in the synaptic refinement within key brain regions associated with vocal projection. This deficit results in an excessive number of synapses, the critical points for neuronal communication, which may significantly impact brain function. Considering the integral role of astrocytes and microglia in synaptic pruning, our data suggest that these glial cells may have a significant role in the pathophysiology of the stuttering disorder. This study contributes to our understanding of the synaptic processes implicated in the pathophysiology of stuttering disorders and possibly other neurodevelopmental disorders.

Topic Areas: Disorders: Developmental, Genetics

## Specific brain structural changes following a phonological and a morphological intervention in Chinese children with RD

***Poster A62*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Objective: Prior research has focused on phonological intervention in children with reading disability (RD) in alphabetic languages; however, it has been poorly understood what intervention would be effective in Chinese children with RD. The present study investigated how brain structure and function change following a phonological intervention and a morphological intervention in Chinese children with RD. We also examined what factors predict responsiveness to each intervention by using demographic variables, reading skills and brain activation before the intervention. Methods: We recruited 68 Chinese children with RD (Age: 10-12 years) and randomly assigned them to a phonological intervention group (N = 23), a morphological intervention group (N = 24) and a waitlist group (N = 21). All children completed a battery of reading assessments and MRI scans before and after the intervention. Moreover, an age-matched group of typical readers (N = 19) were recruited as controls who did not receive intervention. A visual spelling judgment task and an auditory rhyming judgment task were applied during the fMRI scans. Results: Prior to intervention, children with RD exhibited lower activation than controls in the left IFG and bilateral supplementary motor areas during the auditory rhyming judgment task, and lower activation in the left fusiform gyrus and right SOG than controls in the visual spelling judgment task. However, no significant intervention-induced changes in brain activation were observed. Before intervention, typical readers had thicker bilateral fusiform cortex and thinner bilateral frontal and occipital cortex than children with RD. Repeated-measures ANCOVAs showed that the phonological and morphological intervention groups had greater improvement than the waitlist group on the phonological and morphological awareness tests respectively. Meanwhile, both the phonological and the morphological intervention groups showed greater improvement on character naming and Chinese reading fluency tests than the waitlist group. Compared with the waitlist group, the phonological intervention group had a greater increase in cortical thickness in the right precentral gyrus, supramarginal gyrus, MTG, STG, and angular gyrus, while the morphological intervention group showed greater cortical thickening in the bilateral SPL, left fusiform gyrus and left IFG than the other two groups. Greater cortical thickness at right STG and

MTG before the phonological intervention predicted greater pre-to post-intervention progress of phonological awareness tests. Meanwhile, thicker cortex at right SPL and left fusiform gyrus prior to the morphological intervention predicted greater improvement on morphological awareness tests. Socio-economic status was negatively correlated with behavioral and neural changes following intervention in the phonological intervention group, suggesting that children from low SES family benefit more from the phonological intervention. No such relationship was found in the morphological intervention group. Conclusions: Both the phonological and the morphological intervention were effective in Chinese children with RD. Brain structural changes in different parts of the brain were caused by each intervention. Thicker cortex in the right SPL and the left fusiform gyrus is correlated with greater responsiveness to the morphological intervention, and thicker temporal cortex expects greater responsiveness to phonological intervention. These results provide important insights about reading intervention in Chinese children with RD.

Topic Areas: Disorders: Developmental, History of the Neurobiology of Language

## Reward-related processing of familiar maternal speech in six-month-old infants with different likelihoods of ASD

***Poster A63** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Caregivers' voices, mostly mothers', are known to have positive effects on the language and social development of infants. Moreover, the mother's speech critically affects the neonatal brain network (Uchida et al., 2020). However, voice responses may vary between infants with elevated likelihood (EL infants) and typically likelihood (TL infants) of Autism Spectrum Disorder (ASD). The brain activity of EL infants exhibits a unique response to human voices (Xiao, 2022; Lloyd-Fox, 2013). Children with ASD demonstrate weaker connectivity between voice processing and reward-related areas (Abrams, 2013). However, how brain processing, including functional connectivity of EL infants to familiar voices, such as the mother's voice, differs from that of TL infants remains unknown. We examined the differences in brain activity and functional connectivity when EL infants and TL listened to their mothers and female strangers speak. Twenty 6-month-old EL infants (with siblings diagnosed with ASD) and 26 age-matched TL infants (without siblings diagnosed with ASD) were included. We measured frontal and temporal cerebral activity in response to speech using functional near-infrared spectroscopy (fNIRS). We used speech stimuli from the infant's mother or a stranger in an infant-directed manner presented to the infants for 15 s per block. Brain activity was assessed using permutation tests on the average block of changes in the oxyhemoglobin concentration. Functional connectivity was analyzed using phase-locking values. Furthermore, we examined the correlations between these brain responses and other behavioral data (video recordings of the still-face paradigm and developmental testing) and questionnaires (e.g., CDI) from our longitudinal study. TL infants showed significant activation in several areas, including the supramarginal gyrus, superior temporal gyrus (STG), and right orbitofrontal cortex (OFC) when listening to their mothers' voices. Conversely, EL infants exhibited decreased activation in the left STG and left inferior frontal gyrus (IFG). TL infants showed significantly higher activation in these areas than EL infants when listening to their mothers' voices. This suggests a difference in voice processing between the TL and EL groups, which may be related to their differential attachments and language development. TL infants exhibited significant functional connectivity between the right STG, right dorsolateral prefrontal cortex, and left ventrofrontal area, including the OFC and the frontal pole, exclusively for the mother's condition. EL infants did not show such connectivity under either condition. Significant functional connectivity was found between the left STG and left IFG only in the mother's condition. Some of these connections were positively related to subsequent socio-language development. These results suggest that TL infants identify their mother's voice and process it as a reward, as reflected by the strong functional connectivity between the STG and OFC. The maternal voice serving as a reward may facilitate language development in TL infants. In contrast, weak response to familiar voices observed in infants with EL at six months may reflect their lower interest or attention to human voices, regardless of the speaker. This may partially explain the slower language and social development in EL infants.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Corrective and Adaptive Responses to Auditory Errors

***Poster A64*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Auditory perturbations are powerful techniques, offering invaluable insight into the processes of speech motor learning. In response to perturbations, subjects produce corrective and adaptive responses, reflecting the contributions of the feedback and feedforward control systems, respectively. To measure corrective responses, studies have applied perturbations on a set of randomly selected trials—the compensation paradigm. To measure adaptive responses, studies have applied perturbations on several successive trials—the adaptation paradigm. However, these paradigms measure the contributions of the control systems in isolation, discounting the bidirectional interactions between the two systems. These paradigms are also time-consuming, making it particularly challenging to examine the control systems in patient populations and children. Therefore, we developed a novel paradigm to address these limitations; in our novel paradigm, we (1) concurrently measured corrective and adaptive responses and (2) determined the sensitivity of both feedback and feedforward systems to different error magnitudes. Our paradigm consisted of several blocks of trials. In each trial, subjects produced a target word (e.g., "head") while receiving perturbed auditory feedback. We frequently changed the perturbation magnitude and direction to measure feedback-driven responses (resembling a compensation paradigm). We delivered the perturbations for several succeeding trials to measure the adaptive responses (resembling an adaptation paradigm). Perturbations were randomly selected from 7 different perturbation configurations. We measured subjects' early responses (0–100 ms) and late responses (200–300 ms). As a measure of feedforward error sensitivity, we used early responses (i.e., adaptive responses), and as a measure of feedback error sensitivity, we used the difference between late and early responses (i.e., corrective responses). We recruited 30 healthy adults to complete this study. Our preliminary results showed that, as the perturbation magnitude increased, the magnitude of the corrective responses and adaptive responses increased. However, the magnitude of responses reached a plateau at large perturbation magnitudes. These results are consistent with previous compensation and adaptation studies' results.

Topic Areas: Speech Motor Control, Computational Approaches

## Neural representations of the content and production of human vocalization

***Poster A65** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speech, as the spoken form of language, is fundamental for human communication. The phenomenon of covert inner speech implies a functional independence of speech content and motor production. However, it remains unclear how a flexible mapping between speech content and production is achieved on the neural level. To address this, we recorded magnetoencephalography (MEG) in human subjects performing a rule-based vocalization task. Content (one of two vowels) and production (overt or covert) were instructed separately and in random order. Applying multivariate pattern analysis (MVPA), we found robust neural information about the content and production of vocalization several seconds before vocalization behavior. Source analysis revealed neural information in speech areas of the left hemisphere. The strength of both types of neural information correlated with the degree of motor involvement. When isolated, both types of information overlapped. Later in the trial, the neural format of production information transformed depending on the content, whereas content information remained stable independent of production type. Our results provide new insights into the neural dynamics underlying basic human vocalization and open a new window for non-invasive speech research in humans.

Topic Areas: Speech Motor Control, Control, Selection, and Executive Processes

## Thetaburst Repetitive Transcranial Magnetic Stimulation and Speech Motor Adaptation

***Poster A66** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The application of neuromodulation methods have furthered our understanding of speech-related brain networks. The goal of this study was to investigate the role of left ventral motor cortex (LvMC) in performance on a speech adaptation task using thetaburst repetitive transcranial magnetic stimulation (rTMS). A priori power calculations determined that 75 participants were required to detect across group differences (Tang et al., 2021). We have screened 33 participants (age 18-36) that we identified as responders to the speech adaptation task and then randomized to receive excitatory (intermittent thetaburst stimulation at 90% Resting Motor Threshold), inhibitory (continuous thetaburst stimulation at 90% RMT), or sham rTMS to LvMC.

Immediately following rTMS, participants completed an auditory perturbation task administered by Audapter and MATLAB. The auditory perturbation paradigm required participants to perform the task while listening to unaltered auditory feedback of their own voices for 60 trials (start phase), then perturbation of the auditory feedback was gradually shifted until it reached a maximum of a 25% increase in the F1 formant and 12.5% decrease in the F2 formant for 30 trials (ramp). The maximum perturbation was maintained for 30 trials (stay), and then removed again for 30 trials (end). The stay phase responses illustrate the participants' online compensation for the perturbation, whereas the end phase responses represent lingering adaptive effects of motor learning from the previous perturbed state. To extract steady-state portions of the vowel, F1 and F2 for each trial were determined from a segment of the formant trace spanning 40% to 60%. Mixed ANOVAs were conducted separately for the F1 and F2 formants, with phase (start, stay) as a within-subject factor, and group (facilitatory, inhibitory, sham) as a between-subject factor. Significant effects of phase or group or their interaction, were followed by post-hoc t-tests. Preliminary results show that the excitatory rTMS group had a F1 MFR= -7.08 and a F2 MFR= 1.26, The inhibitory excitatory rTMS group had a F1 MFR= -6.37 and a F2 MFR= 1.89, and the Sham rTMS group had a F1 Mean Formant Ratio= -8.10 and F2 MFR= 3.20. There is a significant phase effect in F1 ($F_{2,30}$=39.81 $P<0.001$) and F2 ($F_{2,30}$=15.04 $P<0.001$), but there was no interaction between group and phase in F1 ($P=0.85$) or F2 ($P=0.38$). As per our a priori power calculation, we required 75 participants to detect a statistically significant difference across groups, data collection and advanced analyses are ongoing and updated results will be presented at the conference in November. Our results clearly replicate the speech adaptation response that is well documented in the literature. Our preliminary findings show, that an interaction across rTMS group and phase of APE is statistically unclear but that should be resolved as we approach our target sample size. Neuromodulation paired with APE has the potential to delineate the role of LvMC in speech adaptation and advance our understanding of the neural processes underlying speech motor adaptation, as well as inform potential neuromodulation therapeutic options.

Topic Areas: Speech Motor Control, Control, Selection, and Executive Processes

## Pars opercularis underlies speech motor efference copy and successful auditory feedback processing: Evidence from left-hemisphere stroke

***Poster A67*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Hearing one's own speech allows for acoustic self-monitoring in real time. Left inferior-frontal brain regions are thought to give rise to efferent predictions of the sensory consequences of speech motor acts. These efference copies are then thought to be compared to true auditory feedback in superior temporal cortex, causing suppression of the neural response when there is a match, and reduced suppression when there is a mismatch. Reduced suppression is therefore a candidate neural signal driving online correction of deviant speech sounds. The present study assessed the integrity of this circuit in persons with aphasia (PWA) with lesions in the territory of the left middle cerebral artery. We recorded MEG while 15 PWA and age-matched controls spoke monosyllabic words and listened to playback of their utterances. We measured suppression of the M100 neural response in the speaking condition (with an efference copy) relative to the listening condition (without an efference copy) in left and right hemispheres and related it to lesion profiles and speech behavior. We found that bilateral speaking-induced suppression, comparable to controls', was maintained despite large left-hemisphere lesions. PWA with more spared tissue in left pars opercularis had greater left-hemisphere neural suppression and greater behavioral correction of deviant, atypical pronunciations ("vowel centering"), whereas sparing of the left superior temporal gyrus was not related to either neural suppression or acoustic behavior. In turn, PWA who made greater acoustic corrections had fewer overt speech errors in the MEG task, suggesting that vowel centering is related to successful production. Overall low signal in lesioned left hemispheres precluded analysis of the direct relationship between reduced suppression and correction of deviant productions, but we replicated a prior finding that cortical sensitivity to self-produced vowel typicality is a left-lateralized phenomenon. We did not find evidence that lesions drove neural plasticity in the right hemisphere in terms of response amplitude, suppression, or sensitivity. Together, these results suggest that some degree of efference copy-mediated neural suppression can survive damage to left-hemisphere motor- and speech-related regions, but that pars opercularis plays a significant role in the magnitude of that suppression, with putative consequences for the ability of PWA to successfully process and limit variation in their own speech.

Topic Areas: Speech Motor Control, Disorders: Acquired

## Investigating brain dynamics of Motor Speech Encoding through speech modes

***Poster A68*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Bryan Sanders[1], Monica Lancheros[1], Marion Bourqui[1], Marina Laganaro; [1]University of Geneva

Humans have mastered their control over speech production throughout centuries to overcome signal transmission obstacles and to communicate effectively in various settings. Despite its prevalence in everyday life, speech modes (loud speech (LS) and whispered speech (WS) for instance), which are specific types of modulated speech, have received little interest in the neuropsycholinguistic scientific community. Even the Direction Into Velocities of Articulators (DIVA) model (Guenther, 1995), which accounts for most speech production mechanisms, does not clearly clarify which processes underly the modulation of speech (Tourville & Guenther, 2011). Here, we will investigate whether specific speech modes and standard speech (SS) share the same processes or if modulated speech require additional processes relative to normally phonated utterances. We will use two speech modes (WS and LS) to investigate the processes underlying speech modulation. WS is characterized by the absence of vibration of vocal folds (Tsunoda et al., 2011) resulting in reduced intelligibility and perceptibility (Zhang, 2012). WS is the speech mode which involves the most distinct behavioral and phonatory pattern in comparison to SS (Kelly & Hansen, 2021). By contrast, LS consists in increasing vocal loudness, without necessarily improving the intelligibility of the message conveyed (Whitfield et al., 2021). Utterances are usually considered loud when intensity is approximately 10 dB higher than SS utterances (Huber & Chandrasekaran, 2006). This change in intensity leads to modified articulatory pattern and increased effort (Schulman, 1989). Here we present two studies in which behavioral (vocal onset latencies) and electrophysiological signature of these speech modes is investigated through a delayed production task. In the WS study, 24 participants produced pseudo-words in the WS and SS conditions; in the LS study, 24 different participants produced the same pseudo-words in the LS and SS conditions across 8 experimental blocks alternating between the speech modes. Event-related potentials (ERPs) were extracted aligned to the vocal onset of speech backwards (response-locked) to study motor speech encoding processes across speech modes. Waveform amplitudes and microstates analyses have been performed to compare across conditions. In the WS study, participants had overall good accuracies (over 93%) in both speech conditions, but with 16 ms longer initialization latencies for WS. For the LS study, LS utterances were produced 29 ms faster than SS utterances with a similar accuracy across conditions (over 94%). Differences in waveform amplitudes and in the global dissimilarity index appeared in both studies, but in different time windows (300 ms before the vocal onset for WS and closer to the vocal onset for LS). In both cases, the microstate analyses indicate a shift of the same topographic maps in these time-windows. The results show that brain activity in the period preceding articulation indeed differs between speech modes. The microstates analyses indicate that the differences do not seem to be due to additional processes but rather a different distribution of the same brain activations. Unexpectedly, the differences occur in different time windows depending on the speech mode, a result which will need to be further investigated using other speech modes or other analyses.

Topic Areas: Speech Motor Control, Language Production

## Speech motor planning in monosyllabic and disyllabic pseudoword production

***Poster A69*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Monica Lancheros[1], Marina Laganaro[1]; [1]University of Geneva

Speech planning processes include the retrieval of motor codes from a mental store. Some psycholinguistic models have proposed the syllable to be the functional unit explicitly represented in such centre of storage, also called syllabary (Levelt, Roelofs, and Meyer, 1999). Although many studies have brought evidence suggesting that speakers in fact retrieve stored syllabic units (e.g. Carreiras & Perea, 2004; Cholin, Levelt, & Schiller, 2006), it remains unclear how the syllabic retrieval is achieved during the production of multisyllabic utterances. More specifically, are all syllables retrieved in advance before actual production begins, or is only the first syllable retrieved prior to its production while subsequent syllables are planned during the articulation of the initial syllables? To unravel these mechanisms, in the present study we examine the brain dynamics underlying the production of monosyllabic and disyllabic pseudowords (i.e. /pra/ or /prati/, respectively) by means of electroencephalography (EEG). In order to target speech planning processes, pseudowords were produced in a delayed paradigm, upon the presentation of a response cue. Event-related potentials (ERPs) were aligned to the participants' vocal onset (1) backwards (i.e. -300 ms preceding the vocal onset), to investigate if the initial syllable composing disyllabic pseudowords are similarly planned as monosyllabic pseudowords before the actual production, and (2) forward (i.e. 200 ms following the vocal onset, corresponding to the minimal duration of the first syllable), to capture potential neural differences between the actual production of monosyllabic pseudowords and that of the first syllable of disyllabic pseudowords. Preliminary results on seventeen participants revealed no differences between monosyllabic and disyllabic pseudowords in terms of accuracy (93% and 95%, respectively) or reaction times (658 ms and 667 ms, respectively). Despite the absence of behavioral differences, ERPs uncovered significant differences in the global dissimilarity index and in the distribution of the same topographies between monosyllabic and disyllabic pseudowords in three time-windows prior to the vocal onset (i.e. from -35 to -61 ms, from -84 to -104 ms and, from -240 to -256 ms). No differences were found between the two types of pseudowords from the initialization of vocalization onwards. Those preliminary results suggest that differences in speech motor planning between monosyllabic and disyllabic pseudowords are evident solely before the actual vocalization takes place. Thus, the retrieval of both syllables comprising the disyllabic pseudowords is achieved prior to the vocal onset, instead of the second syllable being retrieved during the production of the first one. We plan to conduct further analysis on these results using alternative approaches. Additionally, we aim to increase the participant pool by October to enhance the robustness of our findings. Carreiras, M., & Perea, M. (2004). Naming pseudowords in Spanish: Effects of syllable frequency. Brain and Language, 90(1-3), 393-400. Cholin, J., Levelt, W. J., & Schiller, N. O. (2006). Effects of syllable frequency in speech production. Cognition, 99(2), 205-235. Levelt, W. J., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. Behavioral and brain sciences, 22(1), 1-38.

Topic Areas: Speech Motor Control, Language Production

## Differentiation of the Role of the IFG and STG in Overt and Covert Speech Using fNIRS

***Poster A70** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background. Neuroanatomical models of language processing have underscored the importance of the inferior frontal gyrus (IFG) and superior temporal gyrus (STG) in speech and reading processes; however, the contribution of these regions to overt vs. covert language processes is not well characterized. Distinguishing language processing for overt speech vs. covert speech is important for disambiguating speech planning versus brain activity related to motor commands. Here we explored brain activity via functional near infrared spectroscopy (fNIRS) from overt and covert tasks to better characterize the role of the IFG and STG under various task requirements. Methods. Young adult participants (N = 55) were presented with 380 letter strings that were randomly followed by a green square (say overtly) or red square (say silently). Standard preparation and preprocessing of the fNIRS data was applied using HOMER3 and included: 1) scalp coupling index, 2) downsampling, 3) intensity to optical density conversion, 4) artifact removal by channel and motion correction using a SplineSG, 5) removal of linear trends, 6) low bandpass filter, 7) optical density to concentration conversion, and 8) extraction of the averaged hemodynamic curve for the overt (green) and covert (red) trials. Results. We saw clear differences in the timing and magnitude of the peak of activity in the IFG and STG between overt and covert trials. Overt speech elicited stronger but relatively delayed activity peaks in both regions compared to covert speech (all p’s $< 0.05$). Conclusion. The IFG and STG are clearly involved in overt speech and silent reading processes, however there is a clear differentiation of brain activity of these regions between these tasks. Characterizing how these activity patterns differ is vital to theories of reading and speech production and will inform the development of brain computer interface technologies. The clear distinctions in these tasks identified with our approach can contribute to studies of speech/reading

development and how these processes are compromised in disorder populations.

Topic Areas: Speech Motor Control, Language Production

## Cortical dynamics underlying speech sequence planning

***Poster A71*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Fluent speech production requires the planning and articulation of accurately sequenced speech sounds. This process is commonly thought to result from the progression of activity across cortical areas, each of which has a specific function in the planning and execution of articulation. The classic model is that Broca's area sends planning commands to the precentral gyrus which in turn sends motor commands to the vocal tract. However, recent evidence suggests that Broca's area is not critical for articulation, and the neurological basis of how speech is sequenced is unknown. To address this, we used high-density direct cortical recordings (electrocorticography) from distributed speech cortical areas to investigate the dynamics of cortical activity while participants were cued to read, wait a short delay, and speak simple or complex syllable sequences. While we found activity related to execution and feedback, we found unexpectedly prominent sustained activity across multiple cortical areas that lasted throughout all periods of the task. Sustained activity was found in the middle precentral gyrus (mPrCG), posterior superior temporal gyrus, supplementary motor area, supramarginal gyrus, and the inferior and middle frontal gyri. Sustained neural activity reflected distinct internal states that transition between the encoding, delay, pre-speech, and execution periods. Trial-averaged sustained population activity also showed distinct trajectories associated with each of these task phases. Encoding and execution period trajectories occupied roughly 2D planes, which were not parallel to each other, suggesting that activity prior to production does not directly trace the eventual neural trajectory associated with execution. Increased sequence complexity was associated with greater sustained activity, most prominently in the mPrCG. Pre-speech activity in the mPrCG also correlated with behavior, predicting single trial reaction times. These results suggest that speech production planning is dependent upon sustained cortical dynamics supporting speech sequence execution. Importantly, we identify the mPrCG as a novel and critical node of speech-motor planning.

Topic Areas: Speech Motor Control, Language Production

## A tradeoff between acoustic and linguistic feature encoding in spoken language comprehension

***Poster A72*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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When we comprehend language from speech, the phase of the neural response aligns with particular features

of the speech input, resulting in a phenomenon referred to as neural tracking. In recent years, a large body of work has demonstrated the tracking of the acoustic envelope and abstract linguistic units at the phoneme and word levels, and beyond. However, the degree to which speech tracking is driven by acoustic edges of the signal, or by internally-generated linguistic units, or by the interplay of both, remains contentious. In this study, we used naturalistic story-listening to investigate (1) whether phoneme-level features are tracked over and above acoustic edges, (2) whether word entropy, which can reflect sentence- and discourse-level constraints, impacted the encoding of acoustic and phoneme-level features, and (3) whether the tracking of acoustic edges was enhanced or suppressed during comprehension of a first language (Dutch) compared to a statistically-familiar but uncomprehended language (French). We first show that encoding models with phoneme-level linguistic features, in addition to acoustic features, uncovered an increased neural tracking response; this signal was further amplified in a comprehended language, putatively reflecting the transformation of acoustic features into internally-generated phoneme-level representations. Phonemes were tracked more strongly in a comprehended language, suggesting that language comprehension functions as a neural filter over acoustic edges of the speech signal as it transforms sensory signals into abstract linguistic units. We then show that word entropy enhances neural tracking of both acoustic and phonemic features when sentence- and discourse-context are less constraining. When language was not comprehended, acoustic features, but not phonemic ones, were more strongly modulated, but in contrast, when a first language is comprehended, phoneme features are more strongly modulated. Taken together, our findings highlight the flexible modulation of acoustic, and phonemic features by sentence and discourse-level constraint in language comprehension, and document the neural transformation from speech perception to language comprehension, consistent with an account of language processing as a neural filter from sensory to abstract representations.

Topic Areas: Speech Perception, Computational Approaches

## Dendritic non-linearity supports the formation and reactivation of word memories as cell assemblies

***Poster A74*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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During speech comprehension, words are recognized based on the order of phonemes (e.g., /b/æ/t/ versus /t/æ/b/) and retrieved from long-term memory. Behavioral studies demonstrated that lexical access happens in a cascade manner, and items in the lexicon are co-activated (McQueen & Gaskell 2008); however, the underlying neurobiological mechanisms of storage, maintenance, and retrieval are poorly understood (Poeppel & Idsardi 2022). One idea is that word memories are learned through Hebbian plasticity and maintained and reactivated as neuronal assemblies (Buzsáki 2010). To test this idea, we built a neurobiologically-constrained network model of word recognition. The network is composed of spiking neurons with dendrites and we hypothesized that dendritic structure might be crucial to induce and reactivate word assemblies that are structured in time. We simulated two 5-minute-long phases to test the formation and retrieval of word memories. In the association phase, neurons were exposed to phoneme sequences and target words, represented as overlapping cell populations. In the retrieval phase, networks only received phoneme sequences as input, and we measured the reactivation of the corresponding word populations. We tested the network model on seven distinct lexicons of increasing complexity, with 10-15 words each, and varying numbers of phonemes that were shared between words. We compared a network of neurons with dendritic structure (Quaresima et al., 2022) with two networks of point neurons without dendrites (Duarte & Morrison 2019, Litwin-Kumar & Doiron 2014). The dendritic neurons have segregated branches with non-linear, voltage-gated N-methyl-D-aspartate receptors (NMDARs) which endow them with short-term dendritic memory. All networks implemented spike-timing-dependent plasticity on excitatory synapses and were homeostatically balanced with inhibition. When presented with phoneme sequences in the retrieval phase, the dendritic network reactivated the correct word populations with high accuracy (above 70%), including words composed of the same phonemes in a different order (e.g., /d/o/g/ versus /g/o/d/). In contrast, networks of point neurons reactivated only words containing phonemes that were unique to these words, and confused words with shared phonemes (success rate below 20%). Phoneme overlap between words was the main source of difficulty for these networks while lexicon size was less important. In order to identify why the dendritic network was superior, we systematically compared variants of these networks. We found that dendritic memory, supported by slow, non-linear synaptic integration at NMDA receptors, was critically responsible for binding phoneme information over time. The analysis also showed that retrieval accuracy was modulated by the strength of inhibitory control exerted on dendrites. Heterogeneity in integration timescales, induced by asymmetric dendritic lengths, only played a minor role. Our study indicates that word memories can be stored through long-term, associative plasticity and reactivated reliably when dendritic structure is modeled explicitly. Thus, we propose a linking hypothesis between a psychological phenomenon (word recognition) and a neurobiological mechanism (dendritic non-linearity). Future work needs to test whether this mechanism is also able to encode the detailed semantic and morphosyntactic feature structure of words.

Topic Areas: Speech Perception, Computational Approaches

## What we do (not) know about the mechanisms underlying adaptive speech perception

***Poster A75** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Xin Xie[1], T. Florian Jaeger[2], Chigusa Kurumada[2]; [1]University of California Irvine, [2]University of Rochester

One of the central questions in the neuroscience of language concerns the mechanisms by which listeners perceive and categorize speech amidst its inherent variability. Empirical research over the past two decades has documented that listeners make rapid, and potentially long-lasting, adaptive changes to accommodate a priori unfamiliar talkers or accents. However, the mechanisms underlying this remarkable adaptivity remain largely elusive. Studies have often attributed the adaptivity to mechanisms such as auditory signal transformations (Tang et al., 2017; Johnson & Sjerps, 2021) or the learning or “remapping” of cues to linguistic categories (Myers & Mesite, 2014; Blanco-Elorrieta et al., 2021). However, these hypotheses have not been contrasted with each other, limiting our knowledge of the unique contribution of each mechanism as well as the potential interplay between different mechanisms. To address this critical gap, we present a novel analytical framework aimed at formalizing the mechanisms underlying adaptive speech perception ("ASP" for brevity). ASP is the first comprehensive framework that integrates three mechanistic models of speech categorization: (a) low-level, prelinguistic auditory normalization; (b) mapping from prelinguistic percepts to linguistic representations; and (c) psychometric lapse-bias model of decision processes. Crucially, ASP also formalizes how each of these levels of mechanisms can dynamically change in response to recent experience ("change models"). We tested the predictions of the three change models using two standard paradigms: perceptual recalibration (Norris et al., 2003) and natural accent adaptation (Bent & Baese-Berk, 2021). Here we focus on the former. In this paradigm, listeners receive acoustically ambiguous tokens in a lexical context (e.g., crocodile), simulating talkers with shifted acoustic distributions. Listeners subsequently categorize phonetic input sampled along a continuum (e.g., /d/ vs. /t/) according to the exposure input, demonstrating a corresponding boundary shift. All three models predicted the characteristic boundary shift observed in human categorization responses. Simulations of a non-native accent adaptation experiment replicated this finding: even a computationally parsimonious mechanism (e.g., cue normalization or decision bias change) predicted data patterns often considered indicative of exposure-related changes in category representations. Our results thus demonstrated that common empirical results have limited diagnostic power when it comes to discerning the mechanisms of adaptive speech perception. In summary, our simulation studies underscore the pressing need to reevaluate current standards of empirical testing. In this presentation, we will explore how a formal modeling framework, such as ASP, can facilitate simulation-based experimental designs, enabling better differentiation of predictions derived from the three mechanisms. Crucially, this approach will advance the standards of neuroimaging research by generating more concrete—and thus more testable—predictions about the types of computations taking place in different brain regions or networks. Additionally, we will discuss how future behavioral and imaging studies can leverage ASP to investigate the interconnected auditory, perceptual, and cognitive processes that underlie complex human behavior in the face of input variability. By unraveling the puzzle of adaptive speech perception, we can gain a deeper understanding of the neural underpinnings of speech processing in naturalistic contexts.

Topic Areas: Speech Perception, Computational Approaches

## Context and Attention Shape Electrophysiological Correlates of Speech-to-Language Transformation

***Poster A76*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To understand speech, the human brain must accommodate variability in intonation, speech rate, volume, accents and so on to transform sounds into words. A promising approach to explaining this process has been to model and predict electroencephalogram (EEG) recordings of brain responses to speech. Contemporary models typically invoke hand-crafted speech categories (e.g. phonemes) as an intermediary representational stage between sounds and words. However, such brain models are incomplete because sounds are externally categorized. This also means they cannot predict the neural computations that putatively underpin categorization. By providing end-to-end accounts of speech-to-language transformation, new deep-learning systems could enable more complete brain models. We here reference EEG recordings of audiobook comprehension to one such model – Whisper – which transforms speech into a time-aligned linguistic representation across a series of feedforward layers. Notably this transformation is achieved through encoding prior speech context which may supply linguistic cues that help disambiguate periods of noisy speech (e.g. "President Joe <noise>"). Such contextual information is not present in purely categorical speech models. We first reanalyzed a dataset of publicly available EEG recordings taken from 19 subjects as they listened to ~1hour of an audiobook. We hypothesized that the contextualized internal representations of Whisper would more accurately predict EEG responses than models of concurrent speech acoustics. This was because Whisper, like the human brain, is adapted to transform speech to language. To test this hypothesis, we ran a series of cross-validated multiple regression analyses that mapped different layers of a Whisper model of the speech stimulus to predict EEG data. We observed that Whisper's deep most linguistic layers dominated prediction in bilateral temporal scalp electrodes that are traditionally linked to acoustic speech responses. These deep layers proved to be more accurate predictors than models of speech acoustics or linguistic prediction (derived from GPT-2). Furthermore, constraining Whisper's access to prior speech context impacted EEG prediction accuracy – though contrary to our expectation the relationship was concave in that access to ~10s context was more beneficial than either shorter or longer contexts (e.g. 1s or 30s). To consolidate evidence that the new EEG correlates reflected linguistic transformation of speech, we examined a second publicly available "cocktail party" dataset (27 subjects). Here listeners heard two concurrent speech streams, but only paid attention to one. We hypothesized and found that Whisper's predictive advantage over the acoustic models, would selectively dwindle when the unattended speech stream was modelled and predicted – in line with listeners inability to accurately report on the unattended speech content. The current study helps advance understanding of the neurophysiological processes underpinning speech comprehension by identifying a self-contained EEG model of speech-to-language transformation that is relatively accurate, sensitive to listener attention and potentially revealing of how the brain could exploit prior speech context in comprehension. We hope that the approach may lead towards user-friendly methods to help index the linguistic depth of speech processing in developmental and disordered populations.

Topic Areas: Speech Perception, Computational Approaches

## Bridging hierarchical speech processing with perceptuo-motor theory

***Poster A77*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Perception and production of complex vocal gesture sequences is a typical trait of many animal species, from songbirds to humans. This communication system involves many processes at different scales: auditory perception and motor control of the vocal tract to sense and produce vocal gestures, continuous audio stream segmentation, and categorization into relevant language units (e.g. the syllables), and a hierarchical organization of the units sequences, used for both comprehension and production. There exists a vast literature covering several of these stages of speech and language processing. Several modeling works answer specific developmental, computational, and neurophysiological aspects of the language emergence problem, but the whole picture remains obscure. In particular, how and when processes happening at different timescales share information about current stimuli and context is unclear, and the type of information exchanged is largely unknown. Brain oscillations at different frequencies may mediate exchange between higher and lower order processes and would be modulated by both bottom-up and top-down information flows, tracking and segmenting relevant speech units in one case and relying on contextual information to disambiguate the stimuli in the other (Ghitza, 2011; Giraud & Poeppel, 2012; Poeppel & Assaneo, 2020, Nabé et al. 2021). Most models, however, present these effects from a purely perceptual perspective and embed them into a predictive coding framework that let aside the possible sensorimotor nature of the speech comprehension processes and the importance of speech production in that matter (Liberman & Mattingly, 1985; Schwartz et al. 2012; Moulin-Frier et al. 2015). We thus propose to extend models of speech segmentation and perception built upon brain oscillations (Nabé et al 2021; ten Oever and Martin, 2021) to explore different hypotheses on the nature of information flows in the speech and language hierarchy. We want to check the benefits of predictive coding in constructing relevant hierarchical language representations against a more sensorimotor approach, where brain oscillations would not just subserve perception but also production, and where relevant segmented representations would be constructed from speech using motor information. Moreover, we would like to explore to what extent these oscillation-mediated top-down and bottom-up processes may be chained to build deep hierarchical representations, in a similar way to Nabé et al. 2021, that could serve both perception and production. This model could then be used to make predictions about speech perception in noisy environments and provide an interesting framework to investigate developmental aspects of speech acquisition.

Topic Areas: Speech Perception, Computational Approaches

## Why does predictable emotional language deactivate the amygdala?

***Poster A79*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Nati Beltrán[1], Winnie Yeh[1], Jeremy Skipper[1]; [1]UCL

Introduction: What role does the amygdala play in speech perception and language comprehension? It is activated by emotionally valent and/or arousing words. In contrast, when participants are asked to perform linguistic tasks like ‘affect labelling’ or ‘reappraisal’, the amygdala is typically deactivated. This suggests that engaging speech production systems deactivates the amygdala. Indeed, we discovered that the intersection between ‘language’ (N=1101), ‘speech’ (N=642), and ‘motor’ (N=2565) term-based meta-analyses demonstrates that the amygdala is deactivated when regions associated with speech production are engaged. We and others have shown that speech perception regularly engages speech production systems to predict acoustic patterns arriving in auditory cortex. This led us to test the hypothesis that emotional words that are highly predictable from context will activate speech production systems and, thus, deactivate the amygdala. Methods: Participants watched full length movies during functional magnetic resonance imaging (Naturalistic Neuroimaging Database; Aliko et al., 2020). We first located peaks and troughs in the left and right amygdala, defined as 1.5 standard deviations above or below mean activation. Only those with positively or negatively valenced words above/below 1.5 standard deviations from mean valence in the preceding 4-second windows were kept. To quantify high/low context predictability, we used BERT to calculate the semantic distance between the 4 seconds before troughs/peaks and the preceding 4 seconds, keeping those whose distances were in the top and bottom third. Finally, we averaged brain data in the 4-second window before each remaining peak/trough by hemisphere and condition. These images were entered into two linear mixed effects group analyses (left/right amygdala), each with factors peak (peak/trough), valence (positive/negative), and context (high/low). Results: Preliminary results suggest that, in highly predictable contexts, there was a strikingly lower frequency of amygdala peaks and troughs. Nonetheless, there was a significant three-way interaction between peak, valence, and context in the left ventral central sulcus and the right pars opercularis and precentral sulcus ($q < 0.05$). This interaction was driven by troughs in the high context and negative valence conditions. General linear tests showed more activity for troughs in the precentral gyrus and sulcus, central sulcus, inferior frontal gyrus, and supplementary motor area for both the left and right amygdala for high context and negative valence. Conclusion: These results suggest that highly predictable emotional words result in deactivation of the amygdala and that this result is at least in part driven by the engagement of speech production systems. This is in line with the aforementioned meta-analyses, where engagement of speech production systems results in deactivation of the amygdala on average. This could be because high contextual constraints engage the emotional processes associated with the amygdala in a predictive manner, explaining deactivation of the amygdala at the time the predictable emotional words occur. As the amygdala is only transiently engaged, it is not reactivated by the predicted words. This leads to the paradoxical suggestion that generally engaging speech production systems results in lower amygdala reactivity which might explain some of the variance in ‘affect labelling’, ‘reappraisal’, or even why psychotherapy works.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

## The Role of Domain General Working Memory in Predictive Sentence Processing

***Poster A80*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Yasemin Gokcen[1], David Noelle[1], Rachel Ryskin[1]; [1]University of California Merced

To keep up with conversation, humans tend to make predictions about the next word someone will say. Among other neural signatures of prediction, the N400 ERP component tends to be more negative when listeners hear a word that is not predictable from the preceding context (Kutas & Federmeier, 2011). The predictability of a word can be estimated using surprisal, the negative log probability of a word in context, from a neural language model (Levy, 2008; Hahn et al. 2022). However, human memory is imperfect. How do humans maintain the linguistic context for prediction over multiple timescales (e.g., immediately preceding words as well as the larger discourse) and optimize working memory resources such that elements that are most informative for prediction are maintained while others are lost? Working memory processes associated with prefrontal cortex (PFC) have been proposed to perform similar functions, modeled via neural networks with gating mechanisms which learn when to maintain important information and when that maintained information needs to be updated (Servan-Schreiber & Cohen, 1992; Hochreiter & Schmidhuber, 1997). Yet, past fMRI work suggests that the prefrontal regions associated with non-linguistic working memory (the multiple demand network; Fedorenko et al., 2013) are not meaningfully engaged during listening comprehension tasks (Blank et al., 2017; Diachek et al., 2020; Shain et al., 2019). To shed light on this, we are collecting EEG data from a story listening task, using the Natural Stories corpus (Futrell et al., 2020). Data collection is still in progress. N400 and other neural indices of prediction will be extracted for each word in the stories and compared to surprisal values from multiple neural language models with varying context gating mechanisms. Long-short term memory (LSTM) networks include these PFC-like gating mechanisms while recurrent neural network (RNN) models do not. By comparing how well the model surprisal values fit the human neural responses and examining which sentences elicit the most dissimilar surprisal estimates across the models, we can explore the contributions of PFC-like working memory gating mechanisms to linguistic prediction. We predict LSTM data will fit the human N400 data better than the RNN (Aurnhammer & Frank, 2019) as the RNN is much simpler with no gating mechanisms (Tripathi, 2021), and we believe context maintenance and updating is necessary for robust linguistic predictions. We also predict that the LSTM surprisal values will fit the human N400 fairly well, such that as model surprisal increases, N400 values will increase as well. However, this may not hold to the same extent throughout the duration of stories, as both RNNs and LSTMs tend to struggle with memory for context on a longer timescale.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

## Alterations in the Processing of Temporal Features for Speech Associated with Musicianship and Instrument Type

***Poster A81*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

McNeel Jantzen[1], Katie Harrison[1], K.J. Jantzen[1]; [1]Western Washington University

Musical competence requires precision and as a result musicians are more sensitive to acoustic features such as onset timing and frequency (Patel, 2011; Levitin, 2006). Musical training may enhance the processing of acoustic information for speech sounds as musicians have a more accurate temporal and tonal representation of auditory stimuli than their non-musician counterparts (Kraus & Chandrasekaran, 2010; Parbery-Clark et al., 2009; Zendel & Alain, 2008). Taken together, this suggests that musical training may enhance the processing of acoustic information for speech sounds. While our previous research did not show a musician advantage for discrimination of temporal cues (Huntemer-Silveira et al., 2017; Jantzen et al., 2014; Jantzen & Scheurich, 2014) there was a trend suggesting that string musicians had enhanced performance compared to their wind musician counterparts (Davis et. al., 2015). Moreover, our results did provide evidence that the voiced stimuli had a strong perceptual effect and that musicians were more sensitive to categorical boundary effects. However, the lack of robust results may have been due to the difficulty of the dichotic paradigm used. Therefore, the current study employed a speeded, same-different (AX), discrimination task using pairs of speech stimuli differing in voice onset time along a voiced to voiceless continuum. Subjects rated pairs on a scale from 1 to 7, with 1 being ‘no difference’ and 7 being ‘very different’. Musical training effects and organization of temporal features were reflected in the EEG as observed by location and amplitude of the ERP’s. In addition, behavioral results indicate that the pattern of performance on the difference-rating task varied as a function of instrument type and sensitivity to rapidly changing temporal cues that indicate a possible translation of musical cues into functional linguistic cues. Consistent with previous results (Jantzen et al., 2016), the voiced phoneme acted as a strong perceptual magnet to the voiceless phoneme thereby producing weaker categorical boundaries for the two phonemes. The voiceless phoneme does not contain the dominant voicing feature and therefore produced stronger categorical boundaries; effectively allowing the voiced phoneme to perceptually exist as a stronger and separate category. The clear categorical boundaries along, not just at either end of, the continuum may reflect musicians' sensitivity to and precise processing of acoustic features of speech due to musical training, an enhanced right hemisphere music network, and an indirect translation of musical cues into functional linguistic cues. Musicians focus on and direct their attention to small changes in acoustical features such as pitch and onset time, thereby developing an acute processing of spectrotemporal acoustical information (Schneideretal, 2002; Marieetal, 2012). However, pitch and onset time are not used to convey the same information in language and music. It is possible that processing these features as musical cues may not translate to how they function in language. Consistent with Patel's (2011) OPERA Hypothesis, our results suggest ananatomical overlap of neural areas that process acoustic features present in both speech and music. Additionally, musical training requires repetition that continually engages these neural areas and enhances musicians' left hemisphere language network.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

## Functional and structural connectivity of auditory areas that process talker variability in speech

***Poster A82*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Tyler Perrachione[1], Ja Young Choi[2]; [1]Boston University, [2]Harvard University

The acoustics of speech are highly variable across talkers, and listeners must recognize speech efficiently in the face of this variability. The computational challenge of talker variability is evident when listeners recognize words spoken by single talker (quickly and accurately) vs. spoken by multiple different talkers (slower and less accurately) – a phenomenon called "talker adaptation." Prior neuroimaging, noninvasive neurostimulation, and invasive electrophysiology in humans have suggested that talker adaptation reflects processes in bilateral superior temporal gyrus (STG), but it is unknown how these local computations are integrated with processes supporting speech recognition throughout the rest of the brain. Here, we modelled generalized psychophysiological interactions (gPPI) using functional MRI and probabilistic tractography using diffusion MRI to investigate how auditory areas that are sensitive to talker variability are functionally and structurally connected to the rest of the brain during speech recognition. Using sparse-sampling fMRI, we obtained whole-brain BOLD data from healthy neurotypical participants (n=19) while they performed a word recognition task. Participants matched visually-presented pictures to auditory words in blocks where the words were spoken by either a single consistent talker or multiple different talkers. Univariate analysis of the fMRI data revealed talker adaptation (reduced BOLD response during single- vs. multiple-talker blocks) in bilateral STG. A whole-brain parcellation obtained via group-constrained, subject-specific (GCSS) analysis revealed that within-subject talker adaptation effects were localized in four probabilistic parcels, including left and right, anterior and posterior STG. We circumscribed subject-specific functional regions of interest (fROIs) within each of these parcels, corresponding to the decile of voxels with the greatest univariate response to talker variability (multiple > single talkers). We used these fROIs as the functional and structural seeds for the gPPI and probabilistic tractography analyses. From the gPPI analyses, we found that these auditory fROIs had greater functional connectivity to domain-general brain areas outside of the spoken language network (including left middle frontal gyrus, anterior cingulate, bilateral visual areas, thalamus, and right cerebellum) when listening to a single talker vs. multiple talkers. Of the fROIs, right posterior STG showed the most extensive task-dependent changes in functional connectivity to the rest of the brain. From the probabilistic tractography analyses, we found that all four auditory areas sensitive to talker variability had similar patterns of ipsilateral structural connectivity, including prominent connections to posterior parietal and occipital cortices, as well as contralateral projections via the splenium of the corpus callosum. Taken together, these results suggest that auditory areas that are sensitive to talker variability are functionally and structurally integrated in a broader whole-brain attentional network. These neural results are consistent with recent models of speech processing proposing that behavioral phenomena associated with talker adaptation are due in part to domain-general auditory attention and streaming of a single auditory source (the talker), whereas auditory detection of talker changes incurs stimulus-driven attentional reorientation and thereby imposes additional domain-general cognitive demands on speech recognition as listeners must reorient their attention from the prior talker to a new one.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

## Task-dependent functional connectivity of language-selective regions

***Poster A83*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A cortical network for spoken language processing encompasses a consistent array of regions in the frontal, temporal, and parietal lobes, the precise location of which varies uniquely across individuals. Much of the neuroimaging work characterizing these regions has used univariate response magnitudes or multivoxel pattern analyses to investigate differences in local selectivity for language vs. nonlinguistic stimuli or tasks. However, little work has asked how the connectivity of these language areas – either to each other or to the rest of the brain – is affected by task demands. Here, we used generalized psychophysiological interaction (PPI) models to examine how functional connectivity between individually defined language areas and the rest of the brain changed during linguistic vs. nonlinguistic processing. Using functional magnetic resonance imaging (fMRI), we measured whole-brain BOLD responses from N=24 neurotypical adults during an auditory language localizer task that contrasted passive listening to intact speech vs. incomprehensible degraded speech (Scott et al., 2017). Using group-constrained, subject-specific (GCSS) analyses, we obtained a probabilistic parcellation of the intact > degraded speech contrast, yielding bilateral anterior and posterior STG, IFG pars opercularis, IFG pars triangularis, MFG, SFG, and right cerebellum parcels. Within each of these parcels, we defined subject-specific functional regions of interest (fROIs) corresponding to each participant’s maximally selective (top 10%) voxels. We used the mean BOLD timeseries extracted from each of these fROIs to construct generalized PPI models that analyzed task-dependent changes in connectivity between that fROI and the rest of the brain when listening to comprehensible intact vs. incomprehensible speech. We analyzed these results in two ways: (1) in univariate group analysis examining task-dependent connectivity from the parcelwise fROIs across the whole brain, and (2) by extracting the models' interaction term coefficients within the individually defined language-network fROIs for each participant. The whole-brain group-average analysis revealed that listening to comprehensible speech was associated with a broad reduction in functional connectivity from language fROIs. Notably, much of this reduced connectivity was localized to tissue proximal to, but distinct from, core language areas. Analysis of task-dependent functional connectivity within individually-defined nodes of the language network revealed a more complicated pattern, with some areas tending to show increased connectivity during spoken language processing (e.g., left IFG), while others tended to show decreased connectivity (e.g., left MFG), and while still others showed a mix of increased and decreased connectivity (e.g., left STG) to the rest of the language network. Taken together, these results suggest that cortical language network dynamics are more complicated than just a wholesale increase in response during language processing and decreased response to nonlinguistic stimuli or domain-general cognitive tasks. Instead, activity in the cortical language network appears to become broadly decoupled from other areas, especially spatially proximal areas, during language comprehension. Furthermore, the complex dynamics of increasing and decreasing connections between language areas hint that, despite homogeneous patterns of univariate responses in these regions, they may nonetheless have functionally dissociable roles during online language processing.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

## Bilateral human laryngeal motor cortex in perceptual decision of lexical tone and voicing of consonant

***Poster A84*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Recent neuroanatomical models propose that the left motor cortex maps phonological analyses onto motoric representations, which may compensate for degraded speech perception in challenging listening conditions. Transcranial magnetic stimulation (TMS) studies have identified a causal engagement of the left lip and tongue motor subregions in phoneme perception, while the right motor cortex has been linked to perception of non-lexical prosody. However, three questions regarding the role of bilateral motor cortices in speech perception remain unanswered: 1) whether the laryngeal motor cortex (LMC) is engaged in an effector-specific manner, 2) how bilateral motor cortices cooperate under varying degree of difficulty, and 3) what specific stages of the perceptual decision-making process are modulated by bilateral motor cortices. Four hypotheses targeting the first and second questions (spatial questions) may drive the functional distributions of bilateral motor cortices: the acoustic hypothesis (the left motor cortex for segmental and the right for suprasegmental cues as auditory cortices), the lexical hypothesis (the left motor cortex for lexical cues), the motor hypothesis (bilateral motor cortices show somatotopy during perception resembling production), and the redundancy hypothesis (the left motor cortex is fundamental and the right acts as a backup). For the third (temporal) question, as speech perceptual decision is postulated to encompass the (left) motor cortex in acoustic-phonetic feature extraction, phonemic categorical mapping and response selection, we hypothesized that bilateral motor cortices may interactively involved in all the stages. Methods: To test the hypotheses, we delivered repetitive TMS (rTMS, Experiment 1, an exploratory experiment) or theta-burst stimulation (TBS, Experiment 2) to the left/right motor cortex (in Experiment 1, LMC and tongue motor cortex, TMC; in Experiment 2, LMC only) of Mandarin speakers to investigate if the categorical perceptual decision of lexical tone (a suprasegmental lexical cue determined by laryngeal gestures) and dental plosive consonant (a segmental lexical cue determined by both laryngeal voicing and tongue motions) with/without noisy background would be modulated accordingly. To localize the production-related dorsal LMC (dLMC) and TMC, participants underwent a functional magnetic resonance (fMRI) pretest where they performed phonation and tongue movement tasks. We applied two independent pipelines to investigate the TBS modulation effects upon dLMC on behavioral responses in Experiment 2. For perceptual sensitivity, we fitted psychometric curves to investigate modulations on the curve slope. For stages of perceptual decision, we applied the hierarchical Bayesian estimation of the drift-diffusion model (HDDM) to disentangle what latent dynamic decision processes would be altered. Results: Our results reveal an effector-specific involvement of bilateral dLMCs in perceptual decision of both lexical tone and voicing of dental plosive consonant, supporting the motor hypothesis. Meanwhile, we provide evidence for the redundancy hypothesis, as the left dLMC plays a dominant role, while the right counterpart is only crucial in challenging tasks. Moreover, the specific perceptual decision stages that are modulated by the dLMC hinge on the hemisphere and task difficulty. Conclusion: Taken together, these findings expand our knowledge of the underlying mechanisms and temporal dynamics of bilateral motor engagement in speech perceptual decision-making.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Alpha and beta oscillations differentially support linguistic demands in a rule-switching task

***Poster A85*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Human and non-human primate research has investigated the role of brain oscillations in basic cognitive functions. In particular, alpha oscillations are related to facilitated processing through the inhibition of task-irrelevant networks, while beta oscillations seem to carry content information about task rules. However, little is known with regard to the generalization of fundamental operations to more complex processes. Here, we constructed a novel rule-switching paradigm incorporating functions from working memory and language comprehension to word production, in order to study the role of alpha and beta dynamics during high-level processing. Specifically, Dutch native speakers were required to come up with an alternative exemplar from the same category or a feature of a given target word (e.g., for the word tuna an exemplar from the same category -seafood- would be shrimp, and a feature would be pink) embedded in spoken sentences. In each trial, a cue indicated the task rule (exemplar or feature) either before listening to the sentence (pre-cue) or after the sentence and a delay period (retro-cue). Participants were prompted to verbalize their answer at the

end of the trial. Magnetoencephalography (MEG) was recorded throughout. As expected, reaction times of word production were longer for retro-cue compared to pre-cue, due to higher cognitive load. Reaction times were also longer for features compared to exemplars. Interestingly, participants generated more diverse responses for features compared to exemplars, suggestive of increased association strength for exemplars. Surprisingly, there was a correlation between responses' word frequency and reaction times, potentially due to contextual constraint effects of the sentences. On the neural level, alpha power during a delay period in the working memory task was lower for retro-cue compared to pre-cue in left hemispheric language-related regions. Critically, the power at each individual's peak alpha frequency negatively correlated with reaction times, providing evidence for the role of alpha in facilitating task performance by regulating inhibition in regions linked to lexical retrieval. Furthermore, the spatiotemporal pattern of beta activity was dissociated between exemplars vs. features in right temporo-parietal regions, but only when participants were aware of the task rule, which is in line with the proposed role of beta oscillations in the encoding of distinct categories and recruitment of their respective neural networks. Overall, our study provides evidence for the generalizability of the role of alpha and beta oscillations from perceptual to complex linguistic processes, and offers a novel task to investigate links between rule-switching, working memory, and word production.

Topic Areas: Speech Perception,

## Transcranial magnetic stimulation reveals a causal link between TMS, neural function, and behavior in speech processing paradigms

***Poster A86** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Transcranial magnetic stimulation (TMS) has been widely applied to study neural mechanisms with the underlying assumption that TMS exerts a causal influence on neural circuits involved in sensory perception and motor output, which is then observable as a task-relevant behavioral response. According to this assumption, an excitatory TMS paradigm would augment the activity of neurons involved in a relevant behavioral task. However, questions remain about the exact nature of the neural response elicited by TMS and whether stimulation is in fact directly related to the same neurons involved in volitional motor commands [1-3]. Speech decoding paradigms typically utilize neural signals arising from regions of the motor cortex associated with speech production to serve as inputs for neural speech decoding paradigms [4-6]. Therefore, it is plausible that the stimulation of motor processing areas associated with phoneme articulation could result in an increased neural response in these speech decoding inputs. We sought to determine whether TMS administered to cortical regions governing either lip or tongue movements would (i) produce a significant effect on task performance, and (ii) result in a more accurate prediction of the associated phoneme in a classification analysis. We first reproduced a neurofunctional double disassociation in a phoneme discrimination task [7] and replicated these findings in a separate trial. Next, we found the same double dissociation in a speech decoding classification analysis performed on neural data collected during the behavioral task. The behavioral task was assessed by means of a two-way analysis of variance (ANOVA) with (i) two category levels (bilabial, alveolar) and two target levels (lip, tongue) and (ii) four phoneme levels (b, p, d, t) and two target levels (lip, tongue), followed by a post-hoc Tukey's HSD Test for multiple comparisons. A novel nonlinear signal processing technique, delay differential analysis (DDA) [8,9], was adopted for the decoding analysis. Significant results were obtained between the TMS and control conditions for the behavioral and decoding tasks, which showed increased performance when TMS targeted a brain region associated with articulation of the stimulus (i.e., /b/ and lip motor cortex) and decreased performance when regions not associated with the stimulus were targeted (i.e., /b/ and tongue motor cortex). A Pearson's correlation coefficient test was computed to quantify the association between the discrimination accuracy achieved by participants in the behavioral task and the decoding accuracy achieved by the classification analysis. There was a positive correlation between the two variables, $r(157) = -.21$, $p = 0.008$. Together, these experiments illustrate that the stimulation of cortical regions involved in phoneme production influence speech perception on the behavioral and neural level. We found improved performance on the behavioral task to be a significant predictor of neural speech decoding accuracy, suggesting a causal link between TMS, neural function, and behavior. While additional refinement of the method is required, our findings support neuromodulation as a prospective means of increasing accuracy in neural speech decoding.

Topic Areas: Speech Perception,

## Double dissociations emerge in a "flat" attractor network

***Poster A87*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Double dissociations were long considered a gold standard for establishing functional modularity. For example, one patient with a selective impairment in processing abstract words and another with a concrete deficit would suggest separable representations and/or functions. There have been multiple computational demonstrations that double dissociations can emerge without modularity. Most relevant for us is Plaut's (1995) demonstration that abstract vs. concrete double dissociations are observed by damaging an attractor network with separate orthographic, semantic, and phonological layers. Damage to an orthographic-to-hidden pathway led mainly to abstract deficits, while damage to a semantic-to-cleanup pathway led mainly to concrete deficits. However, random damage to either pathway could result in either kind of deficit. Because only one patient with a complementary selective impairment is sufficient to support a modularity hypothesis on classic double dissociation logic, the finding that random damage to the same pathway could lead to different deficits in different damaged networks supports the conclusion that double dissociations could result without underlying modularity. Plaut's model was complex, with 7 sets of units and 13 layers of connections. We investigated whether double dissociations would emerge in a simpler network with two sets of units and two layers of connections. We used a new variant of Cree, McRae, and McNorgan's (2006) attractor network. Our network takes phonological features (representing multiple phonemes simultaneously) as input, and maps them directly to a semantic layer that has recurrent connections (every semantic node has a connection to every other semantic node, and after input is applied, activation cycles 10 times, with the

model trained via backpropagation). Semantic patterns and words (60 concrete and 20 abstract) were based on Plaut & Shallice (1993). Concrete words tend to have more semantic features than abstract words, and some features are more likely in concrete words, while others are more likely in abstract words. We trained 10 different networks with randomly-initialized weights on these items. After training (which resulted in the networks being able to activate the correct semantics for each of the 80 words), we created 10 copies of each network and randomly damaged 10-80% of connections (in steps of 10%, i.e., 10%, 20%, ... 80%) between phonological and semantic nodes in one simulation, and 10-80% of recurrent semantic connections in another simulation. Double dissociations were apparent at every level of damage to phonological-semantic damage. Semantic-semantic damage led only to concrete deficits. The presence of double dissociations given different degrees of damage in each model reconfirm Plaut's (1995) findings in a much more “flat” architecture, with less potential for modularity. The tendency for concrete impairments given damage to the semantic attractor level is at once surprising and revealing; it demonstrates the division of labor (and partial modularity) that emerges in this network. We will discuss theoretical implications, as well as next steps in this research program.

Topic Areas: Computational Approaches, Disorders: Acquired

## Language meaning elicited by viewing animations of geometric shapes in autistic and non-autistic individuals

***Poster A88*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background: In the 1940s, Heider and Simmel (1944) showed short animations of geometric shapes moving around and asked participants to explain what was happening. All but one of their participants attributed human-like characteristics to the shapes and movements (e.g., “...two men have a fight... the girl starts to...get out of the way...She apparently does not want to be with the first man” (Heider & Simmel, 1944, page 247). Decades later, Ami (2000) showed the same animations to autistic and non-autistic individuals. The answers produced by non-autistic individuals included words that fell into the following domains: actions, social interactions, feelings, and social reasoning. In contrast, autistic individuals (i) identified fewer social elements and (ii) less often afforded social-reasoning skills to the shapes. In our study, we collected neuroimaging data from autistic and non-autistic adolescents while they watched a Heider-and-Simmel-like movie. We used an encoding model to characterize the neural representations of language meaning within the brain imaging data. Methods: In a 1.5T scanner, 30 adolescents (n=15 non-autistic) passively viewed a 7-minute movie of moving geometric shapes, which was accompanied by music, but had no dialogue. The movie depicted the story of a child (i.e., a small triangle) and included interactions such as chatting with a grown-up (i.e., a big triangle), having nightmares of a monster, and finding a friend (i.e., a small square). We created a design matrix representing 1) anthropomorphized nouns and actions seen in each second of the movie, 2) pre-processing motion parameters of the neuroimaging data, and 3) time delays to account for the shape of the hemodynamic response. For each participant, we then ran an encoding analysis to see which voxels responded most consistently to the information in the design matrix (i.e., Fisher p-value<0.05 and correlation coefficient r >0). Following that, on a group-by-group basis, we concatenated the beta weights of the responsive voxels from all participants in that group and ran a principal components analysis, thus carrying out one PCA for each group. Finally, for each of the first four principal components in each group, we used regression to determine how much of the variance in the given component was related to each of 13 different dimensions that paralleled those found by Ami (2000). Results: For autistic adolescents, the two dimensions accounting for most of the brain data variance were 'the Character Shapes', and 'Animacy'; lowest was 'social interaction'. For non-autistic adolescents, top dimensions were 'Theory of Mind', and 'Change'; lowest was 'the Character Shapes'. Conclusion: We uncovered two very different profiles representing what was most salient to each group while viewing geometric animations. For autistic adolescents, the brain activity was primarily responsive to the three anthropomorphizable shapes and their movements, with very little autistic brain activation accounting for higher level social reasoning. In contrast, for non-autistic adolescents, the most-salient constructs were social reasoning (e.g., "trick", "plan"), strong feelings (e.g., "anxious", "sad"), or when items in the movie morphed from one thing into another (e.g., house morphing into a giant monster).

Topic Areas: Computational Approaches, Disorders: Developmental

## Mitigating catastrophic interference in neural network models of bilingual lexical acquisition

***Poster A89*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Catastrophic interference is a classic dilemma for connectionist models. If a neural network is initially trained on one input-output mapping (e.g., mapping semantics to English/EN phonology) and subsequently trained on another (e.g., mapping semantics to French/FR phonology), the second mapping is likely to virtually overwrite the first -- hence the label "catastrophic interference". On the other hand, savings in relearning are often observed if the network is retrained on the first system, showing that not all knowledge has been lost. McClelland, McNaughton and O'Reilly (1995; see also Kumaran, Hassabis & McClelland, 2016) proposed a division of labor between neocortical and hippocampal pathways that could provide a solution. In Complementary Learning Systems (CLS) theory, long-term memories are stored in the cortex, while new learning relies heavily on hippocampal pathways. New learning is influenced by prior learning, but without disrupting prior learning significantly. Gradual consolidation allows new learning to integrate with long-term memory. CLS has not been applied in a detailed way to late second language acquisition. In the current project, we simulated learning of L1 (English/EN) and later acquisition of L2 (French/FR). Models were trained in four stages. (1) We trained an autoencoder network to map phonological inputs (with a slot based approach, replicating phoneme representations at every possible position, with inputs aligned to random starting positions) to identical (but non-shifted) phonological outputs via a hidden layer. (2) We trained the network to map semantic inputs to phonological outputs via the same hidden layer. We mitigated moderate phono-phono mapping interference with regular interleaving of phono-phono and semantics-phonology training. (3) Once the network could stably perform the EN phono-phono and semantics-phonology mappings,

we began training on FR phonological autoencoding. (4) Finally, we trained the model to map from FR semantics (which only differed from EN by addition of grammatical gender) to FR phonology. Unsurprisingly, each new mapping caused substantial interference, with the FR semantics-phonology mapping causing massive interference for EN semantics-phonology. Clearly, it is implausible for L2 to wipe out L1 in humans. Therefore, we explored ways that we might mitigate this strong interference. Specifically, we reserved portions of weights in particular layers for FR training. When we began FR training, we allowed activity to flow via connections trained on EN, but we did not alter these weights during L2 training. As we interleaved training on EN and FR, we alternated between disabling learning for each language's 'dedicated' weights. This coarse analog of CLS is meant only to demonstrate feasibility for planned work to formally implement CLS. This approach appears feasible for late-acquired L2, although results are sensitive to where weights are reserved. Reserving weights in phono-hidden or hidden-output layers has only weak protective effects; we still observe massive interference from FR semantics-phonology, especially on EN semantics-phonology. However, reserving weights in the semantics-hidden pathway robustly mitigates catastrophic interference. We will discuss strong assumptions in the current approach (e.g., that L1 should be active during L2 training and vice-versa) as well as a proposal for implementing CLS formally for this domain.

Topic Areas: Computational Approaches, Language Development/Acquisition

## Complex lexico-semantic networks: cross-linguistic comparison of embedding cosine similarity and human free word associations

***Poster A91*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Numerous achievements in natural language processing over the past decade have led to the development of novel analytical approaches for cognitive neuroscience. For instance, word embeddings can effectively represent word relations and perform a variety of tasks including semantic analysis (Khurana et al., 2023). An attractive feature of embeddings is that they can consider an enormous amount of data that would be infeasible for human data collection efforts. However, while language models are continuously improving, the correspondence between their underlying representations and that of humans remains uncertain (Stevenson & Merlo, 2022). While word vectors have been proven able to capture some semantic and syntactic relations between words, they do not reliably capture the complexity of human semantic spaces which are influenced by language, culture and experience. Given the paucity of cross-lingual research in this area, we set out to compare word associations between humans and embeddings across three languages. Free word association datasets in three languages (English, Dutch, French) were obtained from the Small World of Words (SWoW) project (www.smallwordofwords.org). Word networks for a set of 231 cue words were constructed based on forward association frequency. In each monolingual embedding trained on a Wikipedia corpus, we ran a K Nearest Neighbors (KNN) analysis to identify the top 5 most similar words for each cue and then calculated the mean average precision @ K (MAP@K) and normalized cumulative gain distribution (MNCGD) using the SWoW dataset as ground truth. All responses were preprocessed including lemmatization and removal of NLTK stopwords and proper nouns. Polysemous words were checked within each language and confirmed by

a native speaker; polysemous cues were removed for each language if a mismatch occurred between the SWoW and MUSE output. All embeddings performed relatively poorly on the KNN search, as there was low correspondence between the retrieved KNN words from the embeddings and the most frequently produced responses for each cue word in the SWoW dataset. The best performance (MAP@K, MNDCG) from the three language embeddings was English (0.10, 0.17), followed by French (0.08, 0.15) and Dutch (0.05; 0.09). We sought to compare KNN performance from word embeddings and human free word association to understand how well language models can approximate the lexico-semantic space within and across languages. We found that the embedding performance only partially reflected free word associations from humans and that this was consistent across languages. English embedding performance had the highest correspondence, probably due to the greater number of English Wikipedia pages compared to French and Dutch. Future work will utilize random walks across knowledge graphs to understand the capacity of these models to capture semantic similarity and relatedness across languages.

Topic Areas: Computational Approaches, Meaning: Lexical Semantics

## Syntactic-Semantic Analysis of the Emergence of Novel English-Persian Bilingual Complex Predicates

***Poster A92*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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While none can deny how rapidly our communicative environment is changing as a result of technological advances, we lack formal investigations of the mechanisms leading to the technology-driven emergence of novel linguistic structures. Worldwide, social media platforms such as Facebook, Twitter and Instagram have introduced novel terms or refined the meaning of existing ones like tweet or unfollow, leading, for non-English speaking users, to peculiar code-switching instances. Hence, studying the effects of the current digital revolution holds the potential of deepening our understanding of how languages are not mutually exclusive during naturalistic communication, and of how human communication might develop propelled by cultural plasticity. We analyzed syntactic and semantic properties of 42 different bilingual complex predicates (BCPs) retrieved from 3500 Persian-speaking tweets (LSCP dataset, Khojasteh et al. 2020) in which users discussed 34 different Instagram activities, such as ‘post gozashtan’ lit. “to put a post”. This is the ideal dataset as it allows investigation of a relatively new fixture (i.e, Instagram activities discussed on Twitter) in Persian, a language with a long history of highly productive BCPs, dating back to the seventh century borrowing Arabic nominals (Dabir-Moghaddam,1997). We observe the formation of novel predicates, where the English verb is used as it is in the application (without changing its tense), with the addition of a conjugated Persian light verb, e.g., ‘seen kard’ lit. “she did seen”. In 26% of the tweets, we notice the formation of new simple verbs such as ‘belikeam’ (i.e., I like): be- (Persian subjunctive marker) + like (English verb) + -am (Persian suffix). The use of new simple verbs disproves Bateni (2008). The same English word can be paired with different verbs in diverse conversational scenarios: for example, individuals use “to suggest” with ‘dadan’ (to give) as ‘suggest dadan’ in daily code-switching, and with ‘kardan’ (to do) as ‘suggest kardan’ on social media. Comparing Twitter and

Instagram, a clear departure from language economy appears: the same concept, e.g., “reply”, is expressed differently, e.g., 'zadan' lit. “to hit” used on Twitter, 'dadan' lit. “to give” on Instagram. Overall, this study reveals the complex dynamics leading to the emergence of novel BCPs in Persian, influenced by cultural factors (i.e., the use of different social media platforms) as well as the interaction with English per se. This study is thus a proof of concept of how large scale naturalistic dataset retrieved from social media can elucidate the mechanisms by which language is evolving and shed light onto future developments of humans’ most precious capacity.

Topic Areas: Computational Approaches, Meaning: Lexical Semantics

## Decoding brain states during language processing: deep learning applied on fMRI temporal sequences

***Poster A93*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language is a cognitive function which relies on various brain regions and functional networks depending on the specific task performed by the brain. It is possible to isolate brain regions involved in specific aspects of language (e.g. phonological processing) using fMRI contrasts. It is also possible to identify specific networks based on functional connectivity analysis. However, some spatiotemporal patterns may not be visible through these types of fMRI analyses. Is there a specific algorithm that could learn to classify brain states related to different languages tasks from temporal sequences of fMRI signal? And what if the system could tell us which voxels are important to differentiate these tasks? Deep learning is a supervised learning technique which can classify objects (e.g. sequences of images) without any a priori about the features to take into account to perform the classification. It only needs a large amount of data to be trained on. Deep learning is increasingly used to decode brain states from fMRI signals thanks to the emergence of large-scale open-access fMRI databases like the dataset from the Human Connectome Project – hereafter HCP (Van Essen et al., 2013). HCP database includes fMRI signals recorded during multiple tasks relying on various cognitive functions (e.g motor, short-term memory, language, social) in more than thousand participants. Convolutional Neural Networks (hereafter CNN) have been shown to be able to classify those various cognitive functions/tasks from HCP with up to 97% accuracy (Jiang et al., 2022). Recently, transfer learning of CNN from big datasets to smaller datasets has turned out successful. Would deep neural networks be able to distinguish brain states at a more fine-grained level and differentiate various language tasks? In the present study we trained a CNN on the classification of seven cognitive tasks from the HCP. Using a transfer learning approach, we then fine-tuned this CNN on the InLang dataset which includes 13 different language tasks structured into five groups (Roger et al., 2022). We used a backpropagation algorithm to detect which voxel were critical to perform the classification. The obtained CNN was able to classify fMRI temporal sequences in those five groups with a validation accuracy of 67% while typical machine learning methods (e.g. Support Vector Machine, Linear Discriminant Analysis) were at chance level (20%). Results and perspectives are discussed. References: Jiang, Z., Wang, Y., Shi, C. W., Wu, Y., Hu, R., Chen, S., Hu, S., Wang, X., & Qiu, B. (2022). Attention module improves both performance and interpretability of four-dimensional functional magnetic resonance imaging decoding neural network. Human Brain Mapping, 43(8), 2683-2692. https://doi.org/10.1002/hbm.25813 Roger, E., Rodrigues De Almeida, L., Loevenbruck, H., Perrone-Bertolotti, M., Cousin, E., Schwarz, J., Perrier, P., Dohen, M., Vilain, A., Baraduc, P., Achard, S., & Baciu, M. (2022). Unraveling the functional attributes of the language connectome : Crucial subnetworks, flexibility and variability. 1-54. Van Essen, D. C., Smith, S. M., Barch, D. M., Behrens, T. E. J., Yacoub, E., & Ugurbil, K. (2013). The WU-Minn Human Connectome Project : An overview. NeuroImage, 80, 62-79. https://doi.org/10.1016/j.neuroimage.2013.05.041

Topic Areas: Computational Approaches, Methods

## Individual differences in resting state brain networks involving memory regions in relation to multilingual language experience

***Poster A94*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The neurocognitive effects of multilingualism on human behavior and the brain are well-documented. Brain structural differences between mono- and bilinguals have been observed in areas associated with language, executive control, and memory (Danylkiv & Krafnick, 2020; Hayakawa & Marian, 2019). People who speak multiple languages exhibit a positive correlation between their multilingual experience and the volume of the caudate nucleus, a core component of the executive control and procedural memory networks (Hervais-Adelman et al., 2018). Longitudinal studies have shown that intensive foreign language learning can lead to neuroplastic changes in the brain, with e.g., increased volume of the right hippocampus in interpreters after three months of intense language studies (Mårtensson et al., 2012), and increased gray matter volume in the right hippocampus and left occipital lobe following written foreign vocabulary learning as an episodic memory training paradigm (Bellander et al., 2016). Neural traces of second language proficiency have also been explored using resting state functional MRI (fMRI), uncovering proficiency-related connectivity differences in brain regions involved in cognitive control (Sun et al., 2019). These findings suggest that the cognitive demands of language learning contribute to structural and functional changes in the brain. According to the declarative/procedural memory model for language (Ullman, 2004), different aspects of language learning and processing rely relatively more on declarative versus procedural memory and on their underlying brain networks. Declarative memory is rooted in the hippocampus, and procedural memory is supported by frontal/basal-ganglia circuits, including the caudate nucleus (Ullman, 2004). In the current project, resting state fMRI (rs-fMRI) data from 120 participants with different multilingual language experience (ranging from monolinguals to hyperpolyglots) will be analyzed. The Serial Reaction Time (SRT) (Lum et al., 2013) and Declearn (Hedenius et al., 2013) tests are used to assess procedural and declarative memory, respectively.

Additionally, the Language Experience and Proficiency Questionnaire (LEAP-Q) is used to continuously quantify (multilingual) language experience (Marian et al., 2007). Resting state connectivity pattern of hippocampus and the striatal system (as seed regions) will be analyzed. Previous studies have shown that strength and integrity of the resting state connectivity within hippocampal- and striatal-based networks are associated with better memory performance and procedural learning (Doyon et al., 2009; Wang et al., 2006). In the current study we predict that there will be a positive relationship between the connectivity of the hippocampal network and performance on the Declearn test, and between that of the striatal system and the SRT test results. We will furthermore explore whether and how multilingual language experience modulates this relationship; we predict that greater multilingual language experience will strengthen the brain-behavior relationships, with possible individual differences in terms of which system and memory strategy individuals most rely on. Results will have implications regarding the impact of multilingualism on memory skill and on the at-rest brain functional connectivity patterns underlying it, and regarding the relative reliance on the two memory systems in multilingualism.

Topic Areas: Computational Approaches, Multilingualism

## Language network lateralization is reflected throughout the macroscale functional organization of cortex

***Poster A95** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A fundamental property of brain organization is the presence of asymmetries between hemispheres and the lateralization of brain functions. This architectural feature is thought to support human language development, potentially providing an axis for the specialization of large-scale cortical networks. Individuals exhibiting atypical language organization have been identified, suggesting the presence of considerable variability in the degree of brain asymmetry. To date, this literature has primarily focused on the hemispheric specialization of language without consideration for the extent to which this property of brain organization may reflect a common motif extending across the cortical sheet. Accordingly, the relations linking the atypical lateralization of the language network with the broader macroscale organization of cortex remain an open question. We investigated the impact of language network atypicality on the macroscale functional gradients that underpin complex cognition in humans. The study sample was part of the HCP database. For each participant, a connectivity matrix was calculated using the AICHA atlas. We computed the average strength asymmetry and sum for the language network and its average inter-hemispheric connectivity. Based on the listening-math contrast, we established the BOLD average asymmetry of the language network. Diffusion map embedding was implemented to decompose participants resting state connectivity matrices into three gradients. The first gradient (G1) was anchored in somato/motor and auditory cortex, with the regions at the other end encompassing broad swaths of the association cortex. The second gradient (G2) primarily differentiated the somato/motor and auditory cortex from the visual system. The third gradient (G3) reflected a network architecture contrasting frontoparietal and somato/motor systems. HCP participants with atypical

lateralization were identified using a hierarchical clustering technique. Next, using ANCOVA, we examined the impact of language lateralization (typicality) on the average values of each gradient for 7 large-scale networks. Replicating previous results, we identified 3 groups of individuals. The strong and mild typical groups reflect leftward dominant individuals; these participants were then further grouped as typical. Conversely, the atypical participants were rightward dominant. Analyses revealed a typicality effect through the 3 gradients for the Default, Control, and Salience networks. However, the effects were different across gradients. For G1, the Default and Salience networks shifted in asymmetry, with typical being leftward lateralized and atypical rightward. The Control network being rightward asymmetrical in both cases, but stronger in atypical. For G2, no shift in asymmetry was present between the groups, but atypical were stronger rightward asymmetrical for the Default and Control networks. An opposite effect was found for the Salience network. For G3, the Default and Control networks underwent a reversed shift in asymmetry, with atypical being leftward lateralized and typical rightward. The Salience network being rightward asymmetrical in both cases, but stronger in typical. The presence of language network atypicality parallels the macroscale organization of cortex, spreading from the 1st gradient (association-sensory integration) to the 3rd (frontoparietal and somato/motor anchored). The canonical language network appears to be one component in the broader hemispheric organization of the human brain, reflecting the specialization of distributed large-scale networks across the cortical sheet.

Topic Areas: Computational Approaches, Multisensory or Sensorimotor Integration

## Multimodal Conceptual Representation: Do ChatGPT/LLMs require embodiment to reach human-level representation?

***Poster A96*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To what extent does conceptual representation require sensorimotor grounding? Previous neuroimaging studies observed shared representation on object-color processing between congenitally blind and sighted subjects (Wang et al., 2020; Striem-Amit et al., 2018), according to which the knowledge of colors of blind subjects are represented in the dorsal anterior temporal lobe (dATL, a critical region for language and conceptual/abstract knowledge) despite no color representation in their visual cortex. Recent advances in large language models (LLM) have the potential to provide additional insights into this issue. Despite learning from limited modalities (e.g., text for GPT-3.5, and text+image for GPT-4), LLMs have nevertheless demonstrated human-like behaviors in various psychology tasks (Binz & Schulz, 2023), which may provide an alternative interpretation of the acquisition of conceptual knowledge. We analyzed and compared ratings of ~5,000 words across multiple lexical conceptual dimensions between humans and ChatGPT (versions based on GPT-3.5 and GPT-4). Based on categories explored in psycholinguistic norms, the dimensions we used include (1) emotional aspects (i.e., emotional valence and dominance) (2) salience (arousal, conceptual size, and gender), (3) mental visualization (concreteness and imageability), (5) sensory domains (haptic, auditory, olfactory, interoceptive, visual, and gustatory experiences), and (6) motor domains (actions involving foot/leg, hand/arm, head excluding mouth, mouth/throat, and torso). The dimensions in question provide comprehensive coverage of lexical conceptual processing, typically explored in prior research. They exhibit nuanced variability concerning social-emotional aspects, abstract mental imagery, and direct bodily experiences. The results show that both GPT-3.5 and GPT-4 were strongly correlated with humans in several abstract dimensions, such as emotional valence (rs = 0.90 for both GPT-3.5 and GPT-4) and conceptual size (rs = 0.64 for GPT-3.5 and rs = 0.70 for GPT-4). In dimensions related to sensory and motor domains, GPT-3.5 shows weaker correlations while GPT-4 has made significant progress compared to GPT-3.5 (e.g., rs = 0.69 for GPT-4 as compared with rs = 0.27 for GPT-3.5 in the visual dimension; rs = 0.63 for GPT-4 as compared with rs = 0.33 for GPT-3.5 in the interoceptive dimension). Still, GPT-4 struggles to fully capture motor aspects of conceptual knowledge such as actions with mouth/throat (rs = 0.46), and torso (rs = 0.39). We observed highly similar patterns between aggregated and individual subjects' data. Moreover, we found that dimensions that had stronger association with the visual dimension exhibited greater improvement from GPT-3.5 to GPT-4 (rs = 0.74), suggesting that GPT-4's progress can largely be associated with the newly added visual inputs in its training. Certain aspects of conceptual representation appear to exhibit a degree of independence from sensory experiences, but others seem to necessitate them. Our results are in line with Wang et al's (2020) dual-coding of knowledge theory. Additionally, we provide insights into multiple dimensions of conceptual representation, potential knowledge transfer between different dimensions, and a wider scope of concepts beyond a narrow set of color words. We highlight the complexities of knowledge representation and the potential influence of embodied experience in shaping language and cognition.

Topic Areas: Computational Approaches, Multisensory or Sensorimotor Integration

## Neuroimaging Predictors of Language Outcome in Moderate to Late Preterm and Early Term Infants

***Poster A97*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Most preterm infants are born at moderate to late preterm (MLPT) gestations. Studies have shown that MLPT infants and even early-term (ET) infants are at risk for poorer language outcomes compared to their full-term peers. We hypothesize that a reduction in volume and thickness of the left language network encompassing language regions in the frontal and temporal lobes is most predictive of adverse language outcome in MLPT and ET infants. Alternatively, because preterm birth affects cortical structures more globally, the relationship between the brain and outcomes might be more diffuse. This study aims to identify neuroimaging features that predict MLPT and ET infants' future language ability. Forty-nine healthy Chinese MLPT and ET infants (mean (range) gestation age at birth: 36 (32- 39) weeks) were recruited. Subjects were scanned at approximate two months of chronological age and during natural sleep without sedation on a Siemens Magnetom Prisma 3T scanner. High-resolution T1- and T2-weighted images were acquired by a 16-channel paediatric coil. Regional volumes for 90 ROIs were obtained by using AAL, and the cortical thickness and surface area on each vertex was obtained by using InfantFS. Infant's language ability, including expressive and receptive language, and language composite scores were assessed at 12 months old using Bayley Scales of Infant and Toddler Development III. In ROI-based analysis, four regions showed negative correlations between regional volume and language composite scores: left parahippocampal ($r2= 0.2$, $p=0.002$), superior frontal ($r2= 0.19$, $p=0.01$), middle frontal ($r2= 0.18$, $p=0.02$), and fusiform ($r2= 0.14$, $p=0.05$). However, none of these regions reach significance after correction for multiple comparisons. GLM models with and without neural data were built to predict the language composite score. When we compared the non-neural model (Model 1) which controls for sex, gestational age at birth, and chronological age at scan with the neural model (Model 2) which additionally controls for parahippocampal volume, the neural model has a significantly higher model fit (Model 1: $r2= 0.06$; Model 2: $r2=0.2$; $F=7.43$, $p=0.009$). In cortical surface-based analysis, we found that the right inferior parietal and inferior temporal, right precentral, and right orbital frontal cortices showed negative correlations between thickness and language composite scores. The right lingual cortex showed positive correlations between thickness and language composite scores. The right orbital frontal cortex showed negative correlations between thickness and expressive scaled scores. The left lateral occipital cortex showed positive correlations between area, expressive scaled scores, and language composite scores. The left supramarginal cortex showed negative correlations between area and expressive scaled scores. The right middle temporal and right precentral and superior frontal regions showed negative correlations between area and receptive scaled scores. (All corrected $p<0.05$). We identified several distinct ROIs and cortical features in the left language network are associated with infants' future language abilities. Future research with a larger sample size would be needed to further investigate the precise neurological underpinnings of preterm infants' language problems. For now, our results suggest that MRI is a promising avenue for predicting future language outcomes beyond non-neural measures.

Topic Areas: Language Development/Acquisition,

## Innate neural mechanisms underlying semantic cognition: converging evidences from neonate and twin studies

***Poster A98** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: The anterior part of human temporal cortex, the temporal pole (TP), plays an important role in the neural bases underlying semantic representation in adults. Previous studies suggested functional subdivisions in the TP, with each connecting to different brain networks, supporting the integration of knowledge derived from various domains, including language and sensory/vision. Here, we utilized data from Human Connectome Project (HCP) and developing Human Connectome Project (dHCP) to examine the ontogenetic origins of functional subdivision in TP. Methods & Results: 1) Using a K-means clustering approach, a three-subdivision structure of TP (dorsal, dTP; lateral, lTP; and ventral, vTP) was identified in adults (N=100, 55 females, 28.3 ± 3.4 years old) based on their whole-brain resting-state functional connectivity (FC) patterns of TP. Subsequent seed(subdivision)-based FC analyses revealed specific FC patterns of each subdivision. That is, compared to other subdivisions, the dTP more strongly connected with the language network ($ts > 5.23$, $ps < 0.001$); the lTP with the default network ($ts > 15.31$, $ps < 0.001$); and the vTP with the sensory system (ts > 3.30, ps < 0.003). 2) The same clustering method further revealed an adult-like three-subdivision structure of TP in neonates (N=150, 69 females, 1.25 ± 1.15 weeks old, mean Dice coefficients between neonatal and adult TP subdivisions = 0.76). Moreover, similar to adults, the neonatal brain showed stronger FCs between the dTP and the language network (ts > 11.16, ps < 0.001), as well as between the lTP and the default network (ts > 5.12, ps < 0.001). However, the vTP in neonatal brain did not show the specific FC patterns with sensory system (ps > 0.9). 3) Finally, the heritable patterns of the specific FC of TP subdivisions were examined in the adult twin participants available in the HCP dataset. The subdivision-specific FC was quantified as FC between each subdivision and its preferred system (e.g., dTP with the language system) minus the mean FC between the same system and the other two subdivisions (e.g., lTP and vTP with the language system). The quantitative genetic analyses revealed significant genetic effects on the specific FC of dTP and lTP both when participants were at rest (123 monozygotic pairs and 67 dizygotic pairs; ps < 0.001) and performing a semantic task (i.e., story-comprehension, 129 monozygotic pairs and 71 dizygotic pairs; ps < 0.05). No reliable genetic effects were observed for the specific FC of vTP in either status of participants. Summary: The current findings demonstrated that the adult-like FC-based subdivisions of TP were already present in neonates. Combined with the specific connectivity patterns of dTP and lTP that were early-emerging and genetically programmed, these results suggest innate functional connectivity mechanisms in TP that support its integrative role in the human semantic network. Moreover, our results also highlight the importance of postnatal experiences on the development of neural networks for semantic processing, especially for vTP whose specific connection patterns were mostly environmentally influenced and only observed in adults.

Topic Areas: Language Development/Acquisition,

## The mechanism by which the word or tool category of a novel figure is learned in the human ventral occipito-temporal cortex

***Poster A99*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Rapid and precise categorization of visual stimuli is usually crucial for the survival and reproduction of higher-order animals. The human ventral occipital-temporal cortex (VOTC) has evolved some regions that specifically process these different categories (e.g., tools, animals, faces, and words). Studies have shown that the visual features of visual stimuli play an important role in determining these category-specific regions in the VOTC. However, the role of nonvisual features of the stimuli in forming these categorical regions remains unknown. To address this issue, we engaged 19 healthy subjects in approximately 13 training sessions to learn associations between three homogeneous sets of novel meaningless figures and different high-level features: nonvisual features (pronunciation, grammatical class) for the word category (i.e., word condition), nonvisual features (manipulation, function) for the tool category (i.e., tool condition), and no features in a third category (i.e., baseline condition). The subjects additionally completed pre- and post-training functional MRI (fMRI) experiments for all the stimuli. Training in the two categorical conditions induced higher activity in the VOTC compared to the baseline condition. Moreover, the training between the two categories elicited different intensities and patterns of activity in the categorical preference region of the VOTC but these regions were in

the same location. The training also yielded the categorical dissociation of the functional coupling strengths between the within-category-specific areas, reflecting an interactive mechanism between the VOTC and the high-level regions. These findings offer pivotal evidence elucidating how abstract information of objects is encoded into neural representations in the human VOTC.

Topic Areas: Language Development/Acquisition,

## Language Acquisition in Brains and Algorithms: towards a systematic tracking of the evolution of language representations using stereoelectroencephalography recordings in children and deep learning.

***Poster A100*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The human brain, unlike other species, has evolved a unique ability to communicate through language by combining a limited set of known elements (words) into a representation that is both novel and meaningful. However, how humans learn to perform this task, through computation algorithms and structural organisation in the brain, remains largely unknown.  In this project, we investigate how the representations of language in the human brain change as children mature, using classic models of linguistic features, and artificial neural network models.  To this end, we have collected stereoelectroencephalography (sEEG) signal in 30 children, between 3 and 19 years old, while they listen to an audiobook, Le Petit Prince by Antoine de Saint-Exupéry. This forms the first dataset of its kind on naturalistic linguistic stimuli. We present a decoding analysis on phoneme and lexical level linguistic features, as well as a comparison with the artificial neural network Wav2Vec2.0. We present three main findings from decoding the classical linguistic phenomena. The first finding is that phoneme features such as voicing, as well as lexical features such as word frequency can be decoded in an autistic child of three years old, replicating what is seen in neurotypical adults. Secondly, we show that there is a decrease in reaction time with age, for lexical features, but also an increase in total processing time. This indicates that older children process lexical information more quickly but also maintain that information in the brain for longer, allowing it to be integrated with other information for higher level abstraction. Thirdly, we show the sequence of processing that occurs topographically in the brain. In young children, response times are similar across brain areas indicating that it is only lower level information that is represented even in the frontal cortex. However, in older children there is a delay that increases with distance from the primary auditory cortex indicating that there is integration of multiple levels of information, and more abstract features are represented in the highest brain areas. We also present a comparison with Wav2Vec2.0, where we show that early layers in the model are good predictors of the primary auditory cortex, and deeper layers are able to explain activations in higher brain areas but only in the older children. This research is significant as it provides a better understanding of how language is represented in the brains of children of different ages. While most features can be decoded in even the youngest children, their spatial organisation differs from mature brains, and the presence of delays, and lack of delays across brain areas

indicates a hierarchy of processing algorithms that are not yet in place in the youngest children, and must be learned during development.

Topic Areas: Language Development/Acquisition,

## The Development of Lexical Representation During the Third Year of Life: A Longitudinal EEG Study

***Poster A101*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In the course of early language acquisition, the representation of lexical entries becomes increasingly differentiated depending on language experience and vocabulary growth. However, little is known about specific mental lexical representations in early childhood, how well children understand words used in their environment, and to what degree of precision word forms are specified. To address such questions, the present longitudinal EEG study investigates the segmental, prosodic and semantic specification of words in 24, 30 and 36 months old children. At these time points, a picture-word-matching task was conducted with 15 monolingual, German-speaking children. Language proficiency was assessed at each measurement to ensure typical development. 18 healthy, monolingual, German-speaking adults served as a control control. Visual stimuli were a set of prototypical pictures which were followed by auditory stimuli in one of four conditions: A control condition that matched the expected referents, a segmental violation wherein the word onsets of the target word had been altered to create pseudowords, a prosodical violation wherein the stress of the target word was altered, and a semantic violation wherein close co-hyponyms of the target word were presented. EEG was recorded during the experiment from 32 channels. After offline artifact rejection, ERP effects were investigated in consecutive 100 ms windows starting from word onset up to 900 ms thereafter. For statistical analysis, linear mixed-effects models and bonferroni-corrected post-hoc tests were used and the standardized measurement error (SME) was calculated to gauge noise levels. The adult group shows a significant negativity in response to the phonological violation in the windows from 300 to 700 ms post-stimulus onset, as well as a significant negativity from 300 to 400 ms in the semantic condition. Children at 24 months show early negativities in the phonological condition (100-200, 300-400), as well as a late negativity (600-700) in response to the prosodic manipulation. At 30 months, prolonged negativities are present in the phonological (400-700) and the semantic condition (400-900). At 36 months, the negativity in the semantic condition is similar, from 400 to 900 ms, but there is a positivity in response to the phonological condition from 100-200 ms followed by a later negativity from 500-600 ms. The SME scores indicate more noise in the recordings of children compared to those of adults, as well as an increase with distance from the prestimulus baseline. Effects at 24 months indicate the detection of phonological differences between the expected forms and the presented auditory stimuli, but adult-like patterns of lexical access were not observable before the age of 30 months. Children seem to treat close co-hyponyms as viable word candidates at 24 months, but recognize the semantic distinction with increasing age. Adults show in this condition only a small negative component, which indicates that semantic relationships are well differentiated in their mental lexicon. Prosodic violations apparently do not hinder lexical access. Our results hint at a shift in lexico-semantic processing between 24

and 30 months and warrant further investigations into the change of lexical representations during this period.

Topic Areas: Language Development/Acquisition,

## Domain general cognitive control brain networks are associated with the development of children's language abilities

***Poster A103*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The processing of language is a crucial aspect of complex cognitive functioning in humans. In research on adults, it has been found that this process is mainly supported by a left-lateralized language specific network, distributed across frontal and temporal lobes, with less dependence on brain networks related to domain-general cognitive control (Diachek, Blank, Siegelman, Affourtit, & Fedorenko, 2020). However, could this finding be applicable to children and adolescents? As they may have inferior language skills compared to adults, could they be more reliant on domain-general brain networks? To address this question, in this study, we investigated the developmental patterns and associations between cortical morphology and language abilities in children and school-aged adolescents. We used data from 236 subjects（age=6-18）in the Chinese Color Nest Project (CCNP) . This project was established to create normative charts for brain structure and function across the human lifespan, and link age-related changes in brain imaging measures to psychological assessments of behavior, cognition, and emotion using an accelerated longitudinal design (Liu et al., 2021). To assess language ability, we used the verbal processing scores derived from two subtests, namely vocabulary and comprehension, extracted from the Chinese version of the Wechsler Intelligence Scale for Children, Full Scale, Fourth Edition. Gray matter volume of brain regions was used as an indicator of brain morphology. Based on the networks proposed in Schaefer et al. (2018), we obtained the masks of the language network and the domain-general cognitive control network (defined as the combination of the fronto-parietal network and dorsal attention network). Gray matter volumes of these networks were used as an indicators of brain morphology. Generalized additive mixed models were used to analyze the data. Results showed that in children and adolescents, language ability scores were significantly correlated with the gray matter volumes in both the language network and the domain-general cognitive control brain network, suggesting that these two kinds of networks work in conjunction to facilitate the development of language ability.

Topic Areas: Language Development/Acquisition,

## Disentangling the specific networks related to statistical learning from those for rule generalization

***Poster A104*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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An important part of language learning is the identification of rules embedded in words and phrases. Usually, rules are characterized by sequential co-occurrences between elements (e.g., “These cupcakes are unbelievable”) thus tracking the statistical relationship between these non-adjacent dependencies is fundamental. Previous studies have showed that the tracking of these statistical relations are supported by a ventral fronto-parietal and basal ganglia network. As rules become consolidated, they can be abstracted and transferred to a new language but generalisation is not possible when left parietal lobe is impaired. The objectives of this study are twofold: 1) replicating the behavioral and neural findings which identified the left frontoparietal network involved in both learning and generalisation of linguistic rules and the left parietal lobe (LPL) being necessary for generalisation, and 2) disentangling the specific neural networks associated with the abstract generalization of linguistic rules from those related to statistical learning, involved in early learning of non-adjacent linguistic rules. Procedure: We conducted an experiment using fMRI and TMS in three sessions. Three artificial languages (L1, L2, L3) were used, each with different words presented auditorily. Rule sequences followed a three word A-X-C structure (e.g. cofa male runi), where "A" predicted "C," while no-rule sequences had an X-X-C structure. Implicit learning was measured through a target detection task of “C” (predictable in Rule but not in the No Rule condition). In the first session (L1), participants learned the A-X-C rule. In the second and third sessions, generalization was tested by presenting the same participants with a new language (L2 or L3) with new words but following the same A-X-C structure one week later. In these sessions Theta Burst Stimulation (TBS) was applied to the maximum BOLD signal peak (LPL) from the first session or the vertex (Control area) during fMRI scanning while learning was performed. Results: In the first learning session, results showed the engagement of the left frontoparietal network for rule learning. These findings replicated the role of the LPL in rule learning. Importantly, the TBS results replicated the impaired generalization observed under stimulation of the LPL, while generalization remained maintained under vertex stimulation. Additionally, compared with the results of the first session, TBS at the vertex (i.e. when generalisation was possible), also engaged the frontoparietal network, but with a more bilateral pattern compared with the first session. In contrast, when the LPL was interfered and re-learning was forced due to impaired generalisation, subcortical areas, including the hippocampus, cerebellum and the brainstem , which have previously been associated with statistical learning, take a more important role than in the first session. Conclusion: These results confirm again the key role of the LPL in generalization and highlight the core function of subcortical regions in statistical learning, particularly when cortical areas are not fully available.

Topic Areas: Language Development/Acquisition,

## Small Left Middle Temporal Gyrus Volume Predicts More Advanced Mean Length of Utterance at 5 years of age in the FinnBrain Birth Cohort Study

***Poster A106*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background: This poster will present a study evaluating the extent to which the grey matter volume of developing brains associate with individual differences in a functional language outcome. A long-standing hypothesis states that neural development during language learning involves leftward lateralization, and that lack of leftward asymmetry of language areas is related to poor language development in children. Alternatively, the procedural memory hypothesis proposes that procedural memory, supported by frontal-basal ganglia circuits, is integral to language development. In deed, behavioral studies suggest that performance on tasks measuring procedural memory significantly differ between children with language disorder and typically developing peers (Lum et al., 2014), motivating the study of basal ganglia structures in relation to individual differences in language abilities. We chose a functional language measure, mean length of utterance (MLU) calculated from speech sample, to represent language skills. Arguably, functional measures from everyday situations best represent children's language abilities. Method: Participants were children from the FinnBrain Study who participated in MRI and language visits at 5 yrs of age (n=142). We chose three regions of inferior frontal gyrus: pars opercularis (BA45), pars triangularis (BA44) and pars orbitalis (BA47), superior temporal gyrus (BA22) and middle temporal gyrus (BA21) as well as subcortical basal ganglia (putamen and caudate nucleus) as regions of interest (ROI) as well as asymmetry indices (AI) of those areas (obtained with FreeSurfer). We conducted multiple stepwise linear regression analysis with backward selection to evaluate if variance in children's MLU is predicted by ROI volumes and AIs. Results: Results of cortical ROI analysis indicated that the smaller volume of the left middle temporal gyrus predicted longer MLU's. No significant predictors of MLU were found in cortical AI analysis. Results of subcortical ROI and AI analysis indicated no significant predictors of MLU. Conclusion: Even though the asymmetry indices did not associate with language use, the leftward lateralization hypothesis was partially supported as the left middle temporal gyrus volume was related to functional language usage measured by MLU. Recent publications provide evidence that all language-related ROI volumes are not leftward asymmetric in typically developing matured brains (Kong et al., 2018). We suggest that perhaps more mature asymmetry indexed by smaller volume in language-related ROIs relates to better functional language abilities in children. Evidence for the procedural memory hypothesis was not found in our analyses. Reference: Kong, X.-Z., Mathias, S. R., Guadalupe, T., ENIGMA Laterality Working Group, Glahn, D. C., Franke, B., Crivello, F., Tzourio-Mazoyer, N., Fisher, S. E., Thompson, P. M., & Francks, C. (2018). Mapping cortical brain asymmetry in 17,141 healthy individuals worldwide via the ENIGMA consortium. PNAS, 115(22), E5154–E5163. https://doi.org/10.1073/pnas.1718418115. Lum, J. A., Conti-Ramsden, G., Morgan, A. T., & Ullman, M. T. (2014). Procedural learning deficits in specific language impairment (SLI): a meta-analysis of serial reaction time task performance. Cortex, 51(100), 1–10. https://doi.org/10.1016/j.cortex.2013.10.011

Topic Areas: Language Development/Acquisition,

## Representations of abstract thematic roles outside language in infants and adults

***Poster A107*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Cognitives Marc Jeannerod, [2]Université Claude Bernard Lyon 1

Thematic roles are key linguistic constructs underlying the representation of structured events, in syntax and semantics. We investigated the origins of two major roles – agent marking who does the action, and patient, marking who undergoes the action – outside of the language faculty with a switch-cost task tapping automatic implicit processes in adults (Experiment 1), and two studies with preverbal 7-month-old infants using a habituation paradigm relying on looking time measures (Experiment 2) and an oddball paradigm relying on pupillometry (Experiment 3), respectively. In Experiments 2-3, we investigated how 7-month-old infants encode visual scenes involving two people, an agent-like and a patient-like actor, and whether they spontaneously assign actors to abstract agent/patient role categories. Stimuli featured two individuals, with the purported agent (e.g., a female), leaning forward in a dynamic posture, and the purported patient (e.g., a male) in a less dynamic or static body posture. In Experiment 1 (habituation), infants saw a sequence of up to twelve images presenting the same two individuals, always in different postures but with consistent role assignment as defined by the posture. When infants' reduced looking times signaled habituation, two types of novel images were shown, in which the same two individuals in two novel postures either kept their previous roles or switched roles. In Experiment 2, images of dyads were presented in a pseudo-random order. While body postures, and therefore the type of interaction, changed all the time, role assignment was consistent in the majority (83%) of images and changed in the remaining (deviant) images (17%). We measured surprise to role switch, in the form of dishabituation (increase in looking time after habituation; Baillargeon, Spelke & Wasserman, 1985) in Experiment 1, and pupil dilation (Hochmann & Papeo, 2014; Hochmann & Toro, 2021) in Experiment 2. Finally, the purpose of the agent and patient thematic roles is to generate a relational structure, where the agent acts on the patient. In consequence, we predicted and verified that surprise reactions to role switch, signaling the assignment of abstract agent and patient roles, preferentially happen in a relational context, i.e., when the two individuals in each stimulus faced each-other, as if interacting, rather than in a situation where the two individuals were positioned back to back (Goupil, Hochmann & Papeo, 2022; Papeo, 2020; Zhou et al., 2019). Overall, remarkably congruent results demonstrate that preverbal infants, like adults, can represent the abstract roles agent and patient, which they systematically and automatically assign to actors across very different events, depending on visual cues including posture and position. Role assignment in infants signals a combinatorial capacity that precedes language development, and is key to the productivity and compositionality of human language and cognition. These empirical studies promote the view that the characteristics of natural languages derive from the structured thoughts of the non-verbal/preverbal mind.

Topic Areas: Language Development/Acquisition,

## Word learning through eye gaze cues at 12 to 24 months

***Poster A108*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Osnat Segal[1], Zipora Yegudaye; [1]Tel-Aviv University

Background: Most studies assessed word learning through eye gaze in infants by competing visually salient and non-salient objects . Only by 19 months, infants used the speaker's eye gaze to learn the name of a visually non-salient object, overriding the attraction of the interesting object. These studies left, however, a

few questions unresolved. One question is how infants learn a new word when both objects have similar saliency and therefore word learning is mainly guided by social cues as well as by visual and auditory memory of the labeled object . Also, in the learning phase of previous studies the speaker addressed verbally one object . Thus, it is not clear whether the infant learned to associate the specific label (e.g., bicket) with the object or whether the fact that the speaker looked and addressed the object verbally made it more noticeable for the infant and consequently facilitated its recognition during the test phase. Moreover, previous studies, presented only two objects in the test condition providing a high chance (50%) for guessing. Purpose: The aim of the present study was to assess word learning through eye gaze cues by using a novel paradigm that took into consideration the difficulties of previous procedures. Method: Forty-five typically developing Hebrew-speaking infants 12, 18 and 24 month old, were assessed on their ability to learn a new word (bícket or domát). The procedure included 4 parts presented in a video movie: a) recognition of a familiar word among two presented objects (where is the ball?), b) listening to a speaker (woman) looking and talking towards an unfamiliar object (noisemaker) without labeling it in six concessive phrases (e.g, look, it is here), c) learning phase in which two unfamiliar animal dolls with similar visual saliency were presented, and the speaker looked and labeled one of the dolls in six concessive phrases, and d) testing phase in which the four objects appeared on the screen and the infant had to recognize the target word. Infants were expected to increase their looking time to the target word compared to the distractors after hearing its auditory label during a time window of 1600 ms. Looking behavior was measured with an automatic corneal-reflection eye tracker SMI RED mounted on an LCD monitor. Results and conclusions: (a) 24-month-olds followed the eye gaze of the interlocutor towards the target object more times and showed increased looking time to the target object in the learning phase compared to 12 and 18-month-old infants, (b) a correlation was found between looking time to the target object in the learning phase and test phase, (c) infants across all age groups showed increased looking time to the target object compared to the three other distractors in the test phase; however, 24-month-old infants had longer looking time compared to the other age groups. The results suggest that the ability to follow the eye gaze of the speaker and orient at the target object increases with age, and is related to word learning.

Topic Areas: Language Development/Acquisition,

## Harnessing the Power of Language: Advancing the Prediction of Individual Trajectories in Aging with an Advanced Cerebro-Cognitive Age Estimation Algorithm Targeting Language Networks

***Poster A110*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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It is now possible to characterize an individual's condition on the basis of his/her "cerebral age," derived from observable brain characteristics through neuroimaging and advanced artificial intelligence techniques.

Considering the individual's "biological age" (as opposed to chronological age) has emerged as a pivotal approach to identifying health indicators and patterns of age-related diseases. Nevertheless, the conventional measure of cerebral age remains limited as it relies on an overall assessment of brain structure and a single MRI scan. In the PRESAGE (PREdictions and Stimulations related to AGE) research project, we aim to address the limitations of brain age in order to improve our ability to identify individual trajectories of brain and cognitive change. We propose a new method for estimating "cerebro-cognitive" ages which are specific to cognitive systems, and in particular to the functional networks of language. Our preliminary study conducted on test (MTL local cohort, n = 151) and validation (CamCAN, n = 652) databases, has indeed strikingly revealed that in individuals aged 60 and above, brain age predominantly correlates with language-related brain regions and active engagement in cognitive stimulation activities encompassing language and verbal communication. In addition, the literature shows differential impacts on language-related networks (e.g., lexical-phonological, semantic, and control networks) as a function of the form(s) of aging, making language an optimal candidate to significantly improve the diagnostic sensitivity of the measure. Our estimates will be made from a combination of existing databases, encompassing neuroimaging and language data from various adult populations across a wide age range (local databases, CIMA-Q, CCNA/CCNV, UK BioBank). These databases have been selected to ensure adequate representation of different populations, both clinical and non-clinical, and for the development of robust statistical models. The functional validity of the specific brain ages will be assessed by establishing the links with individual cognitive efficiency in several language domains. Finally, we will leverage follow-up scans and evaluations to analyze age-specific derivative functions. These longitudinal ages will allow us to capture the velocity and acceleration of neurocognitive aging across diverse populations, to accurately delineate individual evolutionary trajectories. Overall, the PRESAGE project should actively contribute to improving diagnostic reliability, detecting high-risk profiles, and promoting precision neuropsychology for tailored interventions. From a fundamental perspective, the project should yield new insights and valuable information on the aging patterns of language systems under different conditions.

Topic Areas: Methods, Computational Approaches

## Language selectivity may be highly localized: Evidence from univariate and multivoxel analyses

***Poster A111*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Rebecca Belisle[1], Terri Scott[2], Tyler Perrachione[1]; [1]Boston University, [2]University of California, San Francisco

A longstanding question in cognitive neuroscience is the extent to which language and domain general cognitive processes are functionally segregated in the brain. Many recent studies using within-subject language localizer tasks claim that there is strict functional segregation of language-selective brain areas. However, these studies typically consider only the voxels that are maximally responsive to language vs. domain general tasks—usually only the top 10%. It remains unclear how the other 90% of voxels are responding to language vs. domain-general tasks, especially whether domain specificity changes in a sharp or gradual manner. We obtained functional MRI scans from 24 healthy, neurotypical young adults, who performed two fMRI tasks: an auditory language localizer (involving passive listening to intact speech or incomprehensible degraded speech) and a visual-spatial working memory task (involving remembering sequences of 6 (hard) or 3 (easy) locations in a grid). Language-selective responses were defined as the magnitude of the intact > degraded contrast from the language localizer, and domain general-selective responses were defined as the hard > easy contrast from the working memory task. In within-subject analyses, we measured the relative language- vs. domain general-selectivity of voxels within bilateral frontal and temporal anatomical regions of interest (aROIs), including IFG, MFG, STG, and MTG. We sampled voxels in these regions as a function of their uniformly distributed deciles of selectivity to the language task and analyzed their selectivity via three metrics: (1) univariate response magnitude within each decile to the contrasts of interest, (2) multivoxel pattern analysis (MVPA) of the response profile within each decile across different runs of the task, and (3) MVPA of response profile magnitudes within decile across the two tasks. All aROIs showed a high degree of localized selectivity for language based on univariate response magnitudes. The top decile of voxels was strongly language selective, with selectivity dropping off dramatically for the second decile and below. The bottom decile also often showed a sharp selectivity inversion, favoring degraded > intact speech. Response to the working memory task showed the opposite pattern, with strongest response in the lowest language-selective decile and relatively weak response in all other deciles. The MVPA analysis of within-task response profiles likewise showed strikingly circumscribed patterns of response consistency in only the highest (and lowest) deciles. The top language-selective decile in all aROIs had very high between-run voxelwise correlations, whereas the intermediate eight deciles showed essentially uncorrelated activity patterns between runs. Interestingly, the bottom decile also showed a high degree of between-run correlation, consistent with its sharper selectivity for the inverse contrast. The between-task MVPA analysis showed near-zero correlations in the top and intermediate deciles of language selectivity and negative correlations in the lowest deciles, where the degraded > intact contrast had a similar response profile to the hard > easy working memory contrast. These results suggest that frontal and temporal regions have sharply circumscribed language-selective and domain general-selective regions, where maximally selective language regions show much stronger responses and much more consistent response patterns than intermediately selective areas.

Topic Areas: Methods, Control, Selection, and Executive Processes

## Contributions of the thalamus to language: A meta-analytic approach

***Poster A112*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Talat Bulut[1], Peter Hagoort[1]; [1]Max Planck Institute for Psycholinguistics

Aim: Language functions are attributed overwhelmingly to the cerebral cortex, while contributions of subcortical structures to language processing have been addressed less systematically. In this study, we aimed to explore language-related functions and functional connectivity patterns of the thalamus. Materials and Methods: The BrainMap database was searched to identify previously published functional neuroimaging experiments conducted with healthy participants and reporting language-related activations within the left or right thalamus. 129 and 88 studies were identified for the left and right thalamus, respectively. Meta-analytic connectivity modeling (MACM) was performed on the identified studies to reveal coactivation patterns of the left and right thalamus during language tasks. In addition, a functional decoding analysis was performed based on the BrainMap database to investigate functional specialization within these regions of interest.

Results: The MACM results associated the left thalamus with more extensive coactivations mainly involving a bilateral frontotemporal system, bilateral subcortical structures, and the right cerebellum. The right thalamus had more circumscribed coactivations without cerebellar involvement. The functional decoding findings significantly associated the left thalamus, but not the right, with language functions; namely, speech, semantics and, to a certain extent, syntax. Conclusion: The findings highlight the role of the thalamus in the cortical-subcortical language network and underline the utility of the meta-analytic approach in explorations of brain-language associations.

Topic Areas: Methods, Language Production

## From decoding elicited to self-generated inner speech

***Poster A113*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Oiwi Parker Jones[1], Natalie Voets[1]; [1]University of Oxford

Recent results show that inner speech can, in important contexts, be decoded to the same high-level of accuracy as articulated speech. This result however relies on neural data obtained while subjects perform elicited tasks, such as covert reading and repeating. By contrast, a practical neural speech prosthetic will require the decoding of inner speech that is self-generated. Prior work has emphasised the differences between these two types of inner speech, raising the question of how well a decoder optimised for one will generalise to the other. In this study, we trained phoneme-level decoders for consonants and for vowels on an atypically large elicited inner-speech dataset, previously acquired using 7T fMRI in a single subject. To this we now add a second self-generated inner speech dataset in the same subject. Details of the model architecture and training procedure are the same as in prior work. We note that the model is a simple fully-connected deep neural network that outperforms linear classifiers on held-out elicited data. The output classes for the self-generated inner speech task are the same as for the elicited tasks, either three consonants (/g, m, s/) or three vowels (/i, a, u/). The task was to imagine one of nine consonant-vowel syllables (/gi, ga, gu, si, mi, ma, mu, si, sa, su/). On each trial, the subject was prompted (1) to decide on which syllable to imagine, (2) to imagine saying it, and (3) to record the identity of the syllable using button presses. Across trials, the prompts were identical for steps (1) and (2), so it was entirely up to the subject to decide on and then imagine the syllables. After many hours of the elicited tasks, the subject was very familiar with the list of syllables to chose from. To exclude motor preparation signals, the buttons used in step (3) were randomised on each trial. For example, the subject might be prompted to press the numbered buttons “1=g, 2=m, 3=s” to record the syllable consonant for one trial and “1=s, 2=g, 3=m” for another trial. Although the decoders were trained exclusively on neural recordings obtained during elicited inner speech, they predict unseen phonemes accurately in both elicited and self-generated conditions. Accuracy was significantly better than chance both when decoding elicited and self-generated inner speech. The accuracy for decoding self-generated inner speech was also no worse, statistically, than for decoding elicited inner speech. Together these results demonstrate the viability of zero-shot task transfer for inner speech decoding. This result has practical significance for the development of a neural speech prosthetic, as labelled data is far easier to acquire at scale for controlled and elicited tasks than for self-generated inner speech. Indeed, elicited tasks may be the only option for acquiring labelled data in clinical populations who would benefit from a neural speech prosthetic (e.g. locked-in patients).

Topic Areas: Methods, Language Production

# Left-Right Asymmetries of Sulcal Patterns in and around Broca's Area

***Poster A114*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language is one of the most strongly lateralized functions in the human brain, and for the vast majority of individuals, the left hemisphere is dominant for language. Especially in the context of presurgical planning, the dominant hemisphere needs to be determined using activation (fMRI) or disruption (Wada-test) methods, so that cases with atypical lateralization can be identified. From a practical but also a basic science perspective, additional markers for assessing language dominance are desirable. In this regard, the macroanatomical structure of the cortex is an obvious but contested candidate. In the present study, our goal was to identify differences between the two hemispheres solely in terms of the structure of their sulci. We assessed to what degree their presence or absence, their position, orientation, shape and configuration were diagnostic for identifying if a hemisphere belonged to the left or right side. We defined sulci by hand, tracing them on lateral views of the native pial surfaces of 50 healthy right-handed participants from the "Narratives" data set (Nastase et al. 2021). Three raters were presented with 100 hemispheres, which were all oriented to the left side, therefore blinding raters regarding the true side. To increase the reliability of the manual definitions, we required that sulcus tracings overlapped in at least two out of three raters. The overall presence and absence of each sulcus was expressed in simple counts. Mass-univariate analyses (pixel-by-pixel) were used to map fine-grained differences in the sulci's locations, orientation and shape. Euclidean transforms (shift and rotation) of sulci provided a metric for their similarity regarding position and orientation. Multivariate pattern analyses used the configuration of all sulci to predict if two hemispheres belonged to the same side. In terms of overall presence, the Diagonal Sulcus within Broca's area was more frequently found in the left hemisphere. The Ascending and Horizontal Rami (AALF and HALF) in Broca's area showed a tendency to be located more anteriorly and inferiorly on the left side, and the Sylvian Fissure' shape had a flatter progression towards it posterior end point. When classifying hemispheres by their similarity (a held-out hemisphere with unknown lateralization was assigned to the side it was most similar to in the unblinded training set), we were able to correctly assign 75 out of 100 hemispheres and 47 out of 50 hemisphere pairs to their respective sides. In conclusion, the position of the Ascending and Horizontal Rami and the presence of the Diagonal Sulcus might be particularly important for determining language lateralization, as they showed left-right differences and are located within language-relevant parts of the brain. However, the shape of the Sylvian Fissure is arguably the best general indicator of left-right differences. In future work, the sulcal folding patterns should be related to fMRI data, to test if intrahemispheric variations in sulcal patterns can predict the location of language-related functional regions. The long-term goal of identifying the language-dominant hemisphere - regardless of whether it is located on the left side - will require to work with samples of atypically lateralized individuals.

Topic Areas: Methods, Language Production

# “Transforming” the neuroscience of language: Estimating pattern-to-pattern transformations of brain activity

***Poster A115*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Olaf Hauk[1], Rebecca L Jackson[1,2], Setareh Rahimi[1]; [1]University of Cambridge, [2]University of York

The cognitive neuroscience of language aims at revealing how linguistic information is represented and manipulated in the brain to enable communication and meaningful behaviour. An important aspect of the underlying brain processes is the integration and transformation of information across multiple brain systems. In order to understand these processes, a detailed characterisation of brain connectivity is key. In order to characterize brain connectivity most accurately, connectivity methods should make use of the full multivariate and multidimensional information available from neuroimaging data. This should include a characterization of transformations between patterns of activation across brain regions, and their dependence on stimulus features, task and context. Methods for this type of analysis in event-related experimental designs have only recently begun to emerge (Anzellotti & Coutanche, 2018; Basti, Nili, Hauk, Marzetti, & Henson, 2020). Here, we describe novel methods developments to estimate the multidimensional relationships between patterns of brain activity from different brain regions. In particular, we will highlight their potential to estimate the voxel-to-voxel transformations between these patterns. This opens up opportunities to characterise these transformation with metrics such as sparsity, divergence, convergence, etc. We will specifically focus on methods that are suitable for event-related experimental designs. A few recent studies employed ridge regression to estimate linear transformation matrices. In fMRI data from an object recognition experiment this revealed that transformations between early visual cortex and inferior temporal areas are relatively sparse (Basti et al., 2019). In dynamic EEG/MEG data, this approach supported a central role for bilateral ATLs with a wider semantic brain network (Rahimi, Jackson, Farahibozorg, & Hauk, 2022). The latter results have been confirmed using a nonlinear extension of this method, indicating that linear methods provide an efficient approximation of multidimensional brain connectivity (Rahimi, Jackson, & Hauk, 2023). A multivariate as well as multidimensional extension of this method has also recently been proposed. We propose methods for analysing pattern transformations in language research in more detail. We illustrate this on simplified examples from the neuroscience of word recognition. References: Anzellotti, S., & Coutanche, M. N. (2018). Beyond Functional Connectivity: Investigating Networks of Multivariate Representations. Trends in Cognitive Sciences, 22(3), 258-269. doi:10.1016/j.tics.2017.12.002 Basti, A., Mur, M., Kriegeskorte, N., Pizzella, V., Marzetti, L., & Hauk, O. (2019). Analysing linear multivariate pattern transformations in neuroimaging data. PLoS One, 14(10), e0223660. doi:10.1371/journal.pone.0223660 Basti, A., Nili, H., Hauk, O., Marzetti, L., & Henson, R. N. (2020). Multi-dimensional connectivity: a conceptual and mathematical review. Neuroimage, 221, 117179. doi:10.1016/j.neuroimage.2020.117179 Rahimi, S., Jackson, R., Farahibozorg, S., & Hauk, O. (2022). Time Lagged Multidimensional Pattern Connectivity (TL MDPC): An EEG/MEG Pattern Transformation Based Functional Connectivity Metric. Neuroimage. doi:https://doi.org/10.1016/j.neuroimage.2023.119958 Rahimi, S., Jackson, R., & Hauk, O. (2023). Identifying nonlinear Functional Connectivity with EEG/MEG using Nonlinear Time-Lagged Multidimensional Pattern Connectivity (nTL-MDPC). bioRxiv. doi:https://doi.org/10.1101/2023.01.19.524690

Topic Areas: Methods, Meaning: Lexical Semantics

# Optimising 7T-fMRI for imaging the anterior temporal lobe

***Poster A116*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Progress in our understanding of semantic cognition - the ability to comprehend and produce language, recognise and classify objects, and understand everyday events – depends on the collection of good-quality data that enable testing of, and adjudication between, different hypotheses (Frisby et al., 2023). The hub-and-spoke model (Lambon Ralph et al., 2017) posits that the anterior temporal lobe (ATL) functions as a semantic "hub", binding modality-specific semantic information into generalisable transmodal and transtemporal representations. This theory is supported by converging evidence from neuropsychology, PET, MEG, and TMS; however, fMRI evidence for the importance of the ATL is relatively sparse. One reason for this is that the ATL is located close to the air-filled sinuses, making it susceptible to signal dropout and distortions (Visser et al., 2010; Devlin et al., 2000) – a problem that is exacerbated in ultra-high-field fMRI (7T-fMRI). This study explored the best method of imaging the ATL with 7T-fMRI while preserving image quality elsewhere. We compared the capabilities of five whole-brain acquisition sequences for revealing activation in the ATL and in other regions implicated in semantic cognition (Humphreys et al., 2015). A parallel transmit (pTx) sequence has recently been developed to reduce signal loss by using multiple transmit elements, controlled independently, to homogenise excitation over the brain tissue (Ding et al., 2022). The other four sequences comprised a 2x2 factorial design. One factor varied was the number of echoes (1 or 3) – it is well known that T2* decay differs across the brain and a shorter echo time is better suited to detect activity in the ATL, while medium and longer echo times are optimal for other regions (Halai et al., 2014; Poser & Norris, 2009). The second factor varied was the multiband factor (1 or 2) - acquiring multiple slices in parallel both improves temporal signal-to-noise (tSNR) and counteracts long repetition times associated with multi-echo sequences (Puckett et al., 2018). Healthy volunteers (N=20) performed a semantic association task that is known to generate activity in the ATL and other regions at 3T (Jung et al., 2019). We found that, compared to a standard (single-echo single band) sequence, the parallel transmit sequence did not offer improved contrast in the ATL. Multi-echo, however, offered improved contrast and precision of model fit, both in the ATL and the wider semantic network, while multiband also improved precision of model fit. In addition to these univariate results, exploratory analyses indicate that multi-echo sequences improve multivariate decoding within our regions of interest. To date, fMRI studies using 7T have not focused on imaging the ATLs due to magnetic susceptibility artefacts. Our results suggest that modified protocols such as a multiband, multi-echo sequence can reliably detect activation in susceptible regions. This will be a valuable resource for the language neuroscience community – it will enable empirical evaluation of language models such as the hub-and-spoke model; it will allow fair adjudication between competing theories; and it will provide a foundation for new findings, both within and beyond the field of semantic cognition.

Topic Areas: Methods, Meaning: Lexical Semantics

## Processing bottlenecks in visual word recognition

***Poster A117*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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When reading this page, you can see many words at once. But can you process the meaning of multiple words simultaneously? I will present psychophysical and fMRI data about the processing bottlenecks that constrain visual word recognition, including with the poor quality of peripheral vision and capacity limits in the 'visual word form area' (VWFA). In many experiments we have found that when two words are briefly flashed together, readers are able to recognize only one of them. This is consistent with a serial model of recognition in which attention must be focused single words. Concurrent fMRI data show that the anterior portion of the VWFA responds to the lexical features of only one attended word at a time. Additional studies, however, suggest important exceptions to this bottleneck when the experimental conditions better approximate natural reading. First, if two unrelated words are short enough and arranged horizontally close together, many (but not all) participants can process them both simultaneously. This suggests that there is a narrow window around the point of gaze fixation within which two words may be recognized independently and in parallel. Second, when two words are presented outside that window, semantic relations between them may nonetheless be detected. Specifically, if the two words happen to form a compound word (like "water + fall"), participants have a better chance of recognizing them both simultaneously. Altogether, this research points towards a limited, context-dependent capacity for parallel processing of multiple written words. The large individual differences in this capacity will be a major topic of future research.

Topic Areas: Reading, Computational Approaches

## Concreteness pre-activated earlier than word length during visual predictive priming: Evidence from EEG decoding

***Poster A118*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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There is a large body of research providing evidence of prediction facilitating language comprehension. However, less is known about what features of upcoming words are pre-activated during this predictive processing. Predictive coding theory suggests that top-down predictions are being made continuously and compared to bottom-up sensory input to generate prediction error. Therefore, some portion of the content of predicted upcoming words should be present prior to encountering that word and as the process is top-down, higher-level features should be predicted prior to lower-level features. This should be reflected in the electroencephalogram (EEG) signal recorded at the scalp. However, to date, univariate measures of EEG have not shown evidence of this hierarchy prior to the onset of the predicted stimulus. Machine learning classification – or decoding – allows us to decode the content of EEG signals and better explore which linguistic features are represented prior to onset of an upcoming word. The present study aims to use a support vector machine (SVM) to decode semantic and lexical content represented within EEG data from a visual predictive priming paradigm. If predicted features are being pre-activated in a top-down fashion, then semantic features should be reliably decodable before target onset, and they should be decodable earlier than lexical features. Participants (n=45) were shown a prime word and instructed to try to predict the upcoming target word. In each trial (480 total trials), word pairs were either related (circus – CLOWN; 320 trials) or unrelated (trim – CLOWN; 160 trials). The forward association strength (range: .4 - .6; mean = .5) of related trials were controlled such that participants had approximately a 50% chance of predicting the target word. This paradigm generates three, plausible experimental conditions: predicted (a related pair in which the participant successfully predicted the target), related (a related pair in which the participant did not predict the target), and unrelated (an unrelated pair in which the participant could not predict the target). In each of these conditions, we used SVM to decode concreteness (a semantic feature) and word length (a lexical feature) of the upcoming target word during a 4000 ms epoch locked to the onset of the prime word. Target word onset occurred 2000 ms after prime onset. This allowed us to assess whether these features were activated before or after the target. We performed cluster-based permutation testing to compare SVM performance against chance-level accuracy (50%) using cluster-based permutation testing. We found that within the predicted condition, concreteness could be reliably decoded prior to the onset of the target word, but not post-target onset. In the related condition, we observed reliable decoding of concreteness before and after target onset. In contrast, we did not observe reliable decoding of concreteness prior to target onset in the unrelated condition. Word length was only decodable after target onset in all three conditions. These findings suggest pre-activation of semantic features occurs prior to lexical features and aligns well with predictive coding models of predictive pre-activation.

Topic Areas: Reading, Computational Approaches

## Can Prediction Error Explain Predictability Effects on the N1 during Picture-Word Verification?

***Poster A119*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Predictive coding models posit that brain activity scales with prediction error: the difference between ascending (bottom-up) input and descending (top-down) predictions. Prediction error captures two key variables: magnitude and certainty of the ascending-descending difference. Greater violations of expectations should elicit greater prediction error signals, and this effect should become larger as certainty increases. We asked whether such a simple predictive coding account could describe neural activity indexed by the N1 (~170 ms) event-related potential component elicited by words. Indeed, findings have shown that the word-related N1 is sensitive to predictions, with unpredicted words generally eliciting greater-amplitude N1s than predicted words. However, effects of error magnitude and certainty have mostly been investigated in isolation, providing incomplete tests of predictive coding. In our pre-registered study, we tested the account via the interaction between prediction congruency (error magnitude) and predictability (certainty). We recorded electroencephalograms for 68 participants while they completed a picture-word verification paradigm. PICTURE-word pairs were congruent (e.g., ONION-onion) or incongruent (e.g., ONION-torch), while predictability was manipulated continuously based on norms of picture-name association (% name agreement). Pre-registered analyses failed to find evidence that the direction of the congruency-predictability interaction matched that expected under a simple predictive coding account. Exploratory Bayesian analyses found strong evidence against the account, with the congruency-predictability interaction 59.98 times more likely in the opposite direction. Specifically, higher predictability elicited larger N1s for picture-congruent words, and smaller N1s for picture-incongruent words. We argue that a simple predictive coding account of the N1 is either incorrect or requires elaboration.

Topic Areas: Reading, Control, Selection, and Executive Processes

## Cortical responses by attentive reading are modulated by prior attentional status. An intracranial-EEG study.

***Poster A120*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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While reading our attention is often switching back-and-forth between the text and surrounding events or waning thoughts, forcing us sometimes to go back a few sentences and to re-read the “missed” information. Attention manipulation involves significant brain network modification in terms of anatomical distribution and brain dynamics (Perrone-Bertolotti et al., 2012; Perrone-Bertolotti et al., 2020). In the present study we evaluated such changes in terms of local network dynamics and anatomical distribution in relation with prior attentional state of reading. Specifically, we collaborated with 140 pharmacoresistant epileptic patients and recorded brain activity, using intracranial-EEG, during a silent attentive reading task (Nobre et al, 1994). We evaluated the effect of the prior attentional status, attending or ignoring a word, on the subsequent attended word. Patients were presented with two intermixed stories, presented word for word (200ms) at a rate of 700ms per word. One of the stories was written in white (on black background) and the other in grey. The words in white were instructed to be ignored (IGNORE) and the grey words to be attended (ATTEND). At the end of the experiment patients had to tell the story formed by the grey words and were asked specific questions. Intracerebral signals were recorded and converted through bi-polar derivation. High-frequency activity (HFA, [50-150 Hz]) was extracted from the intracerebral signal with a standard Hilbert Transform procedure (Vidal et al 2010). Specifically, we evaluated the effect of attentional reading on two different conditions involving n-1 and n trials (n-1_n): ATTEND_ATTEND trials and IGNORE_ATTEND trials. We observed that networks showing a positive modulation of HFA is overall larger to ATTEND than to IGNORE reading. Moreover, more than 50% of early HFA (starting before 300ms after the word presentation) by ATTEND reading are modulated by the attentional status of the previously presented word. We also observed that early HFA elicited by ATTEND reading are stronger if the word before was IGNORE rather than ATTEND. Overall, the results showed that cortical responses by attentive reading across different brain regions are

strongly modulated by the immediate prior attentional status. It seems that the attentional response is stronger if it is preceded by top-down inhibition (IGNORE) than by attentional selection (ATTEND).

Topic Areas: Reading, Control, Selection, and Executive Processes

## Interacting effects of visual features and linguistic processing in the visual word form area

***Poster A121*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The ability to read depends on a region in ventral temporal cortex known as the “visual word form area” (VWFA). Although it responds most strongly to written words, its selectivity is not absolute, and it exhibits top-down modulations related to task demands. Here, we used fMRI to characterize the factors that may boost activity in the VWFA: simply viewing words, attending to the visual properties of words, or explicitly engaging in a linguistic task. Participants viewed three types of character strings: familiar English words, unfamiliar pseudowords, and unfamiliar false fonts with visual properties matched to the words. We presented these stimuli in randomized sequences while participants performed three different tasks: discriminating the lexicality of the character string (word vs. nonword), discriminating the color of the character string, and discriminating the color of the fixation mark. If attending to any character string is sufficient to activate the VWFA, its responses should be elevated in the color task compared to the fixation task, for all stimulus types. If voluntary linguistic processing is necessary and sufficient to engage the VWFA, then for all stimulus types, activity should be highest in the lexical task. Contrary to both of these predictions, we found a strong interaction between stimulus type and task: compared to responses in the fixation color task, the VWFA’s response to text was elevated in the lexical task, but not in the character string color task. This result stands in contrast to predictions based on the automaticity of word recognition. Moreover, the VWFA’s response to false fonts was suppressed in the lexical task compared to the fixation task. Sensitivity to lexicality was also task-dependent: we found a higher response to pseudowords compared to real words during the lexical decision task, but not the color task. These patterns were absent in other nearby category-selective regions, such as the fusiform face area, but were present in a putative Broca’s area in left precentral sulcus. Additionally, we found high functional correlations between the Broca’s area and the VWFA only during the lexical decision task. In sum, activation of the VWFA is not merely dependent on the presence of words nor on engagement in a lexical task, but on the conjunction of both. These results highlight how the exquisite specialization of the ventral temporal cortex involves top-down feedback that is distinct from general forms of attention.

Topic Areas: Reading, Control, Selection, and Executive Processes

## Causal Dissociation of Reading and Naming

***Poster A122*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Lesions in language-dominant ventral occipitotemporal cortex (vOTC) carry the risk of causing impairment to

both reading and naming, resulting in alexia or anomia. At population level, lesions resulting in reading or naming deficits display highly comparable localizations raising questions on how distinct the representations of these two visual language functions truly are. Prior stimulation studies in vOTC have provided evidence that reading and naming are partially dissociable within individuals, however these studies have all been performed in small populations (<5 individuals), due to the relative inaccessibility of this region to direct cortical stimulation, reducing the ability to generalise the localisation of these effects across individuals. Here, we present data collected from 51 language mapping sessions performed with 49 adult patients (18-62 years). Stimulation was performed in the context of the preservation of function prior to resections in the language dominant hemisphere. We co-registered 2,829 direct cortical stimulation sites during reading and naming to create population-level, probabilistic, surface-based maps of stimulation-induced language disruption. Further, in 8 patients we used chronometric stimulation during single word reading or lexical semantic judgements, to better characterise the temporal profile of vOTC's causal involvement in reading. Chronometric stimulation was triggered with a pseudorandom delay from the onset of the word, with delays from 0 to 800ms in steps of 200 ms. Language testing was performed using passage reading (216 disruption sites) and visual naming (304 disruption sites). Within vOTC we were able to dissociate sites that selectively disrupted reading (24 sites in 11 patients) or naming (27 sites in 12 patients), or disrupted both tasks (75 sites in 21 patients). Posterolateral vOTC had a higher probability of producing reading-selective disruptions while more anteromedial regions resulted in greater naming disruption. This resulted in a distinct causally-reading-selective region posterior to a multi-modal region that disrupted both reading and naming. Chronometric stimulation of reading in vOTC demonstrated greatest disruption of function when stimulation was applied 200-400ms after word onset, inducing reading errors and slowing word production of both words and pseudowords. Induced reading errors included reading arrests, letter substitutions and regularization errors. We also demonstrated significant disruption of lexical semantic processing during a concreteness judgement task. This work provides a comprehensive causal dissociation between the reading-specific visual word form area and the classical multi-modal basal temporal language area. The causally reading selective region shows a highly comparable localisation to functional definitions of visual word form area from intracranial and fMRI recordings. This work further demonstrates that pre-surgical mapping of both reading and naming should be essential for patients requiring vOTC resections, as these functions are not co-localized.

Topic Areas: Reading, Disorders: Acquired

## Invasive and noninvasive mapping of the visual word form area in neurosurgery patients

***Poster A123*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The visual word form area (VWFA), typically in or around the left temporo-occipital sulcus, exhibits differentially strong neural responses to printed words compared to other complex visual stimuli (objects, faces, places). Focal lesions to the VWFA can cause pure alexia, or letter-by-letter reading. Mapping this cortical region and its associated white matter fibers is thus critical to preserve reading function during neurosurgical procedures in the posterior-basal temporal lobe. Here we present longitudinal studies of two neurosurgery patients (PI & AX) consisting of pre- and post-operative i) functional MRI mapping of the VWFA and adjacent category-preferring regions of temporal-occipital cortex, ii) diffusion tractography of major white matter pathways, and iii) detailed neuropsychological testing. Each patient had an fMRI-localized VWFA in their left posterior temporal-occipital cortex and normal (or above normal) reading ability, prior to surgery. Patient PI's lesion was in the left parahippocampal gyrus, medial to the VWFA; the location of the lesion compelled resection of the fMRI-localized VWFA to access the lesion in its entirety. PI developed a dense and pure alexia without agraphia post-operatively that largely recovered over the first year after surgery, but remained as a clinically significant reading difficulty 5 years after surgery. Over the first 6 months after surgery, Patient PI could read printed words only using a slow and deliberate letter-by-letter strategy. At the same time, she remained able to fluently name complex Arabic digits (302,432 as 'three hundred and two thousand, four hundred and thirty-two'). The second patient, Patient AX, underwent a focal resection of a lesion that was just lateral to his fMRI-localized VWFA. Patient AX underwent an awake craniotomy with specific reading and object naming tasks. The fMRI-defined VWFA was confirmed using electrical stimulation mapping and intraoperative monitoring of his reading performance, and the surgery spared AX's VWFA. Patient AX had no discernable impairments in reading when formally tested several months after surgery. A comparison of pre- and post-operative fMRI in both patients indicates substantial reorganization in Patient PI, with the emergence of a 'new' VWFA in homologous right posterior temporal occipital cortex after surgery. By contrast, for Patient AX, who had no discernable changes in reading abilities after surgery, the location of his left VWFA, as well as other temporal-occipital category-preferring regions remained the same. These findings demonstrate, with two types of causal evidence, the anatomical localization of the VWFA using fMRI in individual patients in left posterior temporal occipital cortex. Patient PI, whose VWFA had to be removed to access a parahippocampal lesion, exhibited a dense and selective pure alexia that spared complex arabic numeral reading. Those findings imply a segregation of cortical regions for reading printed words versus arabic numerals. By contrast, Patient AX's VWFA, which was confirmed with causal evidence provided by electrical stimulation mapping, was surgically spared, and he consequently retained his ability to read. These findings may also suggest that the involvement of right posterior temporal-occipital regions in reading increases after resection of the VWFA and remains unchanged when the VWFA is surgically spared.

Topic Areas: Reading, Disorders: Acquired

## Voxelwise and connectome lesion-symptom mapping reveals distinct organization of sublexical and lexical reading

***Poster A124** in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Oral word reading relies on knowledge of both sublexical and lexico-semantic properties of words, whereas reading of novel words (e.g., “dofe”) relies primarily on knowledge of sublexical orthography-to-phonology mappings since they have no lexical/semantic representation. Neurocognitive models of reading delineate two distinct routes for sublexical vs. lexical reading, with sublexical reading relying on dorsal stream temporoparietal and inferior frontal regions, and lexical reading relying on ventral stream temporal and parietal regions (Taylor, Rastle, & Davis, 2013). Individuals with post-stroke alexia and specific behavioral deficits (e.g., a lexicality effect) provide an avenue for refining our understanding of the cognitive and neural architecture for reading in the brain. Recent research has sharpened our knowledge of the dorsal stream, finding that different lesion locations produce distinct phonological reading impairments related to deficits in sensory-motor integration vs. motor-phonological processing (Dickens et al., 2021). Here, we replicate and extend this prior work, examining how lesion location and/or structural disconnections explain reading deficits of a new set of pseudowords manipulated on orthographic body-to-phonology mappings. Participants included 64 adults with history of chronic left-hemisphere stroke (Age=62.27(13.97)); Gender (29F/35M); Months since stroke=49.61(58.37)), and 68 age-matched controls. All participants completed an MRI scan and oral reading of 200 real words and 60 pseudowords. Three types of pseudowords were presented, differentiated based on the number of orthography-to-phonology body mappings that exist in English: zero mappings (ZM e.g., “dofe”), one mapping (OM e.g., “yoon”), or multiple mappings (MM e.g., “chead”). Lesions were manually traced and warped to MNI space. Whole brain connectomes were derived from diffusion data. Multivariate Lesion-Symptom Mapping was used for parallel analyses of voxelwise lesion data and connectomes. Age, education level, and lesion volume were regressed out and corrected thresholds were applied based on permutation analyses. We conducted five pairs of analyses: 1) all pseudowords controlling for words, 2) words controlling for pseudowords, 3) ZM accuracy, controlling for OM and MM accuracy 4) OM accuracy, controlling for ZM accuracy, and 5) MM accuracy, controlling for OM accuracy. Lesions to the supramarginal gyrus and disconnections to frontal and parietal regions within the dorsal stream resulted in relative reduction of pseudoword accuracy. Lesions to extensive areas of the superior temporal sulcus (y=-2 to y=-71) resulted in relative reduction of real word accuracy. There were no significant findings for the contrast of ZM accuracy controlling for OM and MM accuracy. However, lesions and disconnections to frontal regions including the middle frontal gyrus and premotor areas resulted in relative reduction of MM and OM compared to ZM accuracy. Disconnections to the premotor regions and parietal areas resulted in relative reduction of MM compared to OM accuracy. These results show discrete organization of sublexical and lexical reading along dorsal and ventral regions respectively. Significant findings within the sublexical contrasts indicate that existing phonology-to-orthography mappings may aid in the reading of pseudowords and may additionally rely on frontal regions and their connections within the dorsal route. Further research will be needed to confirm and clarify these subprocesses and their implications within the reading network.

Topic Areas: Reading, Disorders: Acquired

## Neuroanatomical contributions to oral pseudoword reading

***Poster A125*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Phonological dyslexia is an acquired reading disorder that preserves reading of real words but results in an inability to read pronounceable pseudowords. Despite substantial behavioral evidence of this phenomenon, attempts to identify its neuroanatomical basis have yielded inconsistent results throughout the perisylvian cortex. Notably, much of this prior work has involved a single case study approach, though modern voxel-based lesion-symptom mapping (VLSM) approaches aggregate across cases and may provide more reliable information about selective impairment. The current study focuses on two recent VLSM studies of phonological dyslexia that reported significant clusters associated with selective deficits in pseudoword reading. Ripamonti et al. (2014) identified the left insula (MNI=-38,-4,8) and left inferior frontal gyrus (IFG; average MNI=-40,8,20) as significant regions in a larger network associated with phonological dyslexia, while Dickens et al. (2019) reported a significant cluster centered in the left ventral precentral gyrus (lvPCG; MNI=-38,-2,16) associated with decreased pseudoword reading performance. The current study uses a region-of-interest (ROI) approach to assess replicability of these prior studies. Fifty-four participants with single, unilateral left hemisphere lesions were recruited irrespective of aphasia status (age: 62.80±10.91; education: 15.28±3.46; WAB-AQ: 92.86±9.87; 29 females). All participants completed an MRI scan and oral reading tasks consisting of 128 monosyllabic English words matched for frequency and regularity and 40 monosyllabic English pseudowords. Overlapping voxels between each of the three ROI spheres and each participant's traced lesion were identified. Because Ripamonti et al. used a "syndrome-based approach," with participants grouped by acquired reading disorder, and Dickens et al. used a "process-based approach," with participants not recruited for having alexia or grouped by disorder, we explored both methods for each ROI. Fisher's exact tests were performed for syndrome-based analyses. The results showed no significant associations between phonological dyslexia diagnosis and lesions to the left insula ($p=0.49$), left IFG ($p=0.28$), or lvPCG ($p=0.31$). Linear regression analyses were conducted for process-based analyses, with lesion volume and real word reading performance as covariates. The results showed no significant associations between pseudoword reading performance and lesion overlap percentage for each of the three ROIs when relevant covariates were included (left insula: $b=-0.06$, $t(50)=-0.63$, $p=0.53$; left IFG: $b=-0.08$, $t(50)=-0.64$, $p=0.52$; lvPCG: $b=-0.009$, $t(50)=-0.08$, $p=0.93$)). Overall, counter to our expectations, we did not find evidence for a selective impairment in pseudoword reading in any of three ROIs. This replication failure may be due to one or more methodological differences between studies. For instance, Ripamonti et al.'s study was conducted in Italian, where criteria for phonological dyslexia are different than in English because of syllable stress. Additionally, Dickens et al. used participants recruited for a study investigating aphasia recovery, while only 37% of our participants meet criteria for an aphasia diagnosis. These differences in underlying patterns of lesion location and neuropsychological profile may affect the variance structure of data and, therefore, decrease ROI replicability. Finally, both prior studies used VLSM, which allows for broader investigation of lesioned area. Our study is ongoing, and increased statistical power will allow for parallel VLSM analyses that may yield more convergent results.

Topic Areas: Reading, Disorders: Acquired

## Cortical and subcortical mechanisms of orthographic learning

***Poster A126*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Research on language learning has been carried out largely independently from basic research on learning and memory. However, their greater integration may be valuable. The learning/memory literature offers increased understanding of mechanisms of encoding, memory formation, consolidation and retrieval, while language provides a learning domain that is far richer, more complex and more highly integrated within existing knowledge structures than those typically considered in learning/memory research. The Complementary Learning Systems framework (McClelland, et al., 1995) has been highly influential in the learning/memory literature. CLS theory proposes that hippocampal and neocortical regions instantiate different types of learning systems performing different computations, with contributions that vary over the time-course of learning. While there has been some research on spoken word learning within the CLS framework, research on orthographic learning (in reading and dyslexia) has largely considered cortical mechanisms. In this study we examined the neural substrates of orthographic learning in real time, focusing on neocortical and hippocampal contributions. To do so, we adapted the Law et al. (2005) learning paradigm requiring participants to learn the relationship between the pronunciations and spellings of pseudo-words, while undergoing fMRI scanning. Thirteen healthy volunteers participated in a forty-minute fMRI scanning session during which they learned the spellings of pseudowords that were repeatedly presented to track the trajectory of in-scanner orthographic learning. Spelling accuracy of the items was evaluated immediately post scanning and one week later. In the hippocampus and the left ventral occipital cortex (LVOT; associated with orthographic processing), we analyzed BOLD response for learning trials that differed in their memory strength (weak, medium, strong; Smith et al., 2004). We found: (1) Both left and right hippocampi showed that activation increased with memory strength (LH: $p=0.0021$, RH: $p=0.0002$), whereas the LVOT showed decreased activation with memory strength ($p=0.03$); (2) Higher post-scan accuracy was correlated with greater activation changes of the hippocampus ($r=0.61$, $p=0.01$), but not LVOT ($r=0.38$, $p=0.11$); (3) Whole brain analyses identified two bilateral sets of brain areas that exhibited either the increasing or decreasing patterns exhibited by the hippocampus and the LVOTC, with independent functional connectivity analyses indicating that these two sets of brain areas functioned as two internally synchronized, integrated networks, at least during initial stages of learning; 4) The degree of internal synchronization of these two networks was associated with accuracy of recall up to one week after training. The results are consistent with the hypothesis that two distinct neurocognitive mechanisms are involved in orthographic learning. Generally consistent with the CLS framework, the hippocampus specifically contributes to better learning outcomes, while the decreased activation observed in LVOT orthographic processing regions may reflect BOLD adaption/familiarization that, at least in early in learning, does not support long-term retention.

Topic Areas: Reading, Writing and Spelling

## Assessing sensitivity to semantic and syntactic information in deaf readers: An ERP study

***Poster A127*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A previous study by Mehravari et al. (2017) found ERP differences between deaf and hearing readers when they read RSVP sentences that contained semantic errors (The machine quickly hopes complicated tasks.), syntactic agreement errors (The machines quickly performs complicated tasks.), double violations with both types of errors (The machines quickly hopes complicated tasks.), or no errors (The machines quickly perform complicated tasks.). The ERP components of interest were the N400 (sensitive to semantic errors) and the P600 (sensitive to syntactic errors). Mehravari et al. (2017) found that deaf and hearing readers had a similar pattern of N400 effects to semantic errors, but only hearing readers showed a clear P600 effect for agreement errors in the single and double violation sentences. There are several possible explanations for the lack of a syntactic P600 effect for deaf readers. First most of the deaf participants were bilingual in American Sign Language (ASL), and the cross-linguistic dissimilarity (lack of transfer) could have reduced the P600 for the deaf readers (ASL does not have English-like agreement). Another possibility is that the lack of sensitivity to grammatical violations was due to early language deprivation since 90% of the deaf participants were exposed to ASL later in childhood. Third, deaf and hearing readers may rely on different types of linguistic information when reading sentences, with deaf readers relying more on semantic information. To explore these hypotheses, we used the same RSVP ERP methods and sentence stimuli as Mehravari et al. (2017) but also implemented two changes. First, we added a phrase structure violation condition (I poured some coffee him for this morning.) because phrase structure constraints are parallel for ASL and English, and thus we could investigate whether the lack of a P600 effect in deaf readers reflects an overall lack of sensitivity to English syntactic structure or only a lack of sensitivity to verb agreement violations. Second, the current study only included native and early ASL signers who were not at risk for language deprivation. As in the Mehravari study, we compared deaf readers (N = 31) with a group of reading-matched monolingual English speakers (N = 31). We replicated the N400 and P600 effects found by Mehravari et al. for hearing readers, and also observed a strong P600 for phrase structure violations. We also replicated the lack of a P600 effect for verb agreement violations for deaf readers who were native/early signers, suggesting that early language deprivation does not account for this group difference. Deaf readers exhibited a robust P600 for phrase structure violations, indicating sensitivity to word order constraints. For only the deaf readers, we observed an N400 that extended into the P600 window (600-900ms) for both the semantic and double violation conditions, and moreover the N400 effects were larger for the deaf than hearing readers. This result suggests that deaf readers may be more sensitive to semantic information during sentence reading. Mehravari, A. S., Emmorey, K., Prat, C. S., Klarman, L., & Osterhout, L. (2017). Neuropsychologia, 101, 153-168.

Topic Areas: Reading,

## Discrete repetition effects for visual words compared to faces and objects, but no modulation by expectation: An event-related potential study

***Poster A128*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Repetition suppression (RS) refers to the reduction in neuronal responses to repeated stimuli as compared to non-repeated stimuli. Previous studies have reported RS for various stimulus categories, such as faces and words, but it remains unclear whether the timing of these effects differs between stimulus categories. Moreover, in previous functional magnetic resonance (fMRI) imaging studies with faces RS was modulated by repetition probability (expectation), also known as P(rep). Because P(rep) effects with visual non-face stimuli were inconsistent, P(rep) effects may depend on the expertise of the stimulus category. The visual expertise hypothesis can be tested by including written words, for which literate individuals have expertise. Moreover, using time-sensitive EEG allows to assess the temporal order of RS and P(rep) effects and to test for differences between stimulus categories. Method: Data from 33 native Cantonese speakers (16 females, mean age = 20.19 years, range = 18-28) are reported. Participants were presented with stimulus pairs of Asian faces (subcategories: male, female), written Chinese words (subcategories: living, non-living things), and animal pictures (subcategories fish, birds). The second stimulus of a pair could be the same as the first stimulus (repetition trials) or different (alternation trials). The sub-category of S1 served as a cue to signal P(rep) of S2, e.g., a living word could signal a high repetition probability (75%) and a low alternation probability (25%). Following the presentation of each stimulus pair, participants classified the sub-category of S1 (e.g., living vs. non-living) by button press. EEG data were analyzed using Topographic Analyses of Variance (TANOVA) on raw ERPs that estimate differences between entire ERP maps by generating a randomized distribution of dissimilarity of map differences between conditions. To identify the temporal dynamics of repetition effects and P(rep) following S2 onset, we ran time point-by-time point TANOVA separately for each stimulus category with factors Repetition (repeated vs. alternated) and Expectation (expected vs. unexpected), followed up by pairwise contrasts. Results: TANOVA revealed significant repetition effects after the onset of the second stimulus across multiple time intervals from 92-560ms for words, from 207-358ms for faces, and from 324-486ms for objects. Repetition effects were not modulated by expectation in any of these analyses. Irrespective of expectation, pairwise TANOVA contrasts showed larger repetition effects for written words compared to faces (152-262, 282-456ms) and objects (150-238, 265-440ms), and for faces compared to objects (213-332ms). Conclusion: The findings suggest that repetition effects occur for all stimulus categories, but that the timing of these effects differs. Repetition effects were earlier for expertise stimuli (words and faces) than non-expertise stimuli (animals). However, stimulus properties, such as spatial frequency, seem to further influence the occurrence and direction of repetition effects. Finally, while some spatially sensitive fMRI studies had revealed modulation of repetition effects by expectation, no evidence of such a modulation was observed in our study with temporally-sensitive EEG, underlining the importance of time resolution for investigating neural processing.

Topic Areas: Reading,

## Predicting Semantic and Phonological Information in Language Comprehension: Evidence from ERP Representational Similarity Analysis

***Poster A129*** *in Poster Session A, Tuesday, October 24, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Existing studies demonstrate that comprehenders can predict semantic information during language comprehension. Most evidence comes from highly-constraining context, in which a specific word is likely to be predicted. One question that has been investigated less is whether prediction can occur when prior context is less constraining for predicting specific words. Here, we aim to address this issue by examining the prediction of animacy features in low-constraining context, using electroencephalography (EEG), in combination with representational similarity analysis (RSA). In Chinese, a classifier follows a numeral and precedes a noun, and classifiers constrain animacy features of upcoming nouns. In the task, native Chinese Mandarin speakers were presented with either animate-constraining or inanimate-constraining classifiers followed by nouns. We quantified the similarity between patterns of neural activity following the classifiers. RSA results revealed that the similarity between patterns of neural activity following animate-constraining classifiers was greater than following inanimate-constraining classifiers, before the presentation of the nouns, reflecting pre-activation of animacy features of nouns. These findings provide evidence for the prediction of semantic features of upcoming words. Unlike semantic prediction, evidence for phonological prediction is less clear, and thus we aim to examine the prediction of phonological information in the processing of Chinese idioms using ERP RSA. The study utilizes four-character Chinese idioms, and phonological overlap was manipulated by varying the syllable at the idiom-final part between idiom pairs so that pairs of idioms share a syllable (i.e., within pairs) or not (between pairs). We quantified the similarity between patterns of neural activity of idioms for within and between pairs. RSA results revealed greater similarity in neural activity patterns for idioms within pairs, compared to between pairs, and critically this similarity effect was observed prior to encountering phonological overlap, providing evidence for the pre-activation of upcoming phonological information. These findings contribute to a growing understanding of linguistic prediction in language comprehension.

Topic Areas: Reading,


# Poster Session B

## Neural correlates of spoken discourse of women with Alzheimer’s disease with low levels of education and socioeconomic status

***Poster B1** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Lilian Cristine Hubner[1,2], Bárbara Luzia Covatti Malcorra[1], Alberto Osa Garcia[3], Karine Marcotte[3], Lucas Porcello Schilling[1,4], Irênio Gomes Silva Filho[1], Fernanda Loureiro[1]; [1]Pontifical Catholic University of Rio Grande do Sul (PUCRS), [2]National Council for Scientific and Technological Development (CNPq), [3]University of Montreal, [4]Brain Institute of Rio Grande do Sul (InsCer)

Background: The study of spoken discourse in Alzheimer's disease (AD) has been much more incipient as compared to the studies of other cognitive functions, such as memory. There is evidence pointing to early language impairments in spoken discourse abilities in people diagnosed with AD. So far, the impact of AD on spoken discourse and the associated neuroanatomical correlates have mainly been studied in populations with higher levels of education, although preliminary evidence seems to indicate that socioeconomic status (SES) and level of education have an impact on spoken discourse. Aims: This study has three main aims: 1) to analyze discourse production in people diagnosed with AD having low-to-middle socioeconomic status and low level of education; 2) to identify microstructural markers of language decline; and 3) to study the association between spoken discourse measures and their structural grey matter (GM) correlates. Methods & Procedure: Nine women with AD and 10 women in the control group matched by age, education, and SES without brain injury (WWBI) underwent a battery of neuropsychological tests, which included two spoken discourse tasks (a funny story and a picture-based narrative), and structural magnetic resonance imaging (MRI). Microstructural variables were extracted from the two combined discourse samples using NILC-Metrix software. Brain density, measured by voxel-based morphometry, was compared between groups and then correlated with the differentiating microstructural variables. Outcomes & Results: The analyses of microstructural variables using the software showed that the AD group produced a lower diversity of verbal time moods, fewer words and sentences than WWBI, but a greater diversity of pronouns and prepositions as well as a greater lexical richness. At the neural level, the VBM analyses showed that the AD group presented a lower GM density bilaterally in the hippocampus, the inferior temporal gyrus, and the anterior cingulate gyrus. The number of words and sentences produced were associated with GM density in the left parahippocampal

gyrus (L-PHG) whereas the diversity of verbal moods was associated with the basal ganglia and the anterior cingulate gyrus bilaterally. Conclusions & Implications: At both behavioral and neural level, the findings are consistent with previous studies conducted in groups with higher levels of education and SES. Nonetheless, the results of this study suggest that atrophy in the left inferior temporal gyrus could be critical in the early stages of AD in populations with lower levels of education and SES. This research provides evidence on the importance of pursuing further studies including larger samples with and without AD as well as with various SES and education levels.

Topic Areas: Language Production, Disorders: Acquired

## Influence of choice of task and items as well as lesion location on error elicitation under stimulation mapping in brain tumour patients

***Poster B2*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: During language mapping with navigated Transcranial Magnetic Stimulation (nTMS), non-invasive stimulation causing temporary disruption of neural activity in a brain area is coupled with a picture naming task in order to reveal the area's involvement in language production. These nTMS maps are used in neuroscientific research as well as in surgery guidance in brain tumour patients. Few efforts have gone into questioning choice of task during picture naming and its parameters: most centres solely employ home-made, unstandardized versions of the classic object naming (ON). Recently, the benefit of a verb task, Action Naming (AN), in nTMS was unravelled. Yet, which item features (length, age of acquisition etc.) lead to this benefit or which linguistic values drive both tasks remain unexplored. We therefore investigate picture naming during nTMS mapping in a healthy and clinical population using validated tests for both ON and AN, in order to investigate: (1) which task and item factors influence the breakdown of language production during nTMS (2) which patient group, depending on lesion site, is affected most by task and item choice. Methods: 20 controls and 21 tumour patients with heterogeneous lesion location underwent nTMS mapping. This entailed baseline naming of all stimuli (75 AN, 80 ON; formerly standardised (Ohlerth et al., 2020)). During nTMS mapping, 46 left-hemisphere spots were targeted with a 5Hz/5pulse electromagnetic stimulation, while individuals named picture stimuli appearing on screen for 700-1000ms. Trials where the individual was unable to produce the target items, were evaluated as errors. Binomial general mixed-effect models were established, entailing item factors (age of acquisition, length, transitivity etc.) and demographic factors (age, group healthy/clinical, lesion) as predictors. Patterns in lesion location were revealed through hierarchical clustering. Analyses were split into: models (1) including all individuals, task and item factors to reveal predictors driving naming errors; models (2) including clinical cases for recommendations of task and item choice depending on lesion characteristic. Results: Models regarding predictors for errors in all individuals (1) revealed consistently more errors during AN than ON, more errors for clinical than healthy individuals and for longer over shorter items. In ON, longer items and in AN, transitive items led to more errors. In (2) analyses of tumour patients, lesion location was a significant predictor. Discussion: Choice of task (AN over ON) consistently influences language production under nTMS across individuals. We suggest this is driven by higher complexity of lexico-semantic or syntactic weight in retrieval of verbs over nouns (Ohlerth et al., 2021, Ntemou et al., 2021). This is corroborated by the significance of transitivity within AN performance, further increasing retrieval difficulty through more complex argument structure. Moreover, item length seems to affect error count and should be taken into account. nTMS may trigger breakdown of language production at its most challenging point, through increased cognitive load of retrieving long and lexico-semantically complex items. These findings may inform our understanding of nTMS, and lead to recommendations for different lesion locations, calling for an a-priori choice of task and items to best map and preserve language.

Topic Areas: Language Production, Disorders: Acquired

## The roles of the bilateral MdLF and ILF in verbal effectiveness and lexical retrieval in people with post-stroke aphasia

***Poster B3*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In people with aphasia after left hemisphere stroke, neuronal responses in the right, non-dominant hemisphere were shown to relate to contextually constrained picture naming (present in the left hemisphere for controls; Piai et al., 2017). Subsequently to these findings, the splenium was suggested to have a role in this neuroplasticity. However, later research showed a similar shift of language to the contralateral hemisphere after stroke while the corpus callosum was damaged (Chupina et al., 2022). To complement our understanding of the possible contralateral functional shift at the temporal lobe level, this study focused on the plasticity of two white matter tracts: the middle longitudinal fasciculus (MdLF) and the inferior longitudinal fasciculus (ILF). The role of the MdLF in language is heavily debated in the literature, suggesting its involvement in either dorsal (Makris et al., 2013) or ventral language stream (Wong et al., 2011), or both (Saur et al., 2008). The ILF is more strongly considered to be part of the ventral stream with a role in language comprehension (Saur et al., 2008), but the extent of this involvement is debated (Duffau et al., 2013). Our primary aim was to investigate if the bilateral MdLF and ILF are involved in verbal effectiveness and in (facilitated and interfered) lexical retrieval. Secondly, we investigated if the (micro)structural measures of the tracts between individuals with post-stroke aphasia (n=21) and healthy controls (n=24) were different. Verbal effectiveness is a measure of the ability to convey a message by verbally expressing the necessary content units, and was quantified using the Amsterdam-Nijmegen Everyday Language Test (Ruiter et al., 2011). Facilitated and interfered lexical retrieval were measured in picture-word interference (Piai & Knight, 2018) and context-driven naming tasks (Piai et al., 2017). Using diffusion-weighted imaging and probabilistic tractography, interaction effects of group (matched controls vs stroke) and hemisphere were found for fractional anisotropy (FA) and mean diffusivity (MD) for both MdLF and ILF. Specifically, tracts in the left hemisphere for participants with aphasia showed lower integrity (interaction effects for MD MdLF: $F(1)=12.283$, $p<.001$; MD ILF: $F(1)=11.567$, $p=.001$). No effects of group and hemisphere were found for tract volume ($p>.05$). In individuals with aphasia, higher FA ($\rho(15)=.55$, $p=.033$ FDR corr.) and lower MD ($\rho(15)=-.58$, $p=.033$ FDR corr.) of the left ILF significantly correlated with higher verbal effectiveness. In addition, correlations not surviving multiple-comparisons corrections were observed between lower MD in the left MdLF and higher verbal effectiveness ($\rho(15)=-.50$, $p=.039$ uncorr.)), overall accuracy in the context-driven naming task ($\rho(18)=-.45$, $p=.046$ uncorr.), and between higher FA in the right ILF and greater naming facilitation due to constraining contexts ($\rho(18)=.47$, $p=.035$ uncorr.). These findings suggest that the left MdLF and the ILF are involved in language processing to some degree, with a more prominent role of the ILF in verbal effectiveness. Future research will combine tractography and electrophysiological data to gain insight into contralateral functional neuroplasticity.

Topic Areas: Language Production, Disorders: Acquired

## Electrophysiological Signatures of Cross-Linguistic Interference Resolution in Bilinguals With and Without Aphasia

***Poster B4*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Katherine Andrade[1,2], Henrike Blumenfeld[2], Stephanie Riès[2]; [1]University of California, San Diego, [2]San Diego State University

The growing prevalence of bilingual speakers has generated great interest in the linguistic abilities associated with bilingualism. Evidence from language production tasks indicates that bilinguals simultaneously activate both languages in parallel during word retrieval. A central strategy used to examine the overlap in linguistic processing across languages is to identify tasks where cross-linguistic interactions can occur. False cognates provide a lens into bilingual processing where cross-linguistic interference is present, increasing reaction times and error rates compared to non-cognates. False cognates are phonetically and orthographically similar words that are semantically distinct across languages (e.g., Spanish “grapa” means “staple” but resembles English “grape”). In Bilinguals with stroke-induced aphasia , deficits can impact each language as well as how the two languages interact with each other. Yet little is known about the neural dynamics supporting the cross-linguistic interference resolution processes that may be affected in stroke-induced aphasia. Here, we examined the impact of three types of distractor words: false cognate (FC), unrelated (UR), and identity (ID) in naming during a picture-word interference (PWI) paradigm. We examined neurophysiological correlates of cognitive control during cross-linguistic processing by focusing on a medial frontal component (at electrode

FCz) peaking prior to vocal onset and previously associated with linguistic and non-linguistic interference resolution. We used electroencephalography (EEG) to compare Spanish-English Bilinguals with aphasia to age-matched controls. Twenty age-matched controls (15F; mean age=51.3yrs; SD=8.9) and 3 Bilinguals with aphasia (2F; mean age=54 yrs; SD=20.4) were included in the analyses. Behavioral results revealed a significant main effect of condition and group on reaction time (Wald $\chi 2(2)=98.76$, $p<0.001$; Wald $\chi 2(1)=15.08$, $p<0.001$) and naming accuracy (Wald $\chi 2(2) =16.95$, $p<0.001$; Wald $\chi 2(1)=14.8$, $p<0.001$). Bilinguals with aphasia were slower and made more errors than age-matched controls. Across groups, reaction times were slower in the FC than UR condition ($\beta raw=0.05$, SE=0.008, t=6.20, $p<0.001$) and faster in the ID than FC condition ($\beta raw=-0.11$, SE=0.011, t=-9.69, $p<0.001$). Accuracy was lower in the FC than UR condition ($\beta raw=-0.61$, SE=0.186, t=-3.29, $p<0.01$) and higher in the ID than UR condition ($\beta raw=0.85$, SE=0.210, t=4.05, $p<0.001$). Stimulus-locked EEG results revealed a medial frontal component with a slope that differed significantly from zero between 200-400ms in age-matched controls ($p<0.001$) but not in Bilinguals with aphasia (p=0.17). Response-locked EEG results revealed a pre-response component with a marginal effect on slope that differed from zero between -600 and -400ms in age-matched controls (p=0.06) but not in Bilinguals with aphasia (p=0.97). Both Stimulus and Response-locked data in age-matched controls revealed cross-linguistic interference (p=0.007, $p<0.001$) and identity facilitation effects ($p<0.001$, p = 0.002) on peak-to-peak amplitudes in age-matched controls. Initial findings suggest that while controls engage the medial frontal cortex to efficiently resolve cross-linguistic interference, this mechanism may be interrupted in Bilinguals with aphasia, perhaps explaining overall slower and less accurate performance in Bilinguals with aphasia. Examining the role of language dominance within these effects may bring further nuance to this pattern. The current work will help to elucidate how aphasia can influence word retrieval processes in the face of cross-linguistic interactions in bilinguals.

Topic Areas: Language Production, Disorders: Acquired

## Decoding intended words in an individual with aphasia using stereo-electroencephalography

***Poster B5*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Aphasia is a devastating speech disorder that affects more than one million people in the US alone. While some patients show improvements over time with speech therapy, many have long-term impairments. Augmentative and alternative communication devices provide compensatory strategies, but these devices are limited and cumbersome to use daily. Alternatively, recent research aims to develop speech brain-computer interfaces (speech-BCIs) that can help restore speech function by detecting the patient’s intended speech based on the neural activity of the language network. Speech-BCIs have been demonstrated to predict speech from healthy individuals and from non-verbal patients with no cortical damage. However, this technology has yet to be investigated with aphasic patients, who have sustained damage to some portion of the cortical language network. We investigated speech decoding for a patient diagnosed with non-fluent aphasia after a traumatic brain injury, using neural recordings from language areas that remained intact. Using stereo-electroencephalographic (sEEG) electrodes, placed for the localization of epilepsy, we recorded broadband gamma activity (70-150Hz) from frontal and parietal cortex as the patient named pictures of eight unique common objects, with each picture repeated about 50 times in a randomized order. In each trial, the patient was shown the picture for 2s, followed by a 1s delay before being probed for a response. The patient correctly articulated 25% of responses with a further 38% containing phonemic errors, 6% resulting in an incorrect response, and 31% resulting in no response. We used a non-linear classification model (support vector machine with gaussian kernel) to decode the patient's response from trials where a word was produced, with and without phonemic errors. The responses were classified with an accuracy of 43.1% (12.5% chance accuracy) during the articulation period, with the most accurate word classified at 70%. Prior to articulation, the response was classified with 16.2% accuracy during the delay period, and with 21.9% accuracy once the patient was probed for a response. We then extended the analysis to evaluate whether the model could also decode the patient's intended response from trials where no word was produced aloud. Since no response was given, the model was used to predict the name of the picture during the delay period with an accuracy of 21.4%, and 18.0% once the patient was probed for a response. These results demonstrate that the remaining intact language areas can provide sufficient information for a speech-BCI to decode intended words from neural population activity in an aphasic patient, despite errors that are common with non-fluent speech. Furthermore, due to high variability in aphasia-related cortical damage patterns, sEEG enables distributed electrode coverage to access as many widespread intact areas as possible with minimal risk. As such, sEEG-based speech-BCIs hold much potential as an assistive device for aphasic patients to overcome difficulties in expressing their thoughts aloud.

Topic Areas: Language Production, Disorders: Acquired

## Cumulative Semantic Interference (CSI) can be repeatedly tested in a web-based paradigm in People with Aphasia showing stable CSI-effects over time.

***Poster B6*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Background: Rapid and precise selection of the correct word is one pillar of linguistic competence, which is regularly impaired in people with aphasia (PWA) (1). It is intuitive that semantic context eases retrieval by limiting the search space or pre-activating the correct lexical entry (e.g. 'she sifts the ___[flour]). However, categorical semantic relations have been shown to slow down picture-naming (semantic interference). This has been studied by three major paradigms: picture-word-inference (PWI), blocked-cyclic-naming (BCN), and continuous-naming (CN). The latter is the most ecologically valid, in that categorical relations are embedded in a sequence of seemingly unrelated objects to be named, similar to typical clinical test and training material. For continuous-naming paradigms it is well attested that with each new member of a given category, naming latencies increase, indicating increasing competition during lexical selection (2) between lexical cohort members (cumulative semantic interference, CSI). Initial models to explain semantic interference rely on spreading activation eliciting competition (3); this has been refined assuming that naming latencies are a net-effect of both facilitatory and inhibitory semantic context effects (4). Extensive research in neurotypical participants has detailed the complex interplay between both aspects of semantic context, while studies in PWA are much rarer. This is the more surprising since semantic paraphasias by PWA (producing 'dog' when intending 'cat') support models of lexical interference. Methods: Here we use a continuous-naming paradigm in 20 PWA and 20 age-/ education-matched controls. PWA all had a lesion to the left hemisphere including parts of the extended language network. For the CN-paradigm participants named 160 colour photographs of items from 24 close categories (e.g. hoofed animals). The assessment was performed in our previously established web-based manner (5), and was repeated on day 2 and day 8 after the initial session. For an exploratory lesion-behaviour-analysis high-resolution MRIs were available in all PWA. Results: (i) Mild-moderate PWA are able to perform the web-based assessment. (ii) The CSI was ~ 22 ms per ordinal position, similar between groups and stable across repeated testing. (iii) In PWA increased error-rates paralleled the latency-based CSI effect. (iv) A cluster including frontal and parietal language areas correlated with larger CSI effects. Discussion: The option to use web-based and repetitive testing in PWA allows for the use of the paradigm to track changes due to adaptive plasticity after a lesion to the language network. Since confrontational naming is one of the most used therapeutic interventions in speech and language therapy (SLT), the effect of therapy may thus be evaluated over time. Extending the correlation between lesion size and site with the magnitude of the effect contributes to define a neuronal network, supporting both facilitatory and inhibitory semantic context effects in confrontational naming (6). Citations: (1) Schwartz, Philosophical transactions Royal Society London. B, Bio.sci. 369, 20120390 (2014). (2) Howard, et al., Cognition 100, 464-482 (2006). (3) Dell, Psychol Rev 93, 283-321 (1986). (4) Abdel Rahman & Melinger, Language, cognition and neuroscience, (2019). (5) Stark, et al., Behavior research methods, (2022). (6) Pino, et al. Neuroimage 246, 118767 (2022).

Topic Areas: Language Production, Speech-Language Treatment

## Neural correlates of decoding and learning to control a covert speech brain-computer interface

***Poster B7*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Disruption in speech production can have a devastating effect on patients and their caregivers in terms of quality of life. Brain-Computer interfaces (BCI) have the potential to revolutionize communication in such patients by providing alternative communication channels (by real-time decoding of speech directly from the remaining intact brain areas) or rehabilitation solutions (by exploiting neural plasticity mechanisms using BCI-feedback). Although recent studies confirm the possibility of decoding covert speech (i.e. imagined speech) from pre-recorded intracranial neurophysiological signals, current efforts focus on collecting vast amounts of data to train classifiers, rather than exploring how the brain can adapt to improve BCI control. In addition, neural signals related to covert speech production are weak as compared to overt speech, and might be subjected to intra-individual differences in the ability to perform the imaginary task. In this study we addressed speech-BCI controllability from a neurophysiological point of view by training 15 healthy participants to operate a BCI based on electroencephalography (EEG) signals during a binary syllable imagery task for 5 consecutive days. We calibrated the decoder based on offline data (i.e. without feedback) using a Random Forest classifier and then applied it to classify the EEG signals in real-time alongside providing the participant with a visual feedback (online session). We investigated whether BCI-control can be improved with training and characterize the evolution of the underlying neural correlates, both in terms of changes in EEG power during syllable imagery and in the neural features used for real-time classification. We found a significant linear improvement in BCI control performance from day 1 to 5. This improvement was found in 11 out of 15 participants and was proportional to the average BCI-control performance. Next, we tested the classifier features' dynamics over the 5 training days. We found a significant decrease in discriminating between the two syllables in low-frequencies (2-10 Hz) over bilateral temporal and frontal regions, together with an increase in high-frequencies (52-66 Hz) over the left fronto-temporal regions. Furthermore, training was accompanied by widespread power increase in theta and low-gamma bands. The change in BCI performance was specifically related to an increase in frontal theta and left temporal gamma power. Overall, our results show that neural features can adapt to improve covert-speech BCI performance. More specifically, we observed focal high gamma oscillations to be involved in multiple aspects of BCI control, including overall discrimination between the syllables (bilateral temporal), feature evolution (fronto-temporal), and neural changes occurring during the 5 training days (left temporal). Low-frequency oscillations below 10 Hz were more distributed and contributed to feature evolution and learning to control the BCI system. These results show that learning to operate a covert-speech BCI involves dynamical changes in both low- and high-frequency neural correlates and provides solid neurophysiological grounds to improve current speech-BCI systems. Moreover, future BCI applications will require a combination of machine and human learning to reach optimal controllability. Improvements on the user side could effectively compensate for the limited success in accurately decoding imagined speech as compared to attempted speech.

Topic Areas: Language Production, Speech-Language Treatment

## Neural mechanisms of operating an intracranial brain-computer interface for imagined speech decoding

***Poster B8*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Silvia Marchesotti[1], Pierre Mégevand[2,3], Laurent Spinelli[2], Anne-Lise Giraud[1]; [1]Speech and Language Group, University of Geneva, [2]Service de Neurologie, Hôpitaux Universitaire de Genève, [3]Human Neuron Lab, University of Geneva

Brain-computer interfaces (BCIs) for speech decoding can provide a new means of communication for patients that have lost the ability to communicate with the surroundings. Recent years have seen great advances in the field of speech-BCI, with systems able to decode attempted speech with impressive effectiveness. However, decoding motor representations cannot be exploited in disorders of language, such as aphasia, in which the damage concerns regions involved in speech production which are located upstream with respect to the motor representations. A BCI suitable for these disorders would rather require decoding representation of speech units produced through imagined, rather than attempted, speech. So far, only a handful of studies have attempted the decoding of imagined speech in real time, thus the knowledge on the neural mechanisms of operating a speech-imagery BCI remains scarce. In this study we have developed a BCI based on intracranial EEG recordings to investigate the neural correlates of operating a syllable-imagery BCI. Four patients, implanted with stereotactic electrodes for pre-surgical epilepsy evaluation, controlled a visual feedback presented on a computer screen by imagining pronouncing one of two syllables, chosen with different articulatory and phonetic features. Results show a high-interindividual variability in the decoding features, but overall similar decoding accuracy across participants (around 60%). Features appeared to be stable across days, as assessed in one patient that agreed to take part in a three-days training. Real-time BCI-control was rather limited and variable across participants, likely due to differences in the site of the implant. These results shed light on the neural mechanisms involved in operating a covert speech-BCI and will be applied in the future to the improvement of the current BCI systems.

Topic Areas: Language Production, Speech-Language Treatment

## Distributed Neural Representations for Semantic Structures During Sentence Production

***Poster B9*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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When speaking and listening, we dynamically compose concepts to build event representations. The neural representations for compositional processing have so far been mostly studied during sentence comprehension. A recent study found that sentence compositional processes are realized via two pathways (Frankland & Greene, 2020). Abstract thematic relations ('man-as-agent') were encoded by the left mid superior temporal cortex (lmSTC), while specific event representations ('man-as-attacker') were encoded by the anterior medial prefrontal cortex (amPFC) and the hippocampus. In an fMRI study (n=38), we asked first whether we could find brain representations for compositional processing during sentence production. We then investigated whether the same regions were involved in encoding semantic structures at different levels of specificity. We used a rapid serial visual presentation sentence recall paradigm to elicit sentence production from the conceptual memory of an event. The stimuli consisted of sentences such as "the musician attacks the athlete", with nouns (athletes vs. musicians) and verbs (contact vs. perception events) distinguishable by semantic categories. With voxel-wise encoding models, we probed the specificity of the semantic structure built during the production of each sentence in three ROIs (lmSTC, amPFC and hippocampus) and in the whole-brain. We compared an unstructured model of word meaning without relational information ('bag-of-nouns') with a model that encodes abstract thematic relations ('musician-as-agent') and a model encoding event-specific relational structure ('musician-as-attacker'). Whole-brain results confirmed that we could find brain representations for compositional structures in sentence production. ROI analyses in the superior temporal cortex (STC) indicated that verb-specific event representations were encoded in the mid-anterior STC. The posterior STC instead encoded sentence meaning abstracting over events, as well as the ordinal and

syntactic structure of the sentence. The amPFC and the hippocampus were not found to encode semantic structures at any level of specificity, in contrast with Frankland & Greene's comprehension results (2020). Whole-brain analyses revealed that the encoding of sentence meaning at different levels of specificity was by no means limited to the STC and instead highlighted a large left fronto-parieto-temporal network. Our results therefore suggest more distributed representations for compositional processing than previously shown by Frankland & Greene (2020). Further analyses revealed that the different results could not be a consequence of modality differences (i.e., production vs. comprehension), since the same analysis over the comprehension of the sentence to be recalled in this experiment showed equally distributed brain representations. Therefore, this study suggests that the encoding of specific as well as abstract semantic structures during sentence production is realized in a distributed network of left-lateralized brain regions.

Topic Areas: Language Production, Syntax and Combinatorial Semantics

## Exploring the neurobiology of Merge at a basic level: insights from a novel artificial grammar paradigm

***Poster B10*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: Human language allows us to generate an infinite number of linguistic expressions. It's proposed that this competence is based on a binary syntactic operation, Merge, combining two elements to form a new constituent. An increasing number of recent studies have shifted from complex syntactic structures to two-word constructions to investigate the neural representation of this operation at the most basic level. Methods: This fMRI study aimed to develop a highly flexible artificial grammar paradigm for testing the neurobiology of human syntax at a basic level. During scanning, participants had to apply abstract syntactic rules to assess whether a given two-word artificial phrase could be further merged with a third word. To control for lower-level template-matching and working memory strategies, an additional non-mergeable word-list task was set up. Results: Behavioral data indicated that participants complied with the experiment. Whole brain and region of interest (ROI) analyses were performed under the contrast of "structure > word-list." Whole brain analysis confirmed significant involvement of the posterior inferior frontal gyrus [pIFG, corresponding to Brodmann area (BA) 44]. Furthermore, both the signal intensity in Broca's area and the behavioral performance showed significant correlations with natural language performance in the same participants. ROI analysis within the language atlas and anatomically defined Broca's area revealed that only the pIFG was reliably activated. Discussion: Taken together, these results support the notion that Broca's area, particularly BA 44, works as a combinatorial engine where words are merged together according to syntactic information. Furthermore, this study suggests that the present artificial grammar may serve as promising material for investigating the neurobiological basis of syntax, fostering future cross-species studies.

Topic Areas: Language Production, Syntax and Combinatorial Semantics

## Influence of transitivity on nTMS language mapping: Insights from healthy individuals and people with gliomas

***Poster B11*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction Navigated Transcranial Magnetic stimulation (nTMS) has been used to causally identify cortical regions involved in language processing within the clinical setting of preoperative language mapping as well as for research purposes with healthy individuals. nTMS has previously indicated that the production of nouns vs verbs engages different cortical regions. However, to this date the influence of linguistic characteristics of the same semantic category on nTMS mapping results has not yet been examined. For example, although the verb variable of argument structure has been investigated with functional Magnetic Resonance Imaging (fMRI), similar investigations are scarce within TMS research. According to fMRI data, bilateral cortical areas connected by the arcuate fasciculus (AF) have been implicated in the processing of transitive compared to unergative verbs. The present study examines the influence of transitivity on the outcomes of clinical and non-clinical language mapping with nTMS. Methods To test this connection between transitivity and bilateral perisylvian regions, we administered a tractography-guided online inhibitory nTMS protocol during picture naming of finite transitive verbs (The man reads) and unergative verbs (The man sails). After tracking the left and right AF, we stimulated the cortical terminations of the tract in frontal, parietal and temporal regions in 20 neurologically healthy native speakers of German. Additionally, we performed the same task and tractography-based nTMS protocol within the preoperative setting of 22 individuals with left hemisphere gliomas. Results Our data revealed that nTMS induced more errors during naming of finite transitive verbs compared to unergative verbs when stimulating the left (vs right) AF terminations in healthy individuals. This effect was specific to the left temporal terminations of the AF, whereas no differences between the two verb types were identified when stimulating inferior parietal and frontal AF terminations. Induced errors for transitive verbs over left temporal terminations mostly manifested as access errors (i.e., anomias, hesitations). Comparable results were obtained from the group of people with gliomas. However, an exploratory analysis suggested that the nTMS-induced effect over left temporal terminations of the AF was absent when gliomas displaced or infiltrated AF terminations. Conclusion The nTMS data from healthy individuals indicate that only posterior temporal regions result in more errors during naming of verbs with more arguments (i.e., transitive vs unergative verbs). The nTMS data from patients indicate that more language-positive sites are identified when patients produce transitive vs unergative verbs. From a neurolinguistic perspective, these results stress the role of left temporoparietal areas in language processing, with a particular emphasis on argument structure processing. From a clinical perspective, we highlight that different verb stimuli can influence the sensitivity of pre-operative nTMS language mappings.

Topic Areas: Language Production, Syntax and Combinatorial Semantics

## Rapid use of argument roles in verb prediction: Evidence from ERPs using a comprehension-production interleaved trials design

***Poster B12*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Previous findings in comprehension paradigms suggest that expectations about upcoming verbs are insensitive to argument roles (i.e., comparable N400 amplitudes to verbs in role-appropriate and role-reversed contexts)[1,2,3]. However, production studies using a speeded cloze paradigm suggest the opposite, with verb continuations showing clear sensitivity to argument roles[4]. To test whether this conflict is due to different tasks or to different measures, we conducted an interleaved comprehension-production study. Results place the blame on task differences. When we recorded ERPs in a setting where comprehenders were ready to speak, we found argument role sensitivity that has rarely been seen in prior ERP studies. A total of 24 English-speaking adults participated in the experiment. Materials were taken from a previous study that did not find the N400 effect to role-reversals [Role-appropriate: The restaurant owner forgot which customer the waitress had served...; Role-reversed: The restaurant owner forgot which waitress the customer had served...; Control: Abby brushed her teeth after every meal (plausible) / game (implausible)]. Sentences were truncated before the verb for production trials. Participants read sentences word-by-word and either judged the plausibility of sentences or produced cloze completions when a probe was given. Crucially, the comprehension and production trials were interleaved and randomized such that participants did not know in advance which task was required, until they either saw the probe eliciting a cloze response or reached the end of the sentence, motivating them to be prepared to generate a continuation at any time as a sentence unfolded. The N400 responses to target verbs in the comprehension trials and rate of role-reversed verb completions in the production trials were analyzed. The production results replicated earlier findings; role-reversed verbs were rarely produced as cloze completions (6%), and when produced, they had slower onset latencies than when produced in the role-appropriate contexts (+250 ms). These findings suggest that argument role information was actively used to constrain productions to role-appropriate verbs. Importantly, the comprehension trials revealed a significant N400 effect to role-reversals; in the 350-500 ms time window, cluster-based permutation tests revealed significant negative clusters between the role-appropriate and role-inappropriate conditions (cluster t-statistic = -544, $p = .001$; cluster t-statistic = -107, $p = .03$). There were no positive clusters found in the P600 time window. The control conditions elicited a significant N400 effect (cluster t-statistic = -2626, $p < .001$) as expected. The results together suggest that engaging in a speeded cloze production task which requires rapid generation of candidates for upcoming words and selection of a response can result in the rapid use of argument roles to constrain initial predictions to role-appropriate verbs. This may occur through increased activation of role-appropriate candidates or stronger inhibition of role-inappropriate candidates that were initially activated based on lexical associations. The findings highlight the effect of task-related goals and strategies on prediction during real-time sentence processing[5].
References: [1] Chow et al. (2016). LCN. [2] Kuperberg et al. (2003). CBR. [3] Kim & Osterhout (2005). JML. [4] Lee et al. (2022). 35th HSP. [5] Brothers et al. (2017). JML.

Topic Areas: Language Production, Syntax and Combinatorial Semantics

## The neural dynamics of sentence production: ECoG reveals sentence-specific networks and temporal patterns

***Poster B13*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Understanding the neural underpinnings of sentence production is a central goal in the neurobiology of language. While significant progress has been made on single word production, a similarly nuanced understanding of sentence production remains elusive. Here, we collect electrocorticographic (ECoG) recordings from nine awake neurosurgical patients during a controlled sentence production experiment, the first such study we are aware of. Our experiment involved 3 blocks: (1) picture naming, where patients repeatedly named six characters; (2) controlled sentence production, where patients described cartoon scenes involving two of the six characters (e.g., "Frankenstein poked the chicken"), and (3) list production ("chicken Frankenstein"), which, similar to sentence production involves sequencing, but unlike sentence production does not engage event semantics or syntax. Employing an unsupervised machine learning method, non-negative matrix factorization, we clustered electrodes into six functional networks. This revealed four networks that pattern with previously-characterized processes that are common to word, sentence, and list production: stimulus processing, motor planning, articulation, and auditory feedback. However, two additional networks, previously undescribed, were active for sentences but not lists or words. Subsequent analysis of these networks, primarily distributed across middle and inferior frontal gyri, revealed sensitivity to two sentence-specific processes: event semantics (i.e., whether the event involved a physical action) and syntax (whether the upcoming sentence was active/passive). Next, we assessed the commonplace characterization of sentence production as a sequence of single word production processes. If accurate, then by decoding what word a patient is saying throughout the course of sentence production, we should expect each word to come online in the order in which it was said. More precisely, because words consist of multiple representational stages (conceptual, phonological, etc.), we should expect the stages to come online in the same order, too. To test this, we trained multiple classifiers (specific to patients and representational stages) to predict word identity using data from the picture naming task (10-fold cross validation; accuracy ~30%, $p < .01$ relative to permutation distribution). We then used these classifiers to predict what word the patient was saying throughout the course of sentence production. The majority of classifiers (89%) successfully generalized from single word production to sentence production data, accurately predicting what words the patient said during sentences, with different stages of word representation largely following the same temporal order observed in single word production. Intriguingly, however, we also observed a systematic exception: Objects — the last word of the sentence — were often predicted far earlier relative to their articulation in sentences than in single word production. In fact, 14% of classifiers predicted objects even before the onset of the first word in the sentence. This result aligns with emerging behavioral evidence pointing toward early object planning. Our findings emphasize the importance of expanding beyond single word production studies to achieve a more comprehensive understanding of language production. Moreover, these findings hold potentially important implications for clinical practice, which still relies heavily on single word production paradigms.

Topic Areas: Language Production, Syntax and Combinatorial Semantics

## When the order is irrelevant and when it matters: order violations in

## conjuctions.

***Poster B14*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Conjunctive sentences reporting two past events, e.g., “She wrote a letter and read a book”, suggest that the events happened in the order of mentioning, even if there is no direct link between the events. In Gricean pragmatics, this phenomenon is often described as “temporal implicature”, and is explained in terms of the speaker’s cooperativity. Other authors have proposed that the phenomenon may result from a more general property of discourse or narration structure. It is still an open question to what extend the temporal representation of events as observed in the real life modulates the linguistic processing, in particular, whether the temporal modulates the predictive processing in language. I present results of a series of ERP experiments investigating the role of contextual relevance of the temporal order for the processing of reversed order sentences. The experimental paradigm resembles a memory game, in which participants assigned points to a virtual player and read sentences describing game events. In each trial, four cards were dealt and the player flipped two of them. Afterwards, the participants assigned points based on the game rules: If the player flipped two cards from the same category (animal or object), she got 1 point. If she flipped two cards from different categories, the points depended on which category was first. Subsequently, a sentence was presented word-by-word describing the game trial, e.g., “Julia has flipped a cat and a flower”. In the Correct-Order condition, sentences described the events in the order in which they happened; in the Reversed-Order condition, the events were described in the reversed order. Reversed-Order conditions, both for conditions where the order was relevant and irrelevant for the points, showed a P600 effect relative to Correct-Order conditions at the first noun at which the order violation could be detected. In addition, Reversed-Order conditions elicited a larger N400 than Correct-Order conditions. In a follow-up experiment, participants gave points only based on whether the cards come from the same category and, thus, the order was irrelevant in the whole experimental context. A similar P600 effect was observed for the order violation but no modulation of the N400. Thus, irrespective of whether the attention was directed towards the order as relevant in the given context, the violation of the order in the linguistic report engages reprocessing mechanisms, as indicated by the P600 effect, which can be linked to revising of the temporal representation. The N400 component was only modulated by the encoded order if the order was contextually relevant. In the third experiment, sentences with “and” along with sentences with explicit temporal connectives “before” and “after” were used. In this case, order violation at the first noun triggered an N400 effect, suggesting that the experimental context where order was relevant for the linguistic report, created an expectation for the first event to mentioned in the first sentence position. Effects on the second noun indicated a late positivity effect for reversed order sentences with “and” and a sustained negativity for the order violation in sentences with “before”.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

## Causal reasoning in language depends on domain-specific semantic networks and not the frontotemporal language system: Evidence from causal

## reasoning about illness

***Poster B15*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language offers a powerful communicative channel by which we convey information about the causal structure of the world (Pinker, 2003). Linguistic description is particularly useful when causes are not directly perceptible. A key example is illness causality, where linguistic communication transmits culturally accumulated knowledge about imperceptible causes – whether biological (e.g., pathogen transmission) or psychosocial (e.g., divine retribution) (Legare & Gelman, 2008; Legare et al., 2012). But what is the role of the frontotemporal language system in causal reasoning? Does the language system compute causality, or does it instead relay causal information to non-linguistic domain-specific semantic systems that ultimately enable causal reasoning? Because illness affects living things, we hypothesized that causal reasoning about illness would recruit the non-linguistic semantic 'animacy network,' particularly dorsal precuneus (Fairhall et al., 2013a, 2013b; Deen et al., 2022; see also Warrington & Shallice, 1984). The present functional magnetic resonance imaging (fMRI) study uses a sentence reading paradigm with tightly controlled stimuli to distinguish between these possibilities. Participants (n=10) undergoing fMRI read two-sentence vignettes that either elicited a causal inference about illness, elicited a causal inference about the mechanical failure of inanimate objects, or did not elicit a causal inference, as confirmed by separate group of online participants (n=26). Illness and mechanical vignettes were matched across linguistic variables known to modulate activity in language regions (e.g., Shain, Blank et al., 2020), including length, frequency, surprisal, and syntactic dependency length. Noncausal vignettes contained the same sentences as in illness and mechanical vignettes, but shuffled across trials, such that causal and noncausal vignettes were perfectly linguistically matched. We included catch trials describing 'magical' events and used a 'magic detection task' that encouraged participants to engage with the meaning of the stimuli. The same participants additionally performed a language localizer task (Monti et al., 2009, Fedorenko et al., 2010; Kanjlia et al., 2016) and an animacy/social localizer task (Saxe & Kanwisher, 2003), enabling us to perform individual-subject univariate ROI analysis and multivariate analysis (MVPA). Reasoning about the causes of illness activated the dorsal precuneus of the 'animacy network' relative to reasoning about the causes of mechanical failure. By contrast, mechanical reasoning activated areas previously implicated in spatial and physical reasoning (e.g., Weiner et al., 2017). Illness reasoning also activated the precuneus relative to noncausal vignettes, which contained sentences from the illness reasoning condition but did not elicit causal inferences. A linear support vector machine classifier trained on multivariate patterns of activity across the whole cortex (10 mm radius searchlight) likewise distinguished between both illness vs. mechanical reasoning and illness reasoning vs. noncausal vignettes in bilateral dorsal precuneus. We also observed preferential responses to causality (illness + mechanical reasoning > noncausal) in bilateral supramarginal/angular gyrus. Critically, we failed to observe responses to causality in the language network. Reasoning about the causes of illness 'borrows' the animacy network and does not recruit language regions. Using illness reasoning as a case study, we offer evidence that causal reasoning elicited by language depends on domain-specific neural systems rather than the language system itself.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

## That rings a bell! How semantic memory strength incrementally promotes a ‘feeling of knowing’ during spoken language processing

***Poster B16*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In daily communication, we rely on semantic memory to access existing factual knowledge about the world, and to distinguish true information from false, in order to build mental representations of knowing and to form beliefs when judging another person's verbal statement. Neurophysiological studies have examined the neurocognitive mechanisms that allow listeners to achieve a feeling of knowing (FOK) based on various linguistic and socio-perceptual cues during language processing (e.g., Jiang & Pell, 2016; Paynter et al., 2009); however, few have considered how internal cues, such as the strength of long-term memory for factual knowledge, affect incremental processes for establishing a mental state of knowing or believing. In this study, we presented pre-recorded, validated statements of world knowledge produced in a neutral tone of voice which varied in truth value (true, false) and memory accessibility (strong, weak). Utterances were rated by 33 healthy English speakers who evaluated how much “the speaker knows what they are talking about” on a 5-pt scale while their EEG was recorded. Statements were: a) true general world facts with strong shared memory strength among listeners and speakers (e.g., a LAMB is a young | SHEEP…); b) false statements widely known to be incongruent with world knowledge (strong memory strength, e.g., a COLT is a young | SHEEP…); c) true but lowly known statements (weak memory strength) with the same critical word (HOGGET is meat from a | SHEEP…); and d) false lowly known facts with weak memory strength (VENISON is meat from a | SHEEP…). Event-related potentials time-locked to the critical word onset (“SHEEP”) revealed significant graded differences in the N400 time window (300-600ms) at central-parietal electrodes across all four conditions of truth value and memory strength: the N400 amplitude was greatest for false statements with weak memory strength, followed by true statements with weak memory strength, false statements with strong memory strength, and was most reduced for well-known true statements with strong memory strength. The interactive effect of memory accessibility and truth value on the N400 was followed by a broadly distributed late positive component (LPC, peaking at 867ms) which generally increased for statements with strong vs. weak memory strength. Graded differences observed in the N400 suggest that this component indexes both memory and contextual cue-based expectations and ease of semantic access mechanisms, which may be actively used by comprehenders as efficient semantic processing strategies depending on task demands. The selective impact of semantic accessibility on the LPC response could reflect an early stage of “feeling of knowing” elaboration, promoting a subjective feeling of high level of certainty and detailed memory recollection success. Taken together, our findings provide new details on how overall memory strength plays a key role in semantic memory access, recollection and feeling of knowing attributions during spoken language processing.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

## Complex neural responses during narrative comprehension may reflect the operation of a universal meaning representation system

***Poster B17*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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One method to encode all possible narratives that could be generated in a language would be to anticipate them and pre-construct the corresponding representational system. A more tenable alternative strategy, that appears to be taken by the brain, is to rely on a form of neural combinatorics that can uniquely represent all possible narratives without specifically anticipating them. This can be implemented in recurrent cortical networks that generate functionally infinite high dimensional representations of sensory inputs and derived internal states. One signature of such architectures is the tuning of neurons to mixtures of multiple task related aspects, or mixed selectivity (Rigotti et al. 2013). Initially bewildering, these complex responses are now understood to be characteristic of recurrent networks and higher cognitive function (Rigotti et al. 2013, Enel et al. 2016). Narrative comprehension represents one of the highest human cognitive functions. We hypothesize the presence of mixed selectivity in the human brain during narrative processing. Baldassano (2018) characterized naturalistic human narrative processing and published an fMRI dataset where subjects experienced 16 naturalistic narrative stimuli with modality (audio, video), schema (restaurant, airport) and event (enter, formalities, transition, realization) dimensions. This multidimensionality is suitable for evaluating mixed selectivity. We used data from 40 runs collected from 10 subjects in this dataset, segmented into ROIs using the Schaefer 7 network 100 region atlas to evaluate mixed selectivity. For each of the resulting 160 narrative instances we extracted neural activity for each of the four temporally successive events, noting the corresponding modality and schema dimensions. We performed multifactor (Modality x Schema x Event) ANOVAs on individual voxels in the 100 ROIs and identified significant main effects, and interactions. We first examined areas that had a modality effect that significantly varied from auditory cortex (LH_SomMot_1 corresponding to BA41) which was assumed not to vary. As expected, this identified areas in the LH and RH visual networks. We then tested for areas that had 3-way mixed selectivity that varied significantly from that in auditory cortex. This revealed a significant effect in the limbic (Limbic_OFC_1, Limbic_TempPole_1 and 2), and default mode (Default_Temp_1, Default_PFC_4) networks. This first demonstration of mixed selectivity in human narrative processing contributes to a mechanistic explanation of how cortex can accommodate the functionally infinite possibility of narrative content and argues for the important role of medial prefrontal cortex in narrative as observed by Baldassano. We will discuss the relation between high dimensional processing and the temporal hierarchy of narrative processing, which can be further explored by combined human fMRI and computational studies with reservoir networks. *Rigotti, M., Barak, O., Warden, M. R., Wang, X. J., Daw, N. D., Miller, E. K., & Fusi, S. (2013). The importance of mixed selectivity in complex cognitive tasks. Nature, 497(7451), 585-590. *Enel, P., Procyk, E., Quilodran, R., & Dominey, P. F. (2016). Reservoir computing properties of neural dynamics in prefrontal cortex. PLoS computational biology, 12(6), e1004967. *Baldassano, C., Hasson, U., & Norman, K. A. (2018). Representation of real-world event schemas during narrative perception. Journal of Neuroscience, 38(45)

Topic Areas: Meaning: Discourse and Pragmatics, Multisensory or Sensorimotor Integration

## The influence of speaker gaze on addressees' response planning: evidence

## from behavioral and EEG data

***Poster B18*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Classical models of speech processing are based primarily on unimodal accounts of language, and neglect the rich multimodal environment in which face-to-face communication takes place (Holler & Levinson, 2019), where the speech signal is accompanied by a broad range of visual communicative signals. A growing body of literature suggests that these visual signals may facilitate efficient turn-taking behavior at various stages in speech processing, such as facilitating the recognition of social actions (Nota et al., 2022), allowing the prediction of upcoming words (ter Bekke et al., 2020), or increasing inter-brain synchrony between interlocuters (Drijvers & Holler, 2022). One prominent visual communicative signal is speaker gaze, however its role in response planning is not well understood. Corpus analyses reveal that questions with static direct gaze receive faster responses compared to questions where the speaker averts their gaze from the addressee, suggesting that speaker gaze may function as a response mobilization cue (Stivers & Rossano, 2010). This mobilizing function may take effect at various cognitive stages of turn-taking behavior. We shed light on this in two experiments (online behavioral, EEG) investigating the effect of speaker gaze on response time and EEG correlates of response planning and motor preparation. In both experiments, participants are presented with animated videos of an avatar. Participants are instructed to respond to 240 polar questions as fast and as accurately as possible via button-press (yes/no). The questions are presented in one of three gaze conditions: (1) static direct, where the avatar's gaze remains fixed toward the participant throughout the video, (2) dynamic direct, where the avatar's gaze starts at an ambiguous position 15 degrees averted, and shifts toward the participant at the beginning of the question, (3) dynamic averted, where the avatar's gaze starts at the same ambiguous position, but shifts further away from the participant at the beginning of the question. To examine the effect of speaker gaze on response planning, the questions were designed to have either an early or late answer point. Contrary to prior corpus analyses, the behavioral experiment (n=56) did not reveal a significant main effect of speaker gaze on response time. However, an interaction between speaker gaze and answer point approached significance, where questions with static direct gaze showed a smaller effect of answer point on response time. This pattern may indicate that speaker gaze influences turn-taking behavior early on in the response planning stage. In the ongoing EEG experiment (currently n = 2, target n = 30), we plan to analyze the planning potential (e.g., Bögels et al., 2015) as a marker of early response planning, as well as the readiness potential as a marker of motor preparation, to examine which stage of response preparation is more strongly influenced by speaker gaze. In light of the current behavioral findings, we expect an interaction effect of speaker gaze and answer point on the planning potential, where questions with early answer points show a larger planning potential in the static gaze condition compared to both dynamic gaze conditions.

Topic Areas: Meaning: Discourse and Pragmatics, Multisensory or Sensorimotor Integration

## Inter-brain synchrony during (un)successful face-to-face communication

*__Poster B19__ in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Human communication requires interlocutors to mutually understand each other. Previous research has suggested inter-brain synchrony as an important feature of social interaction, since it has been observed during joint attention, speech interactions and cooperative tasks. Nonetheless, it is still unknown whether inter-brain synchrony is actually related to successful face-to-face communication. Here, we use dual-EEG to study if inter-brain synchrony is modulated during episodes of successful and unsuccessful communication in clear and noisy communication settings. Dyads performed a tangram-based referential communication task with and without background noise, while both their EEG and audiovisual behavior was recorded. Other-initiated repairs were annotated in the audiovisual data and were used as indexes of unsuccessful and successful communication. More specifically, we compared inter-brain synchrony during episodes of miscommunication (repair initiations) and episodes of mutual understanding (repair solutions and acceptance phases) in the clear and the noise condition. We expect that when communication is successful, inter-brain synchrony will be stronger than when communication is unsuccessful, and we expect that these patterns will be most pronounced in the noise condition. Results are currently being analyzed and will be presented and discussed with respect to the inter-brain neural signatures underlying the process of mutual understanding in face-to-face conversation.

Topic Areas: Meaning: Discourse and Pragmatics,

## Non-arbitrary relationships between sensory meanings and phonological properties of English words

*__Poster B20__ in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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A fundamental question for the neurobiology of language is how the brain attains word meaning. Grounded or embodied accounts assume that concepts are derived from experiences originating from various modality-specific sensory and motor systems. To support this proposal, many neuroimaging studies have employed subjective ratings of words' sensory meanings as regressors and concluded that corresponding activity elicited in sensorimotor cortex during word recognition tasks reflects representation of experiential information. These studies have also assumed that the relationship between a word's meaning and its phonological form is entirely arbitrary. However, across spoken languages, there are some words whose acoustic features resemble the meanings of their referents by evoking sensory imagery, i.e., they are iconic (e.g., in English, "splash" imitates the sound of an object hitting water). While these symbolic form-meaning relationships are well-studied, relatively little work has explored whether the sensory properties of English words also involve systematic (i.e., statistical) form-meaning mappings that might influence their processing. We show that surface form properties are able to predict a significant proportion of variance in sensory experience ratings (SERs) of a large set of English monosyllabic and disyllabic words (N = 4414). Next, we show that iconicity and

form typicality, a statistical measure of how well a word's form aligns with its sensory experience rating, are only weakly related to each other, indicating they are likely to be distinct constructs. To determine whether form typicality influences processing of sensory words, we conducted regression analyses with performance on lexical decision, word recognition, naming and semantic (concrete/abstract) decision tasks from behavioural megastudy datasets. Across all datasets, form typicality was a stronger predictor of performance than SERs. Our results provide the first evidence that non-arbitrary statistical regularities in the mapping of phonological form to sensory meaning significantly influences word processing. These findings challenge the notion that sensorimotor activity elicited during word recognition reflects representation of experiential information.

Topic Areas: Meaning: Lexical Semantics, Phonology

## Dynamic functional connectivity underlying predictive sentence comprehension

***Poster B21** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The human brain is remarkably efficient in language comprehension, which is capable of quickly integrating perceived information and simultaneously predicting upcoming information based on available semantic context. Language prediction is considered to be actively generated in a top-down manner (Friston, 2005, 2010; Kuperberg & Jaeger, 2016), with cognitive control playing an important role in it (e.g., Bonhage et al., 2015; Shao et al., 2022). For example, left inferior frontal gyrus (LIFG), an important control site, exhibits stronger activation during the prediction of incoming semantic information (Shao et al., 2022). Contemporary work has also shown the implication of default mode network (DMN) in semantic integration (e.g., Lanzoni et al., 2020; Wang et al., 2021), with a key role of temporo-parietal junction (TPJ) in sentence comprehension (e.g., Alexandrou et al., 2017; Matchin et al., 2019). While it has been well-documented the neural basis underlying semantic prediction in language comprehension, it remains unclear how these control and integration-related sites connect with other brain areas to support the anticipation and integration phases of processing during online language comprehension. To explore that question, a generalized psychophysiological interaction (gPPI) analysis was performed on our previously published fMRI dataset (Shao et al., 2022). In that sentence comprehension study, the semantic constraint of sentence context was manipulated (Strong tool, Strong building, and Weak), and both the anticipation and integration phases of processing were recorded. Two ROIs (6-mm sphere) were selected: (i) semantic integration ROI of right TPJ (coordinate: 54 -54 28) based on a comprehensive analysis of functional connectivity of DMN (Andrews-Hanna et al., 2010); (ii) cognitive control ROI of LIFG (coordinate: -44 22 24) defined by using the search term “cognitive control” in Neurosynth (Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011). For right TPJ seed, an interaction between Processing phase (Anticipation vs. Integration) and Semantic constraint (Strong vs. Weak) was observed in parahippocampal gyrus (PPA), fusiform gyrus, posterior cingulate cortex (PCC), supramarginal gyrus, inferior parietal lobe and insula; these voxels largely fell within visual network (41.64%), ventral attention network

(VAN; 25.08%), and DMN (9.45%). When the semantic constraint was strong, the functional coupling of right TPJ to PPA/fusiform/PCC/insula was stronger during anticipation phase, and its coupling to all the identified sites was weaker during integration phase, compared with when the semantic constraint was weak. For LIFG seed, an interaction effect was also observed in fusiform gyrus and PCC, which mainly fell within visual network (95.49%). When the semantic constraint was weak, the functional connectivity of LIFG with these sites was stronger during integration phase, compared with when the semantic constraint was strong. No significant semantic constraint effect was found during anticipation phase. Taken together, these results suggest that right TPJ-to-visual/VAN/DMN functional connectivity support top-down prediction based on available semantic context, while the functional coupling of LIFG to visual system is important for the bottom-up integration when the upcoming linguistic input cannot be efficiently predicted. We conclude that top-down prediction and bottom-up integration relies upon dynamic functional coupling of memory, control, and visual systems.

Topic Areas: Meaning: Lexical Semantics, Reading

## Modulation of working memory capacity on predictive processing during language comprehension

***Poster B22*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Prediction is crucial for language comprehension and has been widely explored in this field. Ample evidence has shown facilitations of context-based prediction on language comprehension. However, many aspects of neurocognitive correlates underpinning predictive processing, especially anticipatory processing prior to the predicted information, remain elusive. For instance, the influential effect of working memory capacity on lexical prediction during online language comprehension needs to be investigated more precisely by taking a fine-grained contextual constraint into consideration. To investigate this issue with the electroencephalogram technique, participants with high or low working memory capacity were asked to read strong-, moderate- and weak-constraint sentences which resulted in high-, moderate- and low-predictability for the critical nouns. In the anticipatory processing stage, the strong-constraint (vs. weak-constraint) contexts preceding the predicted nouns elicited a larger positive deflection, which was only observed for the high-span group. Along with the smaller N400s for strong- vs. weak-predictable nouns for both groups, the moderately predictable nouns elicited smaller N400 than the weakly predictable nouns for the high-span group. The aforementioned ERP effects at both verbs and nouns significantly correlated with the noun’s predictability after contributions of other factors were regressed out. These findings suggest that predictive processing involves at least partially an effortful-meaning-computation mechanism, and high working memory capacity facilitates the activation and integration of predicted information during language comprehension.

Topic Areas: Meaning: Lexical Semantics, Reading

# A new eye on semantics: Coregistering eye-movements and EEG+MEG to study semantics in context

***Poster B23*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Semantic cognition is the representation of the acquired knowledge about the world and its controlled and task-oriented use. Two neural systems make flexible semantic cognition possible: a representation system that is the collection of information on features and concepts, and a control system, for the flexible retrieval of information based on task and context. In this study, we aim to better characterise the interaction between these systems during natural reading. We used co-registered eye-tracking and EEG+MEG from 27 participants to explore dynamic brain activity and behaviour in the same paradigm. Each sentence contained a target word that was manipulated for predictability (reflecting semantic control demands) and concreteness (semantic representation resources). This resulted in a 2x2 factorial design, with 80 stimuli per cell. Here, we present preliminary results and a detailed description of our pre-processing methods. We compared different approaches for eye movements artefact correction: we contrasted different high-pass filtering settings (0.1, 0.5, 1, 2 Hz), different methods for selecting ICA components (based on electrooculogram (EOG) correlation, variance ratio during fixations and saccades, or both), and ICA overweighting procedures (no overweighting, saccade onset overweighting, saccade overweighting). We found that a 0.5 Hz high-pass filter decreased the prominence of slow drifts caused by following fixations with minimal loss of neural signal. Removing ICA components that either correlated with EOG or had a variance ratio greater than 1 yielded the best results across participants. For the overweighting procedure, there was no absolute best setting, so we applied the method with the highest SNR across multiple aspects for each participant. The data was then used for source estimation at a whole-brain level and in regions of interest within the semantic brain network (left and right anterior temporal lobe, inferior frontal gyrus, posterior temporal cortex, angular gyrus, and primary visual areas). We applied a conventional evoked as well as a multivariate decoding analysis. Whole brain analysis using cluster-based permutation tests of evoked data did not reveal any effect of concreteness or predictability. We then fitted mixed effects models for each ROI across conditions. While we found some effects of concreteness and predictability in the hypothesised areas within the semantic network, the effects did not survive correction for multiple comparisons. Source space decoding results showed predictability effects in a subset of regions across the semantic network and in visual areas, while concreteness was decodable only in the right ATL. Overall, our results confirm that co-registration is a promising technique for the study of language in naturalistic paradigms, but also highlights the need for further technical and theoretical improvements of these methods. Deconvolution techniques and more advanced data-cleaning procedures might be necessary for reliably detecting effects previously observed in traditional serial visual presentation paradigms. We hope to encourage more researchers to use and develop methods to study the neural correlates of naturalistic language processing. In particular, the co-registration of eye movements and EEG/MEG has the unique benefit of allowing for the simultaneous exploration of dynamic brain activity and behaviour.

Topic Areas: Meaning: Lexical Semantics, Reading

## Valence effects on visual word recognition as a function of concreteness and emotion word type

***Poster B24*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The emotional valence associated with individual words (i.e., the extent to which the emotion evoked by a word is positive or negative) has emerged as an important variable in visual word recognition. Yet, the precise nature of these emotional effects remains unclear. This lack of clarity may be related to the fact that although valence tends to interact with other properties of the word, such as concreteness (e.g., Kanske & Kotz, 2007) and emotion word type (e.g., Zhang et al., 2017), these factors are usually studied separately. To get a more accurate picture, we conducted a lexical decision experiment, in which the target words were carefully selected to differ with respect to valence (positive, negative or neutral words), concreteness (concrete or abstract words) and type of emotional word (emotion-label or emotion-laden words), whilst being matched with respect to arousal, frequency, familiarity, and length. Under these controlled conditions, we found that positive words were easier to identify than negative or neutral words, and that this positivity advantage was more pronounced in abstract than in concrete words. Moreover, within the group of abstract words, emotion-label words were recognized faster than emotion-laden words, and this word type effect was more pronounced in negative than in positive words. These results can be interpreted in the framework of embodied theories, which emphasize the important role of emotional experience in comprehending abstract concepts (e.g., Vigllioco et al., 2014, Borghi et al., 2017).

Topic Areas: Meaning: Lexical Semantics, Reading

## Unraveling the Impact of Neurobehavioral Symptoms on Predictive Language Comprehension: An Event-Related Potential Study

***Poster B25*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: Neurobehavioral symptoms (NBS) may develop as the result of mild traumatic brain injury (mTBI) but are also common in individuals without a history of head injury. These symptoms include processing speed issues and have been associated with lowered cognitive-linguistic performance, and may explain why those with mTBI history may have difficulty following conversations. Regardless of symptom origin, a possible neurocognitive mechanism that may be impacted by high NBS is prediction or the ability to use contextual information to anticipate upcoming words. Prediction ensures language comprehension is quick, timely, and efficient when engaging in a conversation. However, high NBS may disrupt this mechanism, resulting in slower, less efficient conversations due to a decreased ability to use context to predict upcoming words in a conversation. Methods: The relationship between NBS and language comprehension will be examined by using the well-studied N400, an event-related potential component, that indexes the use of contextual information. The N400 will be measured to nouns in adjective-noun pairs of varying predictability (high, low, and incongruent). A normative sample of young adults, who self-report a NBS on a continuum will

actively or passively predict the nouns. The neurobehavioral symptom inventory (NSI) will be used to measure self-reported NBS. Anticipated Results: Typically, unpredictable context generates more negative N400 amplitudes compared to those measured in response to predictable context because there is not sufficient information to facilitate access to semantic memory. If NBS impairs the use of context, then individuals with high NBS should show more negative N400 amplitudes for highly predictable noun pairings as if they were unpredicted, thus yielding a reduced N400 effect, while amplitudes for incongruent and low predictable pairing will remain constant. This reduced facilitation for the more predictable words can be interpreted as highlighting a deficiency in the ability to use meaningful context to facilitate language comprehension. This effect should be emphasized in the active prediction task, but may also be present in the passive reading task if symptoms have a significant impact on prediction. Implications: This study is motivated by the lack of objective measures for language comprehension problems in individuals experiencing persistent NBS, such as after mTBI. The results from this study will shed light on how NBS impact access to semantic memory in those with high NBS and will elucidate the impact of NBS on prediction in language comprehension.

Topic Areas: Meaning: Lexical Semantics, Reading

## Effects of unilateral anteromedial temporal lobe resections on event-related potentials when reading negative and neutral words

***Poster B26** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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We investigated effects of unilateral left (lTLR, N=15) or right (rTLR, N=19) anteromedial temporal lobe resections comprising amygdala and temporal pole on event-related potentials (ERPs) during attentive reading of negative and neutral words, their emotional evaluation, and recognition memory. Emotion-driven ERP enhancements are frequently observed in word processing. They have been found at various processing stages and are most consistently reported in the early posterios negativity (EPN, 200 - 300 ms) and the late positive potential (LPP) time windows. Higher amplitudes during processing of emotional compared to neutral words have bee thought to depend at least partly on the amygdalae. Some previous lesion or resection studies using other stimulus types have suggested component-specific effects of amygdala or medial temporal lobe damage. For faces, the literature reports reduced emotion effects on the P1 and LPP, but intact responses on the N1 and EPN in patients with left or right amygdala sclerosis (Rotshtein et al., 2010). For pictures, smaller P1, N1 and EPN emotion modulations, but intact LPP effects have been found in rTLR patients (Mielke et al. 2022). Here, we tested to what extent emotional word processing is impaired by medial temporal lobe resections. Content effects on behavior did not differ between lTLR, rTLR, and controls (N=18). All groups showed better recognition memory for negative words and intact appraisals of word valence and arousal. Negative words elicited larger ERPs than neutral words for P1, Early Posterior Negativity (EPN), and Late Positive Potential (LPP). However, the rTLR group lacked the P1 enhancement and had attenuated EPN effects. Despite showing generally the largest ERP amplitudes, the lTLR group had smaller occipital N1 and left frontal positivity for negative compared with neutral words in the N1 window. Only lTLR also had smaller left

parietal P2 and larger right parietal P3 and LPP for negative words, indicating a contra-resectional shift in activation. These data help specify left and right anteromedial temporal lobe contributions to the processing of negative and neutral words. They indicate that right hemisphere resections impair rapid pre-lexical selective processing of negative words in a similar way as previously shown for faces and pictures. LTLR affects primarily the N1 which might indicate altered lexical access. Interestingly, negative words elicited EPN and LPP effects in both patient groups which, together with the behavioral data indicates a considerable amount of residual processing of emotion from language following medial temporal lobe resections. This indicates that extraction of emotional significance from words is supported by bilaterally distributed brain regions and relies only partly on the medial temporal lobes of either hemisphere.

Topic Areas: Meaning: Lexical Semantics, Reading

## MEG Encoding using Neural Language & Speech Models and Shared Context Semantics in Listening Stories

***Poster B27*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Self-supervised Transformer-based language and speech processing models have revolutionized the field of both language and speech processing. Inspired by these models, recent neuroscience studies have shown that brain responses of people comprehending language can be predicted well by text-based language models, as well as speech-based models. However, existing studies on brain encoding for natural stimuli focus on functional magnetic resonance imaging (fMRI) recordings which provide high spatial resolution but poor temporal resolution. In this paper, we investigate the shared information between these Transformer-based language and speech models for brain encoding using Magneto-encephalography (MEG) recordings which provide high temporal resolution. We present a systematic study of the alignment between both neural language & speech models and brains across two language modalities (reading vs. listening) in order to estimate the temporal aspect of language and speech processing in the brain. We represent text stimulus using pretrained Transformer-based text models like BERT & GPT-2 and speech stimulus using speech deep learning models like HuBERT, Data2Vec, and Wav2Vec2.0. Our experiments on MEG-MASC naturalistic story-listening dataset (Gwilliams et al. 2022) reveal that Transformer-based text representations lead to a significant prediction in brain alignment across auditory and language regions until 550ms (with several peaks) while speech models like HuBERT and Data2Vec better capture the MEG brain activity to auditory stimulus peaks at around 200ms. Interestingly, predictions from these models agree with previous literature from controlled settings (i.e. pitch task, lateralization task, piano tones), showing similar behavior for naturalistic settings enabling us to conclude that deep learning language and speech models seem to provide relevant features likely to be used during human language and speech processing. Further, the layer-wise analysis reports that text models' brain predictivity seems to increase for the early layer with short context and late layers with long context (i.e. the peaks get larger and higher MEG predictivity), while speech model Data2Vec better encodes the MEG even in frontal language regions and observed peaks after 350ms only in the later layers. Further, we are investigating the shared information between different aspects (semantic vs.

non-semantic) of speech and language processing models across time, what properties vary between these models, and how different neural models can capture the neural activity in brain regions.

Topic Areas: Meaning: Lexical Semantics, Speech Perception

## MEG/EEG responses to spoken ambiguous words reveal neural representations of selected meanings but not prediction error during sentence comprehension

***Poster B28*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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This preregistered MEG/EEG investigates the neural responses to ambiguous words during spoken sentence comprehension. Participants (N=34) listened to semantically constraining sentences such as “While sailing down the river, she noticed the trees along the…”. Sentence-final words were predictable ambiguous homophones in British English (AMB; e.g., “bank”); selected-meaning synonyms (SMS; e.g., “shore”); or alternative words corresponding to a contextually-inconsistent interpretation of the homophone (ALT; e.g., “cashpoint”). To understand ambiguity, listeners must select the correct meaning and suppress the incorrect alternative. This design contrasts two neural computations for combining contexts and words: “sharpening”, in which representations of predictable meanings are enhanced; and “prediction error”, in which the brain represents the difference between the predictable meaning and heard words. While both computations can underlie Bayesian inference, reductions in ERP magnitude for predicted meanings cannot distinguish between the accounts as both explain changes in overall neural activity (Aitchison & Lengyel, 2017). We therefore conducted multivariate representational similarity analyses (RSA; Guggenmos et al., 2018) on pairs of trials since these accounts make contrasting predictions for the similarity of neural responses: whereas sharpening predicts similarity for AMB and SMS trials (bank-vs-shore), prediction error predicts similarity for AMB and ALT trials (bank-vs-cashpoint). Multivariate dissimilarity is measured via correlation distance (0 indicates low dissimilarity), as this metric is less susceptible to differences in response magnitude between conditions. For each subject, we calculated a timeseries of distances for each contrast. Non-parametric cluster-based permutation tests (Maris & Oostenveld, 2007) were used for group-level statistical comparisons of the dissimilarity timeseries. For evoked responses (spatial patterns per time sample), we found evidence for sharpening (i.e., low dissimilarity for AMB-SMS words compared to a baseline contrast of predictable but semantically unrelated word). Significant differences in dissimilarity were observed at both MEG magnetometers and EEG sensors between approximately 200-400ms following the onset of the sentence-final word. However, no significant differences were observed for the AMB-ALT timeseries compared to its analogous baseline. Since correlation distance limits the influence of magnitude on our comparisons, we are confident that shared semantic information is a key contributor to the low dissimilarity for the AMB-SMS timeseries. We also observed a significant difference between our baseline conditions such that the dissimilarity is lower for predictable words, in the absence of shared semantics. This result highlights a need for further investigation into the contributions of predictability and shared semantics on observed dissimilarities. We will discuss these results in comparison with other conflicting findings in the literature concerning the representation of sharpening and prediction error computations for phonological and

semantic information in speech, as well as explore the insights of multivariate and univariate approaches in the interpretation of N400 effects seen for anomalous words. We will also present the results of ongoing RSA of time-frequency features (power and phase), since previous research shows that neural responses in different frequency bands (theta, beta) is associated with predictability and violation detection (Heilbron, 2022). Overall, these results support a multivariate approach to studying ambiguity resolution and the neural representation of semantic computation during sentence comprehension.

Topic Areas: Meaning: Lexical Semantics, Speech Perception

## Revealing task-specific and domain-general neural networks that track coherence and integrate contextual information: evidence from semantic and non-semantic tasks in different perceptual modalities.

***Poster B29*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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We have recently identified the neural networks that support context integration during narrative processing (Branzi et al., 2020; 2021). However, one important question left unaddressed refers to the nature of these context integration processes. Does the neural activity observed during narrative processing reflect semantic-specific or domain-general processes? What brain regions track “meaning”? We addressed these questions across different fMRI experiments, using a variety of naturalistic stimuli (e.g., sentences, numbers, music), delivered in both visual and audio modalities. Using both uni- and multi-variate analyses (ICA) combined with computational linguistic methods, we revealed the neural networks that track coherence and integrate contextual information in semantic and non-semantic tasks. Across all experimental studies, we found that contextual integration relied on a domain-general network. In detail, a fronto-parietal network, overlapping with the multi-demand system (Duncan, 2010), supported contextual integration in both semantic and non-semantic tasks. However, this network was insensitive to whether the integrated content was coherent with the previous contextual support (i.e., coherence tracking). Instead, task-specific networks (e.g., ‘language network’) were sensitive to contextual coherence. Interestingly, in semantic tasks (narratives), activity in the right ATL and posterior cingulate cortex/precuneus tracked semantic coherence in both audio and visual modalities. Our results also provide insights into the role of the left angular gyrus and the ventromedial prefrontal cortex, whose functional role in semantic cognition is still highly debated (Pylkkänen, 2019; Humphreys et al., 2021). In our results, these regions were similarly involved during the integration of contextual information in semantic and non-semantic tasks. We propose that their neural activity reflects domain-general processes to buffer and maintain contextual content, respectively.

Topic Areas: Meaning: Lexical Semantics, Syntax and Combinatorial Semantics

## Fake Diamonds: an EMEG study bridging from semantic composition to semantic cognition

***Poster B30*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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During comprehension, concepts are accessed and combined to build complex conceptual structures to support verbal and non-verbal behaviours. The anterior temporal lobes (ATLs) emerge as critical regions in semantic composition (Pylkkänen, 2019, 2020) and semantic cognition more broadly (Rogers et al., 2004; Patterson et al., 2007; Lambon Ralph et al., 2017). The current study aims to import insights across literatures, using conceptual variables like concreteness and specificity to study models of semantic composition and linguistic semantics to study models of semantic cognition. Within the hub-and-spokes (H&S) framework, conceptual content is represented partially by sensorimotor areas, while generalizable coherent concepts emerge when these sources of information are integrated across sources and time by the left and right ATLs (Rogers et al., 2004; Patterson et al., 2007; Lambon Ralph et al., 2017). This framework explains neuropsychological and imaging data. Concrete relative to abstract concepts, and less relative to more specific concepts, are more robust against ATL deterioration (Rogers & Patterson, 2007; Woollams et al., 2008; Jefferies et al., 2009; Hoffman & Lambon Ralph, 2011) and elicit stronger ATL responses (Gauthier et al., 1997; Grabowski et al., 2001; Bright et al., 2004; Tyler et al., 2004; Dhond et al., 2007; Hoffman et al., 2015; Farahibozorg et al., 2022). The neural bases of semantic composition has been studied using two-word phrases. When two concrete words form a phrase, left ATL activity increased at around 200-250 ms post second-word onset (Pylkkänen, 2019, 2020). Crucially, when modulated by conceptual specificity, composition effects were only elicited in phrases with a low-specificity (e.g., blue boat) relative to high-specificity noun (e.g., blue canoe) (Westerlund & Pylkkänen, 2014; Zhang & Pylkkänen, 2015). Recent work on composition varying denotational semantics (e.g., current president is a president, but fake president is not) by Fritz and Baggio (2020) showed EEG sensitivity: increased negativity around 500-800ms post second-word onset. We address three research questions here. First, we ask if the composition engine is engaged for phrases denoting concrete and abstract concepts (e.g., bad costume vs. bad success). If so, we predict ATL compositions effects for both. Second, we probe how neural representations of phrases are transformed across time as a function of denotational semantics (e.g., blue diamond vs. fake diamond) using spatiotemporal decoding (King & Dehaene, 2014). Third, we directly modulate specificity (e.g., bird vs. nocturnal bird vs. owl) and ask if the neural processing of compositional semantics mirrors that of activating more specific concepts. One prediction stemming from the H&S framework is ATL activity increases as a function of increasing specificity. We plan to record electro- and magnetoencephalographic (EEG and MEG) activity as participants read phrases that differ in concreteness (Q1), in denotational semantics (Q2), and conceptual specificity (Q3). Within a contrast, we matched stimuli on a range of psycholinguistic features. To encourage semantic processing, we opted for comprehension questions as a parallel task suitable for all our conditions and facilitate comparisons. We are planning to pre-register this study, recruiting 36 participants, with 100-140 trials per condition to power our study.

Topic Areas: Meaning: Lexical Semantics, Syntax and Combinatorial Semantics

## Neural and Experiential Semantic Correlates of the Unergative-Unaccusative Verb Distinction

***Poster B31*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Songhee Kim[1], Jeffrey Binder[1], Jiaqing Tong[1], Stephen Mazurchuk[1], Joseph Heffernan[1], Lisa Conant[1]; [1]Medical College of Wisconsin

Introduction. Two types of intransitive verbs, unergative and unaccusative, are distinguished by their argument content and syntactic behavior. Unergatives (e.g., WALK) have an agentive subject argument that actively initiates the verb action (SHE WALKED). Unaccusatives (e.g., FALL) have a non-agentive grammatical subject that is underlyingly a direct object of the action (THE TREE FELL). Unaccusatives are thought to entail additional processing related to derivation of the grammatical subject from the underlying object. Prior fMRI studies have generally shown stronger activation for unaccusative verbs, though the regions implicated varied substantially (Shetreet et al., J Cogn Neurosci, 2010; Agnew et al., Lang Cognition Neurosci, 2014; Meltzer-Asscher et al., Brain Lang, 2015). This inconsistency could be due to the small number of verbs in each study, potentially increasing the influence of random stimulus variables. While observed differences are usually attributed to the additional syntactic movement required for unaccusatives, a substantial literature attests to differences in semantic content between unergatives and unaccusatives. In this study we measured activation differences between these verb types using a larger set of verbs than in prior studies. We hypothesized that some of these differences could be due to systematic differences in semantic content between the two verb classes, and tested this hypothesis by characterizing these semantic differences in terms of a set of neurobiologically-defined experiential features. Method. 86 English intransitive verbs (44 unergative, 42 unaccusative) were rated for 69 experiential features using crowdsourcing. The feature set (Binder et al., Cogn Neuropsychol, 2016) encompasses sensory, motor, temporal, spatial, affective, social, attentional, and event structure phenomena. Participants rated the degree to which they think each type of experience is relevant to the meaning of a given verb. The fMRI study was conducted with 18 healthy participants, who read the verbs 4 to 6 times in a fast event-related design, indicating how familiar they are with the event described by the verb. Activation differences between unergative and unaccusative verbs were contrasted at the group level with cluster-based FWE correction (alpha < .05) determined by permutation testing. Results. Increased activation for unergative relative to unaccusative verbs was found in left angular gyrus, posterior cingulate/precuneus, and medial prefrontal cortex. Left IFG showed greater activation for unaccusative verbs. The two categories differed significantly in their ratings on many experiential features. Unergatives were rated higher on 21 features related to i) human face or head movements, ii) body and limb movements, iii) intentionality and agency, iv) sound generation and perception, and v) communicative and mental phenomena. With these features included as covariates in the unergative-unaccusative contrast, no residual activation differences were observed, suggesting that they account for much of the observed differences in activation. Summary. The different direction and localization of the intransitive verb class effect in our results might be due to our larger stimulus set and use of a task focused on concept retrieval rather than syntactic processing. Our results suggest that the unergative vs. unaccusative distinction in the brain might be explained by their covarying experiential content.

Topic Areas: Meaning: Lexical Semantics, Syntax and Combinatorial Semantics

## Neural encoding of distinct linguistic hierarchies across different languages

***Poster B32*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction. Language comprehension involves understanding a hierarchy of linguistic units, including phonemes, words, phrases, sentences, and paragraphs. The encoding mechanism of these units during speech comprehension has been a subject of ongoing debate. Hasson et al. (2015) proposed a hierarchy along the temporal-parietal axis, with increasing temporal receptive windows supporting the processing of phonemes and syllables to higher-level units such as words and phrases. However, limited research has been conducted in cross-language contexts. In the present study, we investigated the neural encoding of three languages (Chinese, English, French) across three linguistic hierarchies (word, sentence, paragraph) by scanning participants with functional magnetic resonance imaging (fMRI) while they listened to a naturalistic story. Methods. We used the openly-available Le Petit Prince fMRI Corpus (LPPC; Li et al., 2022), where 49 English, 35 Chinese, and 28 French native speakers listened to the audiobook The Little Prince in their respective native languages. We first applied voxel-wise inter-subject correlation (ISC; Hasson et al., 2004) to select the voxels that exhibited the highest correlations among subjects within each language group. We then utilized the Multilingual GPT model (mGPT; Shliazhko et al., 2022) to construct the word-, sentence-, and paragraph-level embeddings of the story in three languages. To estimate how these semantic features at different levels were represented in the brain across the three languages, we trained a regularized ridge regression model using the leave-one-out strategy (Huth et al., 2016). The model's performance was assessed by computing the correlation between the predicted responses and the actual blood-oxygen-level-dependent (BOLD) signals. At the group level, we performed non-parametric bootstrap tests on the prediction results of the three groups with 1,000 bootstraps to identify the cerebral voxels significantly responding to different linguistic units ($p<0.05$). Finally, we employed Multidimensional Scaling (MDS), a dimensionality reduction technique, to visualize the temporal dynamics of the semantic features at different levels. The fMRI signals derived from the significant voxels identified by the regression model were reduced to a 2-dimensional space using MDS. These reduced signals were then plotted against time to illustrate the temporal dynamics of plot-tracking in the three languages. Results and conclusion. We identified three distinct clusters within the left temporal lobe, spanning from more anterior to more posterior regions. These clusters corresponded to the semantic features at the word, sentence, and paragraph levels, respectively. This distribution pattern was found to be consistent across all three languages. The temporal dynamics of these semantic features revealed a higher degree of similarity in tracking sentence- and paragraph-level information across the three languages. This suggests a commonality in how these higher-level linguistic units are processed and represented in the brain, irrespective of the specific language being processed.

Topic Areas: Multilingualism, Computational Approaches

## Effects of both ageing and bilingualism on attention and executive functions

***Poster B33*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Roksana Markiewicz[1], Foyzul Rahman[1], Eunice Fernandes[2], Rupali Limachya[1], Allison Wetterlin[2], Linda Wheeldon[2], Katrien Segaert[1]; [1]University of Birmingham, [2]University of Agder

Ageing and bilingualism have been documented to confer a complex picture of positive and adverse effects on cognition (Donnelly et al., 2019; Veríssimo et al., 2022). Here, we focused on attention and executive functions, which are critical processes allowing us to selectively attend to some aspects of information while ignoring others. Moreover, these functions interact with other cognitive domains, such as language. We investigated the combined impact of ageing and bilingualism on attention (alerting and orienting), executive inhibitory control and task related switch costs. We tested young and older mono- and bilinguals (N=40 in each of these four groups) on the Attention Network Task (ANT). We further examined the impact of bilingual individual differences (N=177 bilinguals) using objective measures including language proficiency (L2 vocabulary) and language switching and mixing (L1 and L2 switch/ mixing costs) on the ANT outcomes. Group comparisons revealed that age decreased alerting ($p<.001$) and increased executive (inhibitory) control performance ($p<.001$), for mono-and bilinguals alike (interactions: $p>.1$). For orienting, bilingual young adults performed better than monolingual young adults ($p<.06$), but, bilingual older adults performed worse than monolingual older adults ($p<.02$). There were limited effects of individual difference measures. Firstly, L2 proficiency improved orienting performance ($p = .04$) for young and older bilinguals alike, that is, the better the L2 proficiency, the more efficient use of the spatial cues to guide attention. Secondly, L2 proficiency was also negatively related with the task-related switch cost ($p=.03$) in the more difficult condition (i.e., L2 proficiency facilitated task-switching behaviour, but only when switching into incongruent trials). Language switching/ mixing performance was not predictive of any cognitive outcomes. Healthy ageing leads to declines as well as improvements in attention and executive functions, but this is network-specific: attention, orienting and executive control should be seen as separate components. We showed adverse effects of ageing on alerting and protective effects of ageing on executive control, which are in line with previous studies (e.g., Verissimo et al., 2020). The impact of bilingualism for attention/executive functions is less clear. However, our study highlights the importance of combining group comparisons with an individual differences approach. Through looking at individual variability within bilinguals and relating it to specific outcomes with the attention and executive function network, we can learn what the characteristics are of those bilinguals who are going to differ from monolinguals the most.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

## Language usage as a modulator of bilingual selective attention

***Poster B34*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Bilingualism leads to significant adaptation of the neural mechanisms of selective attention (Olguin, Cekic, et al., 2019; Phelps, Attaheri & Bozic, 2022). Nevertheless, it remains unclear what are the key factors that influence this adaptation. The degree of usage of multiple languages has been shown to modulate cognitive control processes and language-related brain activity (Tu, Wang, et al., 2015; Verreyt, Woumans, et al., 2016), and we therefore predict that L2 usage will have a significant impact on the adaptation of the neural mechanisms of selective attention in bilinguals. The other key question concerns the dynamics of this adaptation. Biological systems adapt flexibly to their environments (Green, Crinion & Price, 2006; Navarro-Torres, Beatty-Martínez, et al., 2021), hence the degree of bilingual adaptation of selective attention is expected to depend on bilinguals’ language experience. More specifically, this suggests that bilingual adaptation changes over time, and might not be observed in bilinguals who stopped using their L2 actively. In the current study we investigate the neural adaptation of selective attention in proficient bilinguals who differ in the usage of their L2. Forty-six early English-French bilinguals took part in an EEG experiment. They were all highly proficient, but differed in their L2 usage to create 3 groups: High-usage, Low-usage, and No-usage. The participants performed a dichotic-listening task, where they were presented with two simultaneous speech streams and instructed to attend to one and ignore the other. The attended speech stream consisted of simple narratives either in participants' L1 (English) or L2 (French), and the nature of the unattended stream was manipulated to create different types of linguistic or acoustic interference. Preliminary analyses of the neural encoding of the attended and the unattended streams in the three groups are currently being conducted, and will be presented at the conference. We predict that the High-usage bilinguals will show strong adaptation of their selective attention mechanisms, and be least affected by the nature of the unattended stream (following Olguin, Cekic, et al., 2019). Moreover, we predict this effect to be more robust than the adaptation in the Low-usage group of bilinguals, highlighting the importance of language usage. Finally, we expect that the No-usage bilinguals might be most affected by the nature of the unattended stimuli, thus displaying the response pattern most similar to that of monolinguals (Olguin, Bekinschtein & Bozic, 2018). This would suggest that bilingual adaptations are not static once acquired, and highlight the dynamic aspect of neuroplastic changes in the bilingual brain.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

## Exploring Resting State Networks on a continua of Bilingualism and Age

***Poster B35*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The phenomenon of bilingualism provides a neural protective mechanism towards age-related cognitive decline called cognitive reserve (Gallo & Abutalebi., 2023). A putative functional neural substrate underlying bilingualism-related reserve is stronger internal functional connectivity in the Default mode network (DMN; Grady et al., 2015), language network (Berker et al., 2016), and frontoparietal network that can result in better cognitive performance (Grady et al., 2015). We anticipated that with increasing levels of bilingualism, bilinguals will demonstrate more intact brain functional networks, which may be a sign of cognitive reserve. Resting-state fMRI-assessed ROI to ROI connectivity is associated with protective factors (bilingualism) and better maintenance of attention across the lifespan. We assessed the resting-state fMRI of 79 healthy controls (HC). ROI-to-ROI connectivity of resting-state networks (specifically frontoparietal, language, and default mode) was computed, and the reserve was quantified as different measures of bilingualism (Dash et al., 2022) and measures of cognitive reserve (Nucci et al., 2012; Education, work, leisure). The contribution of gender was factored out. Partial least square regression (PLSR) was conducted to yield sets of four orthogonal latent variables (LVs) assessing the association between: a) functional connectivity within the resting state networks; specifically, DMN, frontoparietal and language networks, b) measures of cognitive reserve – age, measures of bilingualism, education, leisure work. Different measures of cognitive reserve (age, bilingualism, work, leisure, education) showed an interactive factor loading that predicted resting-state functional connectivity (rsFC) differently. L2 exposure and proficiency variables, along with a negative loading of CRIq, formed LV1, which predicted positive rsFC within the salience and language networks. Additionally, as LV1 scores increased, there was a decrease in inter-network connectivity for the DMN and language networks. Greater task-based proficiency (LV2) predicted stronger connectivity in the salience and dorsal attentional networks. Interestingly, CRIq also showed positive loading in LV2, along with L2 language task proficiency. Finally, chronological age, along with negative loading of L2 age of acquisition and L2 exposure, formed LV3 and predicted a negative relationship with intrinsic connectivity for the language and salience networks. In other words, as age increases, intra- and inter-network functional connectivity decreases. These novel results extend our previous findings on task-based measures of bilingualism having better potential to predict functional connectivity (Dash et al 2022). Also, PLSR allowed us to look at the individual contribution of measures of bilingualism along with other cognitive reserve variables in unison as these variables are highly collinear.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

## Don’t try and pass them by: Trilinguals’ cognitive control abilities pattern differently from bilinguals’

***Poster B36*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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While many studies integrate multilinguals under the banner of bilingualism without fanfare, others explicitly exclude them from their samples. Does multilingualism warrant separate assessment, or is it justified for bilingualism to include multilinguals by default? Research overtly acknowledging multilingualism has habitually focused on processing, acquisition, and cross-linguistic influence (e.g., de Bruin et al., 2023), but studies comparing bilingual and tri/multilingual participants’ executive functions have observed differences (e.g., Guðmundsdóttir & Lesk, 2019; Hsu, 2014; Madrazo & Bernardo, 2018). Our own pilot study of French–English bilinguals vs. trilingual speakers of French–English and one other language found a monitoring advantage—a readiness to respond to all types of trials, revealed through faster reaction times—for trilinguals compared to bilinguals, as well as group-level language-specific asymmetries pointing to different management strategies (Senécal, Gosselin & Sabourin, 2022). The current follow-up study compared the cognitive control abilities of 21 Spanish–English bilingual and 30 Spanish–English–French trilingual adults. Participants completed an online study including flanker and Stroop tasks, the latter with single-language Spanish and English blocks as well as a mixed Spanish-English block, to assess whether a more challenging task may reveal further differences (Sabourin & Vīnerte, 2015). Participants’ cognitive control abilities were represented as global (i.e., overall reaction times), facilitation (i.e., difference in averaged reaction times for congruent and neutral trials), and inhibition (i.e., difference in averaged reaction times for incongruent and neutral trials) effects. Linear regression models and mixed models were used to evaluate the relation between participant characteristics (demographics and linguistic behaviour, including social diversity of language use (i.e., language entropy (Gullifer & Titone, 2020)) and cognitive control. Bilinguals and trilinguals’ results differed in both the domain-specific (linguistic Stroop) and domain-general (non-linguistic Flanker) tasks. Contrary to

the pilot study, trilinguals did not appear to possess monitoring advantages relative to bilinguals, having overall slower average reaction times (β = 257.09, t = 3.78, $p < .01$ for flanker; β = 1022.99, t = 4.48, $p < .01$ for Stroop). Bilinguals also generally showed greater facilitation (e.g., overall facilitation in the mixed block: β = -225.80, t = 2.00, p = .05) and inhibitory control (e.g., inhibition of English items: β = -308.29, t = -1.98, p = .05) in the Stroop task. However, some divergent trends for interactions with language entropy and English proficiency pointed to significant distinctions between the groups, more often seen in the mixed-language Stroop block. In many cases, these interactions reversed the better performance seen for bilinguals: our most consistent result saw trilingualism showing a protective effect against age-related decline, as previously reported in Alzheimer research (Chertkow et al., 2010). Overall, this study supports the view that multilinguals are not just bilinguals with bonus languages, but rather speakers with distinct characteristics that may impact their cognitive control abilities. We assert that though their exclusion from studies of bilingualism may not be justified, it would be prudent to consider multilinguals' data separately at the onset, should they pattern differently from bilinguals.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

## What would Kuhn Say? Cognitive Control, bilingualism, and paradigm shifts

***Poster B37*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Arturo Hernandez[1]; [1]University of Houston

In the past twenty years, a heated debate has emerged with regard to the link between bilingual experience and performance on cognitive control tasks. More recently, research has begun to look at variability in bilingualism and on the nature of the control tasks used. To date, however, very few studies have focused on the models used to conceptualize cognitive control. In this talk, the views of Kuhn on scientific revolutions are brought to bear on this question. In particular, an alternative to the current models will be presented that is centered on reinforcement learning (RL) and interactive specialization (IS). RL suggests that the interactions between the basal ganglia and the prefrontal cortex are at the core of cognitive control. This view also takes into account neurotransmitters such as dopamine. IS focuses on emergent modularization across development. A natural question that arises is whether a synthesis of RL and IS represent what Kuhn might consider a paradigm shift. The presentation will end by emphasizing the implications of a potential paradigm shift on current views on the impact of bilingualism on the cognitive system and the role of development in this process.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

## Flexible functional adaptation of selective attention in bilingualism

***Poster B38*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Jacqueline Phelps[1], Mirjana Bozic[1]; [1]University of Cambridge

The constant management of competing languages in bilinguals presents a major processing demand for the cognitive system, leading to modifications to many cognitive functions, including selective attention. Yet the

exact mechanism of selective attention modulation in bilinguals remains debated. One recent view (Olguin et al., 2019; Phelps et al., 2022) argues that, instead of enhanced attentional capacity, adaptation to the demands of bilingualism reflects flexible adaptation and redistribution of the available finite attentional resources to support optimal behavioural performance under the increased processing demands. This account is rooted in the general concept of functional plasticity and degeneracy (Mason et al., 2015; Navarro-Torres et al., 2021), where biological systems can flexibly adapt to perform comparable function or achieve equivalent performance with different underlying configurations. Here we tested this hypothesis further by investigating how the bilingual processing system responds to very high attentional processing loads that extend beyond the typical demands. If bilingual modulation of selective attention reflects redistribution rather than enhancement, this is expected to tax bilinguals' performance more strongly relative to monolingual controls when the system is presented with high processing loads. We also tested how this flexible functional adaptation of selective attention in bilingualism might be moulded by development and maturation. To address these questions, 80 monolingual and bilingual children aged 7-12 and 84 monolingual and bilingual adults aged 18-45 took part in a study where they were required to perform auditory and visual attention tasks simultaneously. The auditory task employed a dichotic listening paradigm, where participants listened to a story in one ear, while ignoring a distractor presented in the other ear. The distractor stream was manipulated to create different levels of linguistic and non-linguistic interference. The visual task demanded attending to a pre-specified target image on the screen. Results showed equivalent performance on aspects of the dual attention task (auditory comprehension and visual task accuracy) for monolinguals and bilinguals in both age groups. Reaction times from the visual task however revealed differences between groups, with bilingual children's responses significantly slower relative to monolingual children in conditions of high processing load, but the bilingual adults' performance equivalent to their monolingual counterparts. These results are indicative of distribution of the available capacity and task prioritisation in bilingual children relative to monolinguals, with these differences between monolingual and bilingual performance essentially receding by adulthood. This suggests that maturation of the selective attention system enables adaptation to the combined load of second language processing and competing task demands; resulting in flexibly adapted selective attention system capable of optimal processing even under very high processing loads.

Topic Areas: Multilingualism, Language Development/Acquisition

## Changes of Cortical Activation Patterns during Word Translation Associated with Improvement in Second Language Proficiency of Japanese-English learners

***Poster B39*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Wakana Kawai[1], Kiyomitsu Niioka[1], Katsumasa Shinozuka[1], Yasushi Kyutoku[1], Ippeita Dan[1]; [1]Chuo University

Different cortical activation patterns during word translation of Japanese-English learners with advanced between elementary English proficiency had been reported by Shinozuka et al. (2021). They examined the effect of translation direction (English-into-Japanese/Japanese-into-English) and word familiarity (high/low) on cortical activations with functional near-infrared spectroscopy (fNIRS). The word translation task was used in the study. The word was visually presented on a monitor, and participants typed its translation equivalent with a keyboard. The most distinctly different cortical activation patterns between the proficiency levels appeared in the condition of Japanese-into-English/low-familiarity. There were significant activations in the left temporal regions including the superior temporal gyrus in the elementary group, while bilateral frontal regions including the right dorsolateral prefrontal cortex (DLPFC) and the frontopolar area (FPA) were activated for in the advanced group. However, whether elementary learners exhibit the same cortical activation patterns as the advanced learners as they improve their second language proficiency remains unclear. The current study aimed to seek the changes of cortical activation patterns during word translation associated with the improvement of second language proficiency. We used the same task as Shinozuka et al. (2021), and measured cortical hemodynamics twice for each participant. We analyzed only the Japanese-into-English/low-familiarity condition. The study begun with 60 participants and 48 of them progressed to the second measurement taken approximately six months later. Finally, 22 right-handed participants (8 men and 14 women), Japanese-English learners, and improved their English proficiency, were included in the analysis. English proficiency was measured using TOEIC® scores (first measurement: mean:516±28, max:785, min:135) and their improvement were confirmed with a paired t-test [$t(21)=4.61$, $p<.001$, $d=0.98$]. A fNIRS device, ETG-4000 (Hitachi Corporation, Tokyo, Japan) was used for cortical hemodynamics measurement. The probe holder with 52 channels covered the prefrontal and temporal regions. Locations of each channel were converted to MNI space by probabilistic registration and were labeled for macroanatomy thereafter. For fNIRS data analysis, first, the oxy-Hb of the acquired data were preprocessed to remove noise and general linear model analyses were conducted to calculate beta-values, indicating degrees of activation. Next, one-sample t-tests (vs. 0) for the beta-values were conducted to obtain significantly activated channels. Bonferroni method was used for correcting family wise errors. Finally, the beta-values of significantly activated channels located at the same macroanatomical regions were averaged, and paired t-tests were conducted to examine differences of cortical activations between the two measurements. One-sample t-tests (v.s.0) revealed significant activation in the right pars triangularis Broca's area (BA45) [ch35: $t(21)=4.28$, $p<.001$, $d=0.91$] in the first measurement, and the right DLPFC (BA9) [ch16: $t(21)=4.00$, $p<.001$, $d=0.85$] and FPA (BA10) [ch27: $t(21)=4.01$, $p<.001$, $d=0.86$, ch48: $t(21)=4.07$, $p<.001$, $d=0.87$] in the second measurement. A paired t-test in these regions revealed significant activation increase in the right DLPFC (BA9) [$t(21)=2.17$, $p<.05$, $d=0.46$]. There were no significant differences in the right Broca's area [$t(21)=-1.68$, $p=.11$, $d=-0.36$], and the FPA [$t(21)=2.03$, $p=.06$, $d=0.43$]. Results may indicate that cortical activation patterns approached to be similar to advanced learners of Shinozuka et al.(2021) as they improved their second language proficiency.

Topic Areas: Multilingualism, Language Development/Acquisition

## I hear ce que you're saying: Modality modulates the impact of code-switching on inhibitory control

***Poster B40*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Leah Gosselin[1], Laura Sabourin[1]; [1]University of Ottawa

It is now generally acknowledged that certain dimensions of the bilingual experience may disproportionately explain inconsistent executive functioning advantages among bi-/multilinguals. Code-switching is one such promising dimension, as reading or hearing code-switches is usually accompanied by indices of effortful processing (e.g., Gosselin & Sabourin, 2021). This result is seen as paradoxical, since code-switching is widespread and code-switchers appear to mix their languages effortlessly. One possibility is that producing code-switches is opportunistic (e.g., based on word retrieval ease), but that the underlying processing of code-switches requires (and potentially trains) executive control processes (Gollan & Ferreira, 2009). The present study constitutes a novel attempt to disentangle the effects of modality (producing vs. hearing/processing) when it comes to the impact of code-switching on executive functioning. Fifteen pairs of French-English bilinguals (n=30, age: M=35.3 years, range=18-61 years; 22 women, 8 men) from the same in-group (e.g., couples, siblings, parent/child) came to the lab together and completed speech elicitation activities while their natural interactions were recorded. The final unstructured task (i.e., free discussion; M=19.2 minutes) was transcribed. Individual utterances (M=208 utterances per subject) were coded as a) unilingual French; b) unilingual English; c) inter-sentential switches or; d) intra-sentential switches. These were used to compute a production index for each participant (PCS: 'produced code-switching'; i.e., the proportion of inter-/intra-sentential switches produced by the participant themselves) and a processing index (HCS: 'heard code-switching'; i.e., the proportion of inter-/intra-sentential switches produced by the participant's conversational partner). These indices were inputed as predictors in mixed models, wherein the response variable was the participants' subsequent performance on an individual Flanker task. In the trial-by-trial analyses, condition (neutral vs. incongruent) interacted with both PCS ($\beta$=-1.15, t=-3.67***) and HCS ($\beta$=1.42, t=4.04***). To examine these interactions in more detail, the participants were divided into infrequent and frequent code-switchers (according to the middle value of the switching predictors). This split revealed that the contrast between neutral and incongruent Flanker trials was not modulated by PCS and HCS among infrequent switchers (ts<.75). However, for frequent code-switchers, increased PCS resulted in less distance between neutral and incongruent trials ($\beta$=-3.63, t=-4.54***); this same effect was found for HCS, but with a much steeper slope ($\beta$=-12.61; t=-9.66***). Conditions were then aggregated to compute by-subject Flanker inhibition effects (M neutral RT – M incongruent RT). Aggregated analyses among all participants yielded no relationship between produced switches and the inhibition effect ($\beta$=-.43, t=-1.19). By contrast, a reduction in the inhibition effect was observed as participants heard more switches ($\beta$=.78, t=2.02*), with a steeper effect for inter- compared to intra-sentential switches ($\beta$=2.37, t=2.28*). The results from the present study suggest that producing and hearing code-switches do not entail the same cognitive control mechanisms. In particular, frequently processing (but not producing) switches is linked to better inhibitory control. Nonetheless, producing switches does not seem to hinder executive functioning; among frequent code-switchers, producing more switches is related to faster RTs. Our findings show that modality must be considered when researchers operationalize code-switching habits within the context of bilingual executive functioning.

Topic Areas: Multilingualism, Language Production

## Speak your heart out: Brain potentials reveal reduced sensitivity to negative content during second language production

***Poster B42*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Accumulating electrophysiological evidence points to reduced sensitivity to negative language content when bilinguals operate in their second language. The available evidence, however, is limited to language comprehension. Here, we tested the production of negative and neutral words in Polish (L1)-English (L2) bilinguals in three EEG experiments (N = 35 per experiment) that manipulated emotional cueing (Experiment 1 and 2) and presentation modality (Experiment 3). In Experiment 1 (neutral context), white or black circles indicated whether participants should read aloud (shadow) or translate a subsequently presented word. N400 amplitudes were selectively reduced for negative L2 words regardless of task, indexing an attenuation of emotional response to L2 words at the stage of lexico-semantic access. In Experiment 2 (emotional context), we used black or white emojis, either sad or neutral, as cues. The previous interaction between word valence and language of operation vanished, but late positive potential (LPP) amplitudes elicited by negative words were larger for translation from L2-to-L1 (i.e., production in Polish) than from L1-to-L2 (i.e., production in English), indexing greater re-evaluation of negative words at the stage of L1 word production. Finally, in Experiment 3 we used the same design as in Experiment 2, with the exception that this time participants were exposed to spoken rather than written words. We found a robust reduction of the N400 amplitudes for negative L2 words regardless of task, replicating the results from Experiment 1. LPP increased for negative as compared to neutral words when participants translated them from L2-to-L1 or simply repeated them aloud in L2. Together, our findings parallel the existing comprehension research showing reduced sensitivity to negative language content when opearting in the second language; and, critically, extend the available evidence to language production. As such, we provide first insights into the neural dynamics of production of written and spoken emotional words in bilinguals, shedding light on naturally occurring emotional communication in a bilingual context.

Topic Areas: Multilingualism, Language Production

## Can emotional facial expressions influence spoken language processing?

***Poster B43** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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A growing body of research is showing that the speaker's emotional information may modulate real-time language comprehension. However, it is still debated whether this effect takes place during the early or the later stages of language processing. To this end, this study used a subliminal paradigm to investigate the interplay between emotional facial expressions and language comprehension. Thirty-six participants listened to sentences that could contain morphosyntactic anomalies while viewing a scrambled face. Prior to the target word, emotional facial expressions (happy, neutral, or angry) were presented for 16 milliseconds embedded

within the scrambled face. Event-related potentials (ERPs) were analyzed using non-parametric statistics and cluster-based permutation tests. Analysis for language-related components revealed both LAN and P600 effects in the presence of all emotional expressions. Yet, a larger Left Anterior Negativity (LAN) effect was found for angry faces compared to neutral and happy faces, indicating that angry expressions may bias first-pass syntactic parsing. Subsequently, a reduced P600 effect was found only for angry faces as compared to neutral faces. Collectively, these findings support the view that emotion-laden information is rapidly decoded from facial cues and seems to impact linguistic comprehension at both early and later stages, particularly when facial cues are conveyed by a negative valence.

Topic Areas: Syntax and Combinatorial Semantics, Control, Selection, and Executive Processes

## Syntactic processing is modulated by self-referential information: electrophysiological evidence

***Poster B44*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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It has been a matter of debate to what extent syntactic processing is independent of other perceptual and cognitive processes. In this regard, recent studies have suggested that social information can modulate conscious syntactic processing supporting interactive models of syntax. This study aims to investigate whether and how syntactic processing can be affected by masked self-referential information. Thirty-six native Spanish speakers read sentences that could contain morphosyntactic anomalies in the verb, or be correct while a masked name (self, friend, or unknown names) was presented for 16 milliseconds between the noun and the verb. According to the visibility test, participants were unaware of the presentation of the masked name. Language-related components (LAN and P600) appeared for all conditions. However, a larger LAN effect followed by a reduced P600 effect was observed for self-names, compared to the friend and unknown names. These data suggest that both early and late syntactic processing can be modulated by self-referential information due to automatic prioritization mechanisms. Furthermore, this finding is consistent with the classic cocktail party effect, in which the perception of our own name can rapidly capture our resources and bias cognitive processing. Overall, these results support the view that syntactic processing is, at least under certain circumstances, flexible and content dependent.

Topic Areas: Syntax and Combinatorial Semantics, Control, Selection, and Executive Processes

## Catecholaminergic modulation of garden-path sentence processing: An ERP study with methylphenidate

***Poster B45*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The Catecholaminergic (CA) neurotransmitter system located primarily in the prefrontal cortex and basal ganglia of the human brain play a crucial role in cognitive control[1]. CA levels have been implicated in semantic unification during sentence processing[2]. The link between CA and syntactic unification is yet to be explored. In this study, by combining electroencephalography (EEG) and neuropharmacology, we examined how a CA stimulant (methylphenidate – MPH) impacted the processing of garden-path sentences. Garden-path sentences provide an excellent model system for examining the influence of CA levels on syntactic unification processes. Forty healthy participants were tested in two experimental sessions, one in which they ingested 20 mg MPH and the other a placebo. This was a within-participant, double-blind, randomized, crossover design. In every session participants read 40 sentences in each of three conditions (ambiguous, unambiguous, control; Example below). In the ambiguous condition, it is well established that readers initially treat the 3rd noun phrase (NP; "guitarist") as an instance of NP-coordination, but have to revise their parse upon reading the disambiguating target word (TW; "packed"), which clearly requires a S-coordination reading. In the unambiguous condition, a comma earlier in the sentence helps avoid the garden-path. The control condition includes no ambiguity. Participants' brain responses were recorded from 28 EEG electrodes. Mixed-effects models were used for statistical testing on the standardly preprocessed data. Example Ambiguous: The fan attacked the drummer and the guitarist packed the instruments up. Unambiguous: The fan attacked the drummer, and the guitarist packed the instruments up. Control: The fan attacked the drummer and the guitarist with a knife in his hand. At the TW, we replicated a P600 effect for the comparison between the ambiguous and control conditions (t = 2.23)[3], while there was no difference between the unambiguous and control condition. Both the ambiguous and the unambiguous conditions elicited a more pronounced negativity in the late N400 time window (tambiguous = -2.95; tunambigouous = -2.06). These results suggest that our Dutch participants may not immediately benefit from punctation, but the comma does appear to have an impact on later processes of revision. The only influence of the drug was observed in the early N400 time window. After taking MPH, participants showed a more pronounced negativity in the unambiguous than in the control condition, regardless of the order of drug administration (t = -2.23). On the other hand, a more pronounced negativity was observed for the ambiguous than control condition, only when the drug was administered in the first testing session (t = -2.02). There was no ambiguity effect in this time window under placebo or when MPH was administered in the second testing session. Our results demonstrate a clear neuropharmacological influence on language processing. The locus of our MPH effect was restricted to early, more automatic processing and we did not find any evidence for an influence of CA levels on later, more controlled processes of syntactic unification. [1] Westbrook et al., 2021. TiCS. [2] Tan, et al., (2020). Cerebral Cortex. [3] Kerkhofs et al., (2008). BrainResearch.

Topic Areas: Syntax and Combinatorial Semantics, Control, Selection, and Executive Processes

## The Role of Working Memory During Sentential Language Processing: Evidence from EEG

***Poster B46*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Megan Nakamura[1], Yanina Prystauka[2], Eleonora Rossi[1]; [1]University of Florida, [2]UiT Arctic University of Tromsø

Recent work on neural oscillatory correlates of sentence processing suggests power decreases in alpha and beta can be associated with the processing of syntactic and semantic violations (Kielar et al., 2014). Some findings also suggest changes in alpha may reflect neural processes underlying Working Memory (WM) (Wianda & Ross, 2019). More recently, Rossi & Prystauka (2020) found that when individuals process grammatical information in their second language (L2), alpha and beta oscillations decline earlier in time than in native speakers. The authors hypothesized that processing in the L2 taxes WM resources, and that this reduction might be at the basis of the observed shortening of the oscillatory duration. The present study tests this theory by manipulating WM itself to create a 'taxing condition' while processing in the native language. Method: Participants: 55; (f =38; mean age = 19.7) native monolingual English speakers with no history of neurological and/or learning disorders. All participants completed a behavioral Operational Span (O-Span) (Turner and Engle; 1989) and completed an EEG Acceptability Judgment Task (AJT) which consisted of 60 correct sentences, 60 items with syntactic violations, and 60 items with semantic violations. Critically, participants were randomly assigned to two conditions: 1) Non-Memory condition: the AJT task was completed without the ongoing WM task. 2) Memory condition: the AJT task was completed with an additional ongoing WM task which required participants to memorize a sequence of three words at the beginning of each sentence, monitor the sentence for those words, and randomly recall if a specific word was present in the sentence. Preliminary Results: Linear mixed-effects model analysis was performed to examine mean amplitude EEG responses for the memory manipulation (non-memory, memory), sentence condition (correct, syntactic violation, semantic violation), and EEG ROI (region of interest). The model included fixed effects for Condition, Sentence Type, and ROI, as well as their interactions, while accounting for random effects as a within subject factor. The model was fitted using the REML criterion with the bobyqa optimizer. The results show significant main effects of Condition and sentence type and an interaction by Condition by sentence type. More specifically, the Non-Memory group shows overall larger P600s compared to the Memory group. For sentence type the data indicate a larger P600 for sentences containing syntactic violations. The interaction further demonstrated that the Non-Memory condition by syntactic violation overall had the largest mean amplitude. Additionally for the ROIs, the Central Posterior cluster was predictive of more positive mean amplitudes, which is in line with the typical scalp distribution of the P600. The Left and Right Anterior ROI as well as the Right Posterior ROI were predictive of overall more negative mean amplitude which is in line with the typical scalp distribution of the N400. The time-frequency analysis is currently underway, but we predict to observe the same decline in alpha and beta band for the memory condition in line with Rossi & Prystauka's, (2020) L2 processing results, considering that this oscillatory signature may be a marker of differential WM resources during language processing.

Topic Areas: Syntax and Combinatorial Semantics, Control, Selection, and Executive Processes

## Rhythm and language in post-stroke aphasia: Preliminary findings

***Poster B47*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Anna V. Kasdan[1], Marianne Casilio[2], Katherine M. Bryan[2], Lily Walljasper[2], Noah R. Fram[2], Nori Jacoby[3], Deborah F. Levy[4], Michael de Riesthal[2], Reyna L. Gordon[2], Stephen M. Wilson[2,5]; [1]Vanderbilt University, [2]Vanderbilt University Medical Center, [3]Max Planck Institute for Empirical Aesthetics, [4]University of California San Francisco, [5]University of Queensland

Speech-language pathologists frequently use rhythm-based strategies (e.g., tapping, pacing) in clinical settings to facilitate speech output in individuals with aphasia. These strategies have been incorporated into more formalized therapies such as Melodic Intonation Therapy, predominantly geared towards individuals with severe, non-fluent aphasia. However, there is little empirical research surrounding this well-established clinical practice. Here, we asked which aspects of linguistic processing specifically may be related to musical rhythm in this population using a rigorous battery of tasks. For this sandbox presentation, we present data from 33 individuals with chronic, post-stroke aphasia (age: 58.4+15.9, female: 9) and 29 neurotypical controls matched on age and education (age 62.0+16.6, female: 15). All participants completed rhythm production and perception tasks and a music experience survey designed specifically for the purposes of this study. Individuals with aphasia also completed the Quick Aphasia Battery (QAB; Wilson et al., 2018) and two motor assessments. The rhythm tasks consisted of 1) tapping to three metronome sequences, 2) tapping to the beat of six different musical excerpts, and 3) the perception component of the Beat Alignment Test (Iversen & Patel, 2008). Rhythm tapping data were analyzed using circular statistics, where we derived two dependent variables indexing tapping accuracy and consistency (vector angle and length, respectively). Based on a principal components analysis which supported a single rhythmic tapping construct, we created a rhythm composite score for each individual (sum of z-score normalized vector length and angle, averaged across all tapping trials). Individuals with aphasia varied significantly in their rhythm tapping abilities, with many performing within the range of control participants. However at a group level, individuals with aphasia performed worse than controls ($\beta$=1.35+0.46, 95% CI = [0.42, 2.27], t=2.92, p=0.0049). Demographic factors including age, sex, and education were not significant predictors of rhythm tapping performance. This result highlights that therapeutic approaches incorporating rhythmic elements must consider that some individuals with aphasia are impaired in this domain. Exploratory correlations with QAB summary scores indicated that rhythm tapping was associated with all of the language production measures (word finding: r=0.47; grammatical construction: r=0.49; repetition: r=0.39; reading: r=0.39; QAB overall: r=0.39) but none of the motor speech (apraxia, dysarthria) or language perception (word and sentence comprehension) measures. The strength of these correlations was not influenced by formal music training. Tapping was most strongly correlated with grammatical construction even when controlling for overall aphasia severity (with QAB overall in the model, grammatical construction: $\beta$ = 0.44+0.21, CI = [0.02, 0.86], t=2.15, p=0.040). Our preliminary results largely align with the finding from Zipse et al. (2014) in a smaller sample that some individuals with aphasia exhibit rhythm impairments. In future work, we will explore the neural correlates of rhythm production and perception in post-stroke aphasia using lesion-symptom mapping, which may elucidate possible neuroanatomical links between rhythm and language.

Topic Areas: Disorders: Acquired, Language Production

## Perceived Difficulties with Multiparty Conversation Following Moderate-

## Severe Traumatic Brain Injury

***Poster B48*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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OBJECTIVE: Cognitive-communication impairments are a common consequence of traumatic brain injury (TBI). Group settings present a particularly challenging communication context given the increased cognitive demands of managing conversation with multiple speakers. Individuals with TBI have significant communication disruptions in social contexts but research has largely focused on monologic discourse and dyadic conversations. We developed the Multiparty Communication Questionnaire (MCQ) as a first attempt to capture perceived challenges of multiparty conversation for people with and without TBI. METHOD: Part A of the MCQ includes questions directly modified from the La Trobe Communication Questionnaire (Douglas et al., 2000) to examine specific communication behaviors (e.g., turn taking, interrupting), while other items capture the unique aspects of communicating in group settings (e.g., losing track of what others are saying in a group conversation). Part A includes a Likert-type scale with four response options: (1) never or rarely; (2) sometimes; (3) often; and (4) usually or always. Part B of the MCQ is only for participants with TBI and addresses post-TBI changes in opportunities to participate in group conversations. The 30-item survey was distributed to 4 SLPs for content, grammatical, structural checks and rewording to reduce ambiguity and was administered to participants in-person interview style. ANALYTIC PLAN: Our target sample is 40 adults with moderate-severe TBI and 40 non-injured comparison (NC) participants matched for sex, age, and education level. To date, we have MCQ data from 29 TBI participants and 23 NC participants. We anticipate completing data collection by July 2023, and full analysis of our data completed prior to this conference. We will report descriptive statistics (means, frequencies, distributions across each question) for both participant groups and TBI change over time data. PRELIMINARY RESULTS: Preliminary data from Part A suggest patterns of differences and similarities in multiparty communication between our groups. For example, participants with TBI were more likely than NCs to report having trouble remembering what each person in a group has said, and losing track of what they were saying. The two participant groups were similar in ratings of having trouble making eye contact with others in a group and directing their attention more towards one person in a group than another. Part B preliminary data showed that out of our 29 participants with TBI, 15 individuals reported a change in opportunities to be part of group conversations since their injury. 3 participants reported having more opportunities, and 12 reported having fewer opportunities for group conversations since their injury. CONTRIBUTION: This work expands the study of language use beyond monologic discourse and dyadic conversations to multiparty conversation in group settings, a ubiquitous context for language use. Documenting patterns of spared and impaired language and communication in multiparty conversation offers a new direction in characterizing the nature and scope of cognitive-communication disorders following TBI and may improve communicative outcomes for individuals with TBI. We aim to continue validating the MCQ and hope to expand its use to other clinical populations.

Topic Areas: Disorders: Acquired, Language Production

## Behavioral trajectories of connected speech recovery in aphasia in the first year after stroke

***Poster B50*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Although longitudinal studies have shown overall aphasia recovery after stroke to be dynamic and multidimensional [1–3], the recovery of connected speech—that is, contextualized language production—remains poorly understood. The purpose of the present study was to characterize the behavioral trajectories of connected speech in aphasia in the first year after stroke. Leveraging a large longitudinal study [3], we extracted connected speech samples from 52 patients diagnosed acutely with aphasia following left-hemisphere stroke and tested at four key timepoints—2–5 days (T1), 1 month (T2), 3 months (T3), and 12 months (T4) post-onset. Samples were scored by a speech-language pathologist blinded to other data using the Auditory-Perceptual Rating of Connected Speech in Aphasia (APROCSA) [4], a reliable and validated scheme for the assessment of connected speech that yields scores on four profiles: Paraphasia (misselection of words and sounds), Logopenia (paucity of words), Agrammatism (morphosyntactic omissions), and Motor speech (impaired motor speech programming or execution). Change in connected speech over time was then quantified with growth curve modeling in a mixed effects framework. Specifically, repeated measures of the four APROCSA profile scores were modeled as a function of a fixed effect for time and a random effect for time varying across patients. Fixed and random intercepts were also included. The fixed effect of time was expressed as a categorical variable (reference=T1), which imposes no distributional assumptions about the shape of change, and APROCSA profile scores were standardized prior to analysis. Similar to prior work [1–3], scores on all APROCSA profiles followed an improving yet decelerating trajectory, with impairment lessening over time, and T1 scores were highly influential on the magnitude of change (Paraphasia: $r=-.47$, Logopenia: $r=-.84$, Agrammatism: $r=-.74$, Motor speech: $r=-.83$). By the end of the first year of recovery (T4), Logopenia scores had improved the greatest amount ($\beta=-1.39\pm0.14$, $t=-10.29$, $p<.001$), followed by Agrammatism ($\beta=-1.25\pm0.15$, $t=-8.63$, $p<.001$), Motor speech ($\beta=-1.14\pm0.16$, $t=-7.21$, $p<.001$), and Paraphasia ($\beta=-0.97\pm0.13$, $t=-7.52$, $p<.001$). This divergence between Logopenia and Paraphasia in mean rate change of recovery likely reflects the degree of functional specificity within the language network. Specifically, the features defining the Paraphasia profile (e.g., phonemic paraphasias, paragrammatism) are uniquely tied to damage in the posterior temporal lobe [5], a region not easily substituted by other language areas over the course of recovery [3]. In contrast, the Logopenia profile is associated with damage to multiple brain regions [5], suggesting that its features (e.g., abandoned utterances, pauses within utterances) have sufficient anatomical redundancy to support more effective functional recovery. In future, we plan to quantify the influence of structural brain damage on the behavioral trajectories of the present study, with the goal of developing a comprehensive account of connected speech recovery after stroke. [1] Kertesz, McCabe. Brain. 1977;100:1-18. [2] Stefaniak et al. Brain. 2022;145(4): 1354-1367. [3] Wilson et al. Brain. 2023;146(3):1021-39. [4] Casilio et al. Am J Speech Lang Pathol. 2019;28(2):550-568. [5] Casilio et al. Clinical Aphasiology Conference; 2023.

Topic Areas: Disorders: Acquired, Language Production

## Language Recovery in Aphasia through Structural Priming: Error-based or Activation-based Learning?

***Poster B51*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Aphasia is a language processing disorder affecting the spectrum of communication from single words to sentences. Most aphasia treatments, however, are highly explicit and focus on improving anomia. Moreover, little evidence is available on what learning principles are essential in syntax rehabilitation for patients with aphasia (PWA). This study (a) applies implicit structural priming as a novel treatment for creating lasting recovery of sentence production in PWA and (b) investigates which learning principle (error-based vs. activation-based priming) is an essential mechanism of action. Theories of structural priming - speakers' tendency to reuse sentence structures they experienced (primed) previously- claim that it reflects implicit language learning (Bock, 1986; Pickering & Ferreira, 2008). This learning may be guided by error-based tuning of syntactic processing, caused by discrepancies that the speaker experiences between alternating prime structures (e.g., some actives and some passives) (Chang et al., 2006). Alternatively, repeated priming of a single prime structure (e.g., all passive primes) may strengthen the base-level activation of that structure in memory, supporting long-term learning (Reitter et al., 2011). Sixteen PWA and 16 age-matched controls completed a training study consisting of baseline testing, three sessions of structural priming training, immediate (1-day) and delayed (1-week) post testing. Target sentences were passive (e.g., the child is being chased by the mailman) and double object (DO) datives (e.g., the director is giving the boy a gift). During structural priming training, participants orally read two prime sentences following which they described a target picture. At baseline and post-testing, sentence production probes were administered to assess acquisition and maintenance of trained and untrained target stimuli. All participants received both single-structure (activation-based) priming and alternating-structure (error-based) priming training conditions, with the orders of training conditions and targeted structures counterbalanced. Data are so far analyzed for 9/16 PWA and 16 controls. At immediate post-testing, both groups showed improved production of trained and untrained target sentences, compared to baseline ($t = 6.44$, $p < .001$). PWA showed a greater improvement following the single-structure priming training compared to the alternating-structure priming; however, this effect was reversed in controls ($t = 3.03$, $p < .01$). At delayed post-testing, both groups still showed higher production of target stimuli compared to baseline ($t = 6.18$, $p < .001$). The same interaction with training condition was found at delayed post-testing ($t = 2.69$, $p < .01$). These results suggest that structural priming training is effective for ameliorating sentence production deficits, creating lasting and generalized improvements (Lee & Man, 2017; Man et al., 2019; Saffran & Martin, 1997). Independent production of both trained and untrained target sentences improved significantly following the training, which was maintained one week after training ceased. Unlike age-matched controls, PWA showed greater production improvements when prime sentences did not alternate between the target and non-target structure. Implicit language learning through structural priming remains resilient in post-stroke aphasia. Repeated-activation learning (Reitter et al., 2011) rather than error-based learning (Chang et al., 2006; 2012) is likely an essential mechanism of action that supports syntactic re-learning in aphasia.

Topic Areas: Disorders: Acquired, Language Production

## “Aphasia without aphasia”: A case series exploration of the role of the left pre-supplementary motor area in self-generated speech

***Poster B52*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In 1968, Luria & Tzvetkova described, in their words, “a kind of ‘aphasia without aphasia’”—a syndrome in which motor speech, naming, repetition, and comprehension were all preserved, and yet the ability to produce self-generated connected speech was markedly disturbed. Such paradoxical language presentations are somewhat rare, but have been reported and theorized at various points throughout the history of aphasiology, primarily in stroke populations. However, investigations of stroke are limited by stereotyped patterns of vascular damage as well as limited availability of pre-injury baseline data. Thus, investigation of this language profile in other clinical cohorts is warranted. Here we present a series of seven cases involving surgical resection of left medial frontal regions, predominantly centered on the left pre-supplementary motor area (pre-SMA) and its underlying cortical white matter, demonstrating marked and disproportionate deficits when responding to open-ended questions (e.g. “Tell me about your family”) as compared to constrained speech production tasks (e.g. repetition, confrontation naming, and reading aloud). Connected speech was characterized by severe anomia, perseverations, frequent word finding pauses, and decreased length of utterance. Neither motor speech nor motivational deficits were observed. Only one of these patients displayed measurable deficits in speech production (connected or constrained) prior to surgery. The majority of patients demonstrated recovery of language within normal limits within one month; two, however, demonstrated persistent impairments. This observed constellation of symptoms is similar to but distinct from well-known SMA syndrome, characterized by transient mutism and hemiparesis following resection in the left supplementary motor area. We present these findings (a) in an effort to further integrate the neurosurgical literature into current theories of the language network, (b) to discuss similarities and differences with previously theorized subtypes of aphasia and adynamia, and (c) to highlight the potential role of a region generally excluded from classical models of the language network, the pre-SMA, in the self-generation of connected speech.

Topic Areas: Disorders: Acquired, Language Production

## Neural predictors of narrative-discourse outcomes after naming intervention in aphasia

***Poster B53*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Dirk Den Ouden[1], Sigfus Kristinsson[1], Leonardo Bonilha[2], Greg Hickok[3], Argye Hillis[4], Chris Rorden[1], Brielle Stark[5], Julius Fridriksson[1]; [1]University of South Carolina, [2]Emory University, [3]University of California Irvine, [4]Johns Hopkins University, [5]Indiana University

Introduction We previously reported on variables that predict response to sequential phonological and semantic naming treatment in aphasia (Kristinsson et al., 2023). Based on data from the same trial, we now turn our attention to narrative-discourse measures and their neural substrates. To what extent do lesion characteristics predict discourse measures at baseline, and do lesion characteristics have prognostic value for discourse outcomes after naming treatment? Method 96 Participants with chronic aphasia (41.7% female; mean age 60.6) received six weeks naming therapy, half starting with three weeks phonologically-focused, and the other half starting with semantically-focused treatment, in a cross-over design. Change in naming accuracy was the primary outcome measure, assessed after the first treatment phase, immediately before the second phase, one-week after the second phase as well as one and six months post-treatment. At the same time points, participants were asked to (re)tell the Cinderella story. As potential predictors among the many variables that can be distilled from narrative discourse, we selected Words-per-Minute (WpM), Verbs-per-Utterance (VpU), Propositional Density (PD), Mean-Length-of-Utterance in Words (MLU), Type-Token Ratio, Word-Error ratio, Noun-Verb ratio (NV), Open-Closed-class ratio (OC), and the ratios of phonological errors, semantic errors and unrelated errors. As discourse outcome measures, we focused on WpM, VpU, and PD, as proxies for speech rate, syntactic complexity, and content richness. MRI data were collected at baseline. Lesions were manually drawn based on visual examination of structural T1 and T2 images. For the current study, we performed voxel-based and JHU-region-based univariate lesion-symptom mapping, as well as univariate JHU-region-based mapping analyses between behavioral measures and white-matter integrity, as reflected in fractional anisotropy (FA). Linear regression with permutation thresholding (3000 permutations) was performed with a one-tailed alpha level of .05 and lesion size as a covariate. Results Lower MLU, WpM, VpU and PD were all correlated with partly overlapping damage to left-hemisphere pre and post-central gyri, as well as white-matter (corona radiata, fronto-occipital fasciculus) and other subcortical structures (thalamus, capsula interna). Lower NV was associated with cortical and medial temporo-occipital damage, including posterior middle and inferior-temporal gyri, while lower OC was associated with subcortical frontal damage, medial to precentral and middle-frontal gyri. Increased VpU after phonological treatment was predicted by hippocampal integrity at baseline, and increased PD after semantic treatment was predicted by baseline integrity of parahippocampal gyrus, amygdala and inferior temporal gyrus. Conclusion In line with earlier work (Fridriksson et al., 2018), dorsal-stream damage was associated with lower performance on narrative-discourse measures at baseline. Interestingly, integrity of limbic structures involved in memory consolidation was predictive of discourse outcomes in terms of syntax (VpU) and content (PD) after phonological and semantic treatment phases, respectively. These results provide further evidence that structural stroke characteristics contribute to specific predictions of treatment response in aphasia. References Fridriksson, et al. (2018). Anatomy of aphasia revisited. Brain, 141(3), 848-862. Kristinsson, et al. (2023). Predicting Outcomes of Language Rehabilitation: Prognostic Factors for Immediate and Long-Term Outcomes After Aphasia Therapy. J Speech Lang Hear Res, 66(3), 1068-1084.

Topic Areas: Disorders: Acquired, Language Production

## Neural substrates of the heterogenous evolution of mixed transcortical aphasia

***Poster B54*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Mixed transcortical aphasia (MTCA) is a rare aphasia profile characterized by marked deficits in comprehension and production alongside preserved ability for verbal repetition. MCTA may be interpreted within the conceptual framework of the “isolation of the speech-language perisylvian area”, this is a disconnection between the preserved left perisylvian language network (PSLN), responsible for preserved verbal repetition, and the damaged left extrasylvian networks, which contribute to impairments in language production and comprehension. MTCA may progress towards milder variants of aphasia or even to full language recovery. However, despite significant advancements in in vivo neuroimaging, the structural and functional state of the PSLN network in MTCA and its evolution remains unexplored. Thus, the main objective of this study was to examine the functional activity and structural integrity of the PSLN in four cases who developed acute post-stroke MTCA and progressed to different types of aphasia. To accomplish this, a neuroimaging-behavioral study was conducted during the chronic stage. This study relied on different neuroimaging methods, including: (1) functional magnetic resonance imaging (fMRI) during verbal repetition to explore the residual networks sustaining verbal repetition in MTCA; (2) resting state fMRI (rs-fMRI) to study functional connectivity networks related to multi-demand and language-related networks; (3) diffusion tensor imaging (DTI - Tractography) to examine the dorsal and ventral white matter language pathways; and (4) resting 18Fluorodeoxyglucose positron emission tomography (18FDG-PET) to analyze the functional state of the PSLN. Our results revealed that while the behavioral profile of MTCA persisted in one patient, the other three patients progressed to less severe forms of aphasia: anomic aphasia, dynamic aphasia, and latent aphasia with discourse impairment. All patients had two or more lesions affecting frontal and parietal areas, showing partial damage to the PSLN including part of the inferior frontal gyrus, premotor cortex, inferior parietal cortex, and/or superior temporal gyrus. Structural and functional neuroimaging findings indicated that preserved verbal repetition in MTCA does not always depend on the optimal status of the PSLN and its dorsal connections and therefore it cannot be solely explained by the isolation of the speech area mechanism. Instead, the right hemisphere or the left ventral pathway may also contribute to supporting verbal repetition. The variability observed in the clinical evolution of MTCA can be explained by differences in the extent of PSLN damage and individual premorbid neuroanatomical language substrates. This study offers a modern perspective on MTCA in the light of advances in modern neuroscience and provides important insights into the neural basis involved in repetition.

Topic Areas: Disorders: Acquired, Language Production

## Connected Speech Profiles in Mild Cognitive Impairment are Related to the Severity of Cognitive Changes

***Poster B55*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Individuals with MCI show heterogeneous cognitive deficits (e.g., memory, visuo-spatial and executive functioning). They also have widespread changes in the following Connected Speech (CS) domains: speech production (e.g., more word fragments), fluency (e.g., more pauses), lexical (e.g., greater proportion of pronouns versus nouns), semantics (e.g., fewer Information Content Units (ICUs)), syntax (reduced syntactic complexity), and pragmatics (e.g., reduced coherence). There also exists variability across studies in the CS characteristics that best distinguish controls and individuals with MCI. Our aim was to find CS profiles in MCI and if these profiles are accompanied by specific cognitive patterns and demographic characteristics. To do so, data from 56 controls and 126 individuals with MCI (60-89 years old) were drawn from the COMPASS-ND study of the Canadian Consortium of Neurodegeneration in Aging. All participants completed the Cookie Theft Picture Description Task, and neuropsychological tests (e.g., BORB, WAIS-III Vocabulary, Stroop) in English. Linguistic features covering the following domains: speech production, fluency, lexical, semantics, syntax, and pragmatics were extracted from MCI's and controls' CS transcriptions using Natural Language Processing techniques. To reduce dimensionality, K-means or Two-Step Cluster analyses (depending on the variable types in a category) were carried out for each linguistic characteristic category with the MCI participants' data. A Two-Step Cluster Analysis was carried out using the previously identified linguistic characteristics without predefining the number of wanted clusters, and a two-cluster solution was obtained. Both clusters were compared to one another and to the control group in terms of linguistic, cognitive, and demographic characteristics (e.g., age, education, number of spoken languages) using one-way ANOVAs and Bonferroni tests. Cluster 2 (17.5% of MCI participants) was more educated than Cluster 1 (82.5%). Compared to controls and Cluster 2, Cluster 1 produced shorter CS samples, had more semantic (e.g., fewer ICUs mentioned), and syntactic (e.g., fewer subordinate clauses) difficulties, and slightly more pragmatic (e.g., reduced local coherence) and lexical difficulties (e.g., higher word frequency). Cluster 2 showed more fluency difficulties (more pauses, word and idea repetitions) than controls and Cluster 1. Also, Cluster 1 had a lower performance than controls and Cluster 2 in the following cognitive domains: visuospatial, language/semantic memory, visual attention, and inhibition. Cluster 2 performed similarly to controls in all cognitive domains, except for some portions of the Verbal Fluency task (more repetitions and set-loss errors). Moreover, both clusters performed more poorly than controls, but similarly to one another on the episodic memory tasks. These results show that there exists more than one CS profile in MCI and highlight the fact that CS analysis can help detect individuals with MCI with more severe cognitive changes. Cluster 1 could potentially be in later stages and/or more at risk of progressing to AD than Cluster 2. Furthermore, Cluster 1's more severe changes in CS are coherent with the greater severity of their cognitive decline. Cluster 2's fluency changes could be the result of word-finding/lexical access difficulties. Considering their higher education level, the less severe CS changes observed in Cluster 2 could be attributed to greater cognitive reserve.

Topic Areas: Disorders: Acquired, Language Production

# Evidence for a syntactic production-comprehension asymmetry in post-stroke aphasia

***Poster B56*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Despite decades of research on the relationship between expressive and receptive agrammatism in people with aphasia (PWA), very little recent work has been done on the relationship between expressive paragrammatism and syntactic comprehension deficits (Eling et al., 1987). Here we compare behavioral patterns of sentence production with a measure of syntactic comprehension. By contrast to expressive agrammatism which is characterized by the reduction or omission of syntactic structures leading to “telegraphic speech”, paragrammatism is characterized by long utterances with more-than-necessary morpho-syntactic structure, and deficits in the hierarchical organization of sentences (Kleist, 1914). The two syndromes also have distinct lesion correlates, with expressive agrammatic participants having lesions in the left middle and inferior frontal gyri, and paragrammatic participants having lesions in the left posterior superior and middle temporal gyri (Matchin et al., 2020). PWA displaying expressive agrammatism tend to have relatively spared syntactic knowledge and comprehension (Linebarger et al., 1983), however to date, no work has investigated the relationship between paragrammatic output and syntactic comprehension. As such, it remains to be seen whether a) paragrammatism is constrained to the production domain, b) a paragrammatic production deficit entails a corresponding comprehension deficit, or c) depending on lesion location, paragrammatism can dissociate or co-occur with a comprehension deficit. These questions play a crucial role in distinguishing cortical models of syntax which rely on partially distinct circuits for production and comprehension (e.g.: Matchin and Hickok, 2020) from those that don’t (e.g.: Hagoort, 2016), or those which argue for a distributed rather than localized syntactic system (Fedorenko et al., 2020). Using a recently-developed error coding scheme (Fahey et al., 2022), the speech of 53 PWA retelling the story of Cinderella was characterized according to the proportion of agrammatic, paragrammatic, or grammatical utterances they produced. We used the Sequential Commands subscore of the Western Aphasia Battery (WAB-R; Kertesz, 2007) as a proxy measure for syntactic comprehension. We then carried out a voxel-based lesion-symptom mapping analysis to determine the relationship between lesions leading to paragrammatic errors and syntactic comprehension scores. We found a significant correlation between proportion of paragrammatic errors and syntactic comprehension scores ($r = -0.292$, $p < 0.05$). Critically, however, some participants with high proportions of paragrammatic errors scored at or near ceiling in the syntactic comprehension task. We found that distinct lesions in the posterior temporal lobe (PTL) corresponded to paragrammatic production and syntactic comprehension deficits. Thus, despite a significant negative correlation between paragrammatic production and syntactic comprehension, we did not find that syntactic comprehension deficits always co-occur with paragrammatic production. This relationship between paragrammatic production and syntactic comprehension is explained by their nearby lesion correlates in PTL which is consistent with previous findings on the lesion correlates of syntactic comprehension (Matchin et al., 2022; Yu et al., 2022). This organization would provide a reasonable candidate locus for the lemma system posited by Matchin and Hickok (2020) or correspond to different aspects of the message-structure interface proposed by Krauska and Lau (2023)’s

non-lexicalist framework.

Topic Areas: Disorders: Acquired, Language Production

## Basal ganglia-thalamocortical loop involvement in the speech deficits of Parkinson's Disease

***Poster B57*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction Parkinson's disease (PD) is a neurodegenerative disorder often associated with laryngeal and articulatory related motor speech deficits. Previous studies investigating the neural correlates for laryngeal and articulatory functioning have found ventral pre-central gyrus, ventromedial putamen, and ventrolateral thalamus to be involved in speech production. These areas have cortical-cortical and cortical-subcortical white-matter connections forming the basal ganglia-thalamo-cortical loop (BGTC-loop), which is involved in the control and coordination of feedforward motor signals for speech production (Alexander et al., 1986; Chang & Guenther, 2020; Kearney & Guenther, 2019). Recent studies have shown increased resting-state functional connectivity between dorsal laryngeal motor area and globus pallidus in PD with speech deficits (Manes et al., 2018). However, there is relatively little understanding about the structural properties of the white-matter tracts connecting these regions in the BGTC-loop in PD. Hence, our study aimed to investigate the properties of white-matter tracts concerning these speech related (laryngeal and articulatory) areas in the BGTC-loop. Material and Methods We used pre-collected diffusion-weighted and T1-weighted MRI data of 20 PD with speech deficits, 20 PD without speech deficits, and 20 healthy controls from the Parkinson's Progressive Markers Initiative database. Participants were assigned to PD with and without speech deficits based on the Movement Disorders Society Unified Parkinson's Disease Rating Scale (MDS-UPDRS; Goetz, 2009), Part III speech item scores (scale of 0-4; 0= no speech problems, 4=most speech is difficult to understand or unintelligible) with the score of 2 and above in the speech deficits group. We performed probabilistic tractography between articulatory and laryngeal motor related areas and inner subcortical structures such as ventrolateral thalamus and ventromedial putamen to reconstruct white-matter tracts connecting these areas in the BGTC-loop. White matter metrics of Fractional Anisotropy (FA), Mean Diffusivity (MD), Axial Diffusivity (AD), and Radial Diffusivity (RD) were extracted from each of the laryngeal and articulatory motor tracts and compared using repeated-measures ANOVA with post-hoc analysis. Results Our main findings were observed in MD and AD metrics – i) MD value for left-laryngeal pathway was significantly increased in PD individuals with speech deficits compared to PD individuals without speech deficits, and ii) AD value for left-articulatory pathway was significantly decreased in PD individuals with speech deficits compared to PD individuals without speech deficits. However, there were no significant differences for FA and RD metrics. Conclusion Increased MD and decreased AD values in PD with speech deficits can be an indicative of progressive degeneration and axonal injury of neurons forming the laryngeal and articulatory related white-matter tracts in the BGTC-loop (Basser & Jones, 2002; Pierpaoli et al., 1996; Zhang & Burock, 2020). These aberrant properties of white-matter tracts might be a contributing factor causing imbalance in the excitation and inhibition mechanisms in the BGTC-loop, resulting in reduction of feedforward flow of motor signals from the laryngeal and articulatory related motor areas to the basal-ganglia structures. Hence, these findings support the notion that there might be deficits in the laryngeal and articulatory white-matter tract properties contributing to the speech deficit seen in PD.

Topic Areas: Disorders: Acquired, Speech Motor Control

## Impact of Parkinson’s disease on prosody production: a systematic review and meta-analysis

***Poster B58*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Parkinson’s disease (PD) leads to changes in verbal communications. Prosody is one of the main aspects often reported as being impaired in PD. Investigating prosody impairments in individuals with PD can shed light on the neurobiological basis of prosody production as PD can be used as a model of basal ganglia dysfunction. The goal of this systematic review and meta-analysis was to examine the extent to which PD impacts the acoustic parameters related to prosody production. We conducted a systematic literature search on Pubmed, PsychINFO, and Web of Science. We focused on fundamental frequency and its variability, intensity and its variability, rate and pauses. A total of 649 records were identified. After checking for inclusion and exclusion criteria, 38 articles were included in the study. For each acoustic measurement and task, effect sizes (Hedges' g) were extracted by comparing groups of individuals with PD with control groups. We estimated pooled effect sizes using Bayesian hierarchical regression models. We observed reliable differences between PD and controls regarding F0 variability and pause duration. The pooled estimated effect size for F0 variability was -0.75 (95% CI: [-1.01; 0.48]; evidence ratio: infinite; credibility: 100%, 47 effect sizes). The pooled estimated effect size for pause duration was 0.49 (95% CI: [0.01; 0.94]; evidence ratio: 41.11; credibility: 98%, 20 effect sizes). No reliable difference was observed for other features. These results provide details about the prosody impairment in PD. Physiological processes such as laryngeal mechanisms could explain these findings. However, the finding regarding intensity seems not to be consistent with a purely physiological-based explanation. Another possibility which seems to be more in line with our finding, namely regarding the increased pause duration, is that PD would impact prosody planning. This latter is in line with recent studies on language impairment in PD. Further studies should investigate the role of physiological versus language process in prosody production in PD.

Topic Areas: Disorders: Acquired, Speech Motor Control

## DTI Prediction of Treatment Response to cerebellar tDCS plus language therapy

***Poster B59*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction Neuromodulation techniques especially transcranial direct current stimulation (tDCS) have provided tools to augment language rehabilitation effects in poststroke aphasia. Studies including our work have shown that cerebellar tDCS in conjunction with language therapy, improves language outcomes in aphasia (DeMarco et al., 2021; Marangolo et al., 2018; Sebastian et al., 2017, 2020). However, the results of our study indicate marked individual variability in cerebellar tDCS response. Therefore, it is critical to address the question of who may benefit from neuromodulation. This can inform our knowledge base regarding optimal benefit from adjuvant tDCS. We have shown that aphasia severity and lesion characteristics influence outcome of cerebellar neuromodulation in chronic aphasia (Sebastian et al., 2020). In the present study, we aimed to determine whether cerebello-cerebral white matter integrity is associated with cerebellar tDCS effects in participants with aphasia. Methods Nineteen, right-handed participants with chronic aphasia due to left hemisphere stroke were included in the study (67 ± 9.18 years of age, 3 females). Pre-treatment magnetic resonance & diffusion tensor imaging (MR-DTI) were acquired on a Philips 3T scanner. All participants received language assessments before and after 15 sessions of computerized aphasia therapy (Fridriksson et al., 2018) combined with cerebellar tDCS and sham tDCS in a randomized, cross-over trial study design. The primary variable of interest was post-treatment functional communication scores assessed via the American Speech-Language-Hearing Association Functional Assessment of Communication Skills for Adults (ASHA-FACS, Frattali et al., 1995). The ASHA FACS has two dimensions: Communication Independence (CI) scale and Qualitative Dimension of Communication (QDC) scale. MR-DTI analysis included lesion load and cerebellar lobules segmentation and semi-automated brute force and multiple regions-of-interest (ROI) deterministic tractography of bilateral cerebellar segments and cerebello-cerebral white matter connections (Keser et al., 2023). White matter integrity was measured by mean diffusivity (MD) and fractional anisotropy (FA). Recursive feature elimination and Spearman correlation analyses were performed to evaluate the relationship between baseline bilateral cerebellar segments and cerebello-cerebral white matter integrity and post-treatment functional communication scores (CI and QDC) for tDCS and sham interventions. The analysis was adjusted for age and lesion load. Results The results revealed that lower baseline MD values of the right cerebellar segments (VIIb: R=-0.57, p=0.026; VIIIa:R=-0.48, p=0.039) and left cortico-ponto-cerebellar tracts connecting the left cerebrum to the right cerebellum (fronto-ponto-cerebellar tract: R=-0.57,p=0.01; parieto-ponto-cerebellar tract: R=-0.6,p=0.006; temporo-ponto-cerebellar tract: R=-0.59, p=0.007; occipito-ponto-cerebellar tract : R=-0.51, p=0.026) were associated with greater improvement on the QDC scores for tDCS intervention. Lower baseline MD values of the right cerebellar segments (VIIb: R=-0.52, p=0.03; VIIIa:R=-0.51, p=0.038) were also associated with greater improvement on the QDC scores for sham intervention. Conclusion: Our preliminary analysis showed that the integrity of the left cortico-ponto-cerebellar tracts (as measured by MD) predicted tDCS effects for functional communication skills, whereas white matter integrity of right cerebellar segments predicted effects of tDCS and sham interventions. These findings hold promise that baseline cerebello-cerebral white matter integrity could be used as a biomarker for treatment response to cerebellar tDCS in aphasia, but larger studies are needed.

Topic Areas: Disorders: Acquired,

# The Right Hemisphere's Capacity for Language: Evidence from Primary Progressive Aphasia

***Poster B60*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: The role of right hemisphere (RH) in language processing is still vigorously debated. This study provided additional evidence from analyzing white matter (WM) tract integrity in Primary Progressive Aphasia (PPA). Specifically, we studied: (1) the WM integrity of the left hemisphere (LH) language tracts and their RH homologues, (2) the overall relationship between language performance and WM integrity in the two hemispheres, (3) the domain-specificity of the RH contributions (i.e., specificity to language versus general cognitive processing) and (4) whether the RH uniquely contributes to language, independently of LH contributions. Methods: Participants were 33 PPA individuals and 20 healthy controls (HC). Language scores on naming, syntax and spelling, and non-language scores on spatial span were collected from the PPA group. DTI data were collected from both groups, and mean diffusivity (MD) – a measure of WM integrity - was calculated for seven language tracts and one non-language tract: anterior and posterior inferior fronto-occipital fasciculus (IFOF), inferior longitudinal fasciculus, uncinate fasciculus (UF), long, anterior and posterior arcuate fasciculus and spino-thalamic tract (non-language), bilaterally. Analyses evaluated: (1) MD differences between PPA and HC in both hemispheres. (2) Associations of language scores with tract integrity and (3) domain-specificity in each hemisphere by comparing models with and without language scores. For (3), all models included non-language scores. (4) The unique contribution (unique-R2) of each hemisphere's tract integrity to explaining variability in language scores was assessed by using the hemispheric difference in unique-R2 between homologous tracts to determine if: (i) the magnitude of unique-R2 differences of homologous tracts significantly favored the LH or the RH for specific tracts and (ii) the distribution across tracts of unique-R2 differences significantly favored the LH or the RH. Results: (1) We found significantly higher MD values for PPA versus HC groups in the LH ($p=0.006$) for the language tracts. No significant differences were found in the RH for the language tracts, nor for the non-language tract in either hemisphere. (2) For the language tracts, the R2 attributable to language was 10.3% and 5% for the LH and RH, respectively (p's<0.001), indicating a significant association between language and tract integrity in both hemispheres. For the non-language tract, no significant associations were found. (3) The R2 attributable to language after considering the spatial span scores was 10.7% and 4.2% for the LH and RH, respectively (p's<0.04), indicating a significant association between language and tract integrity beyond general cognitive functioning. (4) Regarding the magnitude of unique-R2, greater variance for Naming was uniquely explained by two LH tracts compared to their RH homologues: (i) UF ($p=0.026$), and (ii) anterior IFOF ($p=0.021$). For the distribution of unique-R2 difference values, we found that 67% of the RH tracts explained more unique variance in language performance than their LH counterparts ($p<0.05$). Conclusions: These results extend previous findings of the effects of PPA on the WM integrity of the language tracts in the LH and provide strong evidence of the relationship between language processing and WM integrity in both hemispheres in the context of LH damage.

Topic Areas: Disorders: Acquired,

## Characterization of functional connectivity in post stroke aphasia during fMRI naturalistic and language tasks

***Poster B61** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language network function is able to be reliably measured in healthy controls using language localizer tasks (Fedorenko et al., 2010). These language localizer tasks involve the reading of words and nonwords, presented in blocks to localize the language network in each subject1. Yet these language localizer tasks are constrained in timing and do not capture natural language processing. During naturalistic language tasks, predictive coding was found in the language network of healthy controls (Shain et al., 2020) . Yet the functional connectivity of naturalistic language processing has yet to be characterized in post stroke aphasia. This is critical for understanding how language is organized in this population. Resting state functional connectivity has also been found to be disrupted in post stroke aphasia (Klingbiel et al., 2019). In the current study, we seek to characterize differences in functional connectivity in people with post stroke aphasia and healthy controls across different states (rest, naturalistic language processing, and language localizer task). Magnetic resonance images (MRIs) are being collected from 40 individuals with chronic aphasia (> 6 months) due to a left hemisphere stroke and 40 healthy controls. They will undergo an MRI collected on a Siemens 3T Magnetom Prisma. During the scan, subjects will complete a resting state scan, a naturalistic language task and a language localizer task. The naturalistic language task consists of story listening. A five minute long story is presented via earbuds and subjects are shown a fixation cross throughout. Following the story, yes no questions are asked to ensure comprehension. The language localizer task consists of reading sentences and lists of nonwords in a block design. We plan to conduct a joint independent component analysis (jICA) using the three conditions from each subject as input. jICA is preferred over a traditional independent component analysis (ICA) because the jICA takes the lesion into account when producing component masks where traditional ICAs only mask the lesion. Then the resulting components will be used as regions of interest in a functional connectivity analysis within each condition. Then we will compare the resulting connectivity matrices across the two subject groups and three conditions. Across the three conditions, we expect to see a spectrum, with the language localizer condition being the most language like, and the resting state being the least language like. Across the two groups, we expect to see the most similar connectivity patterns in the resting state condition and the least similar connectivity patterns in the language localizer condition, with the naturalistic language condition falling somewhere between the two. Preliminary data showed increased connectivity in certain components during story listening when compared to resting state. In turn, these same components had increased connectivity during the language localizer task when compared to story listening.

Topic Areas: Disorders: Acquired,

## Atypical Hemispheric Re-Organization of the Reading Network in High-

## Functioning Adults with Dyslexia: Evidence from Representational Similarity Analysis

***Poster B62*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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It has been argued that university students with dyslexia compensate for their reading deficits by a neural re-organization of the typical reading network that emphasizes semantic similarity between words over orthographic similarity. To investigate the re-organization of neural word representations more directly, we used multivariate representational similarity analyses (RSA) to find out which brain regions of the reading network respond to orthographic and semantic similarity between 544 pairs of words and whether there were any differences between typical and dyslexic readers. In accordance with the re-organization hypothesis, we predicted greater similarity (i.e., correlation of neural dissimilarity matrices) in adult dyslexic than in typical readers in regions associated with semantic processing and weaker similarity in regions associated with orthographic processing. The results showed that all three subparts of the fusiform gyrus (FG1, FG2, FG3) bilaterally were sensitive to semantic information in typical readers, whereas less sensitivity in a posterior subpart of fusiform gyrus (FG1) in the left hemisphere was obtained for dyslexic readers. In typical readers, orthographic information was not only processed in the left fusiform gyrus (FG1, FG2, FG3) but also in left IFG. Adults with dyslexia, in contrast, did not show sensitivity to orthographic information in left IFG. However, they showed increased sensitivity to orthographic information in the right hemisphere FG1. Together, the results show abnormal orthographic processing in left IFG and right FG1 and reduced semantic information in left FG1. While we found evidence for compensatory re-organization in adult dyslexia, the present results do not support the hypothesis according to which adults with dyslexia rely more heavily on semantic information. Instead, they revealed atypical hemispheric organization of the reading network that do not extensively rely on the typical left language hemisphere.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Adaptation and Mismatch Negativity (MMN) in Dyslexia: Comparing First vs. Subsequent Repetitions in a Roving EEG Paradigm with Minimized Expectations

***Poster B63*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Recent research has implicated the implicit learning of statistical regularity as a potential factor contributing to the reading deficit and poorer tone discrimination performance in individuals with dyslexia (Jaffe-Dax et al., 2015). These deficits are characterized by weaker neural adaptation compared to typically developing readers,

suggesting impaired general processing in forming short-term representations of stimulus consistency (Perrachione et al., 2016). In addition, inconsistent findings have been observed regarding the amplitude differences of mismatch negativity (MMN) between individuals with and without dyslexia (e.g., Baldeweg et al., 1999; Meng et al., 2005). Although neural adaptation is believed to contribute to MMN (Jääskeläinen et al., 2004), these two processes have been examined in separate bodies of literature, leaving their relationship in children with and without dyslexia unclear. To address this issue, 42 children with Chinese dyslexia (dyslexia group; fourth to sixth grade; 9–13 years old; 17 females) and 26 children without dyslexia (control group; fourth to sixth grade; 10–12 years old; 17 females) participated in an EEG roving paradigm experiment with continuous pure tone stimuli. Importantly, the stimuli were carefully arranged to minimize expectations and isolate pure adaptation effects. The peak amplitudes of components related to the adaptation effect, including P1a, P1b, and N250, as well as the amplitudes of MMN, P3a, and late MMN, were extracted. By tracing the amplitudes along the first ten tones in each local train, we found that both groups exhibited similar adaptation effects characterized by an initial amplitude decrease followed by a continuous increase of P1a and P1b. However, a continuous amplitude decrease (more negative) of N250 was observed across the ten tones in both groups. We then examined how the initial adaptation (i.e., the peak amplitude difference between the deviants and the 2nd tones) and subsequent adaptation (i.e., the peak amplitude difference between the 2nd tones and the final tones) in each P1a, P1b, and N250 time window were related to MMN, P3a, and late MMN. Preliminary data analyses revealed that the correlation between the late MMN and subsequent adaptation of N250 was significantly different between the two groups. These findings suggest that the main differences between dyslexic and non-dyslexic children lie in late MMN rather than MMN, supporting the notion that dyslexia involves impairments in later auditory processing stages (Halliday et al., 2014). Importantly, the present study highlights that although the adaptation patterns are similar between children with and without dyslexia, the relationship between adaptation effects and the late MMN component can differ even when expectations are minimized.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Neural Mechanisms of Spanish Speech Imitation in native Chinese-speaking children and adults

***Poster B64*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Avoiding foreign accents in second language (L2) speech production for late bilinguals is challenging. The critical period theory argues that children who learn L2 before the end of puberty can produce native-like speech (Flege, 1987). Similarly, people with musical training also have superior pronunciation (Milovanov, 2009). However, brain mechanisms underlying the superiority of children and musicians in foreign speech imitation are poorly understood. In the current study, we examined brain activities during Spanish imitation in native Chinese speakers. We recruited 66 native Chinese speakers, including 15 typically developing children (M =10.3 ± 0.5), 19 adults with extensive musical training (M = 19.8 ± 1.5), and 32 adults as controls (M = 22.6 ±

3.3). All participants had no previous knowledge of Spanish or similar languages. In the MRI speech imitation task, 30 Spanish real words (17 two-syllable words, 10 three-syllable words, and 3 four-syllable words) were orally presented. Participants imitated right after each presented word as best as they could. Each word repeated three times in a row. The quality of participants' pronunciation of Spanish words was measured using Praat (Boersma, 2001) by calculating voice onset time (VOT) for consonants, and the first and second format frequency (F1 and F2) for vowels. We found that children and musician adults had more similar VOTs to the native Spanish speaker for the Spanish consonant [d], [b], and [p] than control adults, and they had shorter distance to the native Spanish speaker in the vowel space for the Spanish vowels [e], [i], [o], and [u]. For the brain functional activities, we found that both children and musicians showed reduced activation from the first imitation to the second imitation in the bilateral STG, left insula, and left thalamus, suggesting a repetition suppression effect; however, the control adults showed less reduction. It suggests that auditory feedback at the STG and insula and motor control in the thalamus are more sensitive in children and musicians than in control adults. We found that musicians showed greater reduction after the first imitation in the left SMA and left postcentral gyrus, while the children and control adults did not, suggesting a specific musician effect that musicians have finer speech motor control at the SMA and greater somatosensory feedback at the postcentral gyrus than the other two groups. We also found that children showed steady activation in the bilateral posterior cingulum, but the two adult groups did not, suggesting that children have less memory retrieval and increased automatic processing during speech learning. These findings provide both behavioral and neurological evidence for the superiority of foreign speech imitation in children and musicians than control adults.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Neural activity associated with learning to articulate pseudowords in children with developmental language disorder

***Poster B65*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Developmental language disorder (DLD) is a neurodevelopmental condition characterised by persistent difficulties in learning and processing language. Children with DLD perform poorly on tests of nonword repetition, a crucial skill for word learning and fluent speech. Despite it being a well-documented behavioural marker for DLD, the underlying neural correlates of nonword learning in children with DLD are not well understood. As part of the Oxford Brain Organisation in Language Development project, we used functional MRI to investigate repetition-suppression effects accompanying pseudoword learning in 55 children with DLD (mean age = 12.36 years) compared with 77 typically developing age-matched controls (TD; mean age = 12.52 years). Our DLD criteria were non-verbal intelligence above 70 and performance of one SD below the normative mean on two or more of five standardized language assessments. In an event-related design, children heard and overtly repeated 2- or 4-syllable pseudowords, corresponding to "names" of aliens they viewed while being scanned. Pseudowords were presented either once or four times. After the scan, children overtly repeated each of the previously presented pseudowords. We predicted that compared with typically developing children, those with DLD would show reduced repetition-suppression effects across the four repetition trials. Data were excluded from 11 DLD and 7 TD participants who moved excessively during the functional run. Behaviourally, post-scan testing revealed that the DLD group performed more poorly on the nonword repetition task compared with their typically developing peers. Functionally, both groups activated an extensive set of brain regions bilaterally when listening to and overtly repeating the pseudowords. These included the posterior inferior frontal cortex, lateral premotor cortex, sensorimotor cortex, supplementary motor area, superior temporal cortex, and large portions of occipital and inferior temporal cortex. There was also activity in the dorsal striatum, medial temporal lobe, and cerebellum. Statistically, the groups differed in superior and inferior portions of the parietal cortex just posterior to the sensorimotor cortex activity seen in each group separately; that is, there were group differences in areas that were task negative. Significant linear decreases in task-evoked activity due to repeated exposure to and repetition of the pseudowords were seen in the TD group in the left inferior frontal cortex, anterior insular, superior temporal and occipital cortex bilaterally, medially in the supplementary motor area, anterior cingulate, and subcortically in the left dorsal striatum. The DLD group showed linear decreases limited to the superior temporal and occipital cortex bilaterally. However, statistical comparison of the two groups failed to show significant differences, perhaps due to greater variance in the DLD group in whom the learning-related decreases in activity were less robust and extensive than those seen in the TD group. In summary, during nonword repetition, children with DLD showed less task-negative activity in parietal areas relative to the TD group. Similar learning related decreases were seen in both groups despite better nonword repetition performance in the TD group. Future longitudinal investigations could shed light on the developmental trajectory of the functional neural architecture of this crucial skill.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Brain mechanisms of statistical sequence learning in children with DLD – methods and initial results of fMRI experiments.

***Poster B66*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The brain is known to rapidly find structure and meaning in unfamiliar streams of stimuli, even with minimal external feedback. One type of probabilistic information is statistical sequence and the most prominent example of natural sequential information is linguistic code. Statistical sequence learning is considered as a sub-process of procedural learning, which was proposed as a one of the core functions underlying language acquisition. Subsequently, its dysfunctions became an important candidate for a mechanism underlying core symptoms of Developmental Language Disorder (DLD). The neural mechanisms of statistical learning (SL) involve basal ganglia, frontal lobes, and medial temporal cortex. Importantly, the involvement of specified networks is dependent on the stage of the learning process and the level of statistical complexity. There are limited findings on neural mechanisms of SL in DLD. One study revealed that adults with DLD activate a typical neural network, however, a regional analysis indicated hyperactivation of regions associated with language processing (Plante et al., 2017). Present project aims to verify hypothesis: - The SL impairment in DLD is related to atypical brain circuit including basal ganglia, frontal and temporal lobes; - The level of SL impairment varies depending on the stimulus type (verbalizable vs. non-verbalizable) and is interdependent with the underlying engagement of specific brain structures. We examined 39 children with DLD (age 7-9) and 46 TD children matched in terms of age and non-verbal IQ with no comorbid dysfunction. All were diagnosed with language, IQ battery and ASD screening. We developed the fMRI paradigm for children of sequential SL that was based on Wang's et al. (2017) paradigm. In contrast to the classic SRT, our task does not involve visuo-spatial information and is independent of motor performance. We used two types of stimuli (verbalizable vs non-verbalizable): 4 abstract symbols, and 4 pictures of recognizable animals. We included structured sequences of 1st-order (Markov's model): probability of one symbol depends on the preceding symbol. Random sequences were a control condition. During fMRI, after being exposed to the sequence, participants were to decide which of the symbols is going to appear next. The distribution of responses was rated as a behavioral result. Children underwent two fMRI sessions separated with one-week training including 4-sessions of SL task. Preliminary results from children will be included on the poster presentation to discuss. In the fMRI experiment conducted initially to validate the SL-procedure with 36 TD adults (age 20-45) we obtained differences for statistical-random sequences in the basal ganglia: Left Putamen for all stimuli; Left Caudate for verbalizable stimuli; Right Putamen for non-verbalizabe stimuli. Moreover for verbalizable statistical sequences, there was an activity increase in the Right Insula and Left MFG. Contrast of random-statistical revealed effects in: Left Caudate, Left Nucleus-Accumbens and Right Putamen for non-verbalizable stimuli; Additionally, processing of random sequences showed an increase in activity in the right inferior frontal cortex. In conclusion, neural processing of statistical sequence is specific for stimulus type. We expect effects of DLD vs TD comparison around similar structures, that will show specificity for stimulus type.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Phonetic Competition and Speech Recognition: Effects of Clear Speech in Aphasia

***Poster B67*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Neurobiological models of language provide evidence linking comprehension deficits to lesions in the left temporal lobe. However, research suggests that damage to the left frontal brain regions can also result in speech perception impairments, especially when dealing with listening to speech under challenging conditions and when the acoustic signal is phonetically ambiguous. Substantiating these findings, recent fMRI studies have demonstrated the activation of the left inferior frontal gyrus during the resolution of phonetic competition. Additionally, the left superior temporal gyrus has been associated with speech intelligibility or perceived "goodness" of speech. When talkers use "clear speech" modes of communication, they naturally increase the acoustic distinctiveness of phonetic tokens, resulting in expanded vowel space, and more released stop consonants (as well as changes in prosody, rate, and amplitude). As such, clear speech provides a natural test case for examining the effect of naturally occurring variation in phonetic distinctiveness on comprehension. This study aimed to accomplish two goals: (1) to examine the influence of clear speech on speech recognition and (2) to investigate the hypothesis that frontal regions play a crucial role in resolving phonetic competition when the signal is more phonetically ambiguous. Nineteen participants with aphasia and 19 age-matched control participants were included in the study. They listened to sentences presented either in a clear or casual manner of production, where phonetic distinctiveness was greater for the clear manner. Immediately after, participants were presented with a word through headphones and asked to determine if it was part of the previously heard sentence. Accuracy and reaction time served as the dependent variables. Among the control participants, clear speech led to a significant advantage in terms of accuracy percentage, whereas no significant effect was observed for reaction time. These findings indicate that clear sentences resulted in reduced phonetic ambiguity, thereby facilitating the speech recognition task. In individuals with aphasia, the overall accuracy was significantly lower when compared to controls. They also exhibited only a slight benefit from clear speech, although the difference was not statistically significant. No significant effects on reaction time were observed. To summarize, the results suggest that clear speech improves speech recognition accuracy, but people with aphasia may not benefit as greatly from reduced phonetic competition. These findings are discussed in relation to the location of lesions in frontal versus temporal brain regions, the severity of aphasia, and their implications for neurobiological models of language.

Topic Areas: Speech Perception, Disorders: Acquired

## The cerebellum and its contributions to the developing linguistic cerebrum

***Poster B68*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language production deficits resulting from cerebellar lesions have been extensively documented in the literature. In children, mutism is often observed as a primary symptom, while adults commonly experience anomia and agrammatism. However, comparatively less attention has been given to language comprehension impairments following cerebellar insult. Addressing this research gap, our study aimed to conduct a comprehensive literature review focusing on language comprehension deficits observed in children with cerebellar lesions. Our review revealed that younger children are more prone to developing persistent language comprehension deficits compared to adolescents, which contrasts with the short-term impairments observed in adults. These findings suggest the existence of a crucial developmental gradient in cerebellar involvement in language processing, highlighting the role of the cerebellum in early speech processing development. One possible explanation for the cerebellum's engagement in language comprehension functions is its contribution to sensorimotor integration. Rapid perception and monitoring of incoming sensory information, such as the auditory perception of phonemes and the visual cues provided by a speaker's mouth movements, are integral to language comprehension (Hickok, Houde & Rong, 2012). Other classic theories of cerebellar functioning, prediction and timing, may be plausible explanations for the cerebellum’s involvement in language perception. In addition to investigating the most suitable theory to explain cerebellar involvement in language processing, we also speculate that disruptions in cerebro-cerebellar circuit development may underlie aspects of language dysfunction observed in dyslexia and autism

spectrum disorder. This intriguing possibility warrants further exploration and could contribute to a deeper understanding of the neurobiological basis of language impairments in these conditions. Overall, our review sheds light on the importance of considering language comprehension deficits in the context of cerebellar lesions, emphasizes the developmental gradient of cerebellar language processing, and proposes potential connections between cerebellar involvement in language and neurodevelopmental disorders such as dyslexia and autism spectrum disorder.

Topic Areas: Speech Perception, Disorders: Developmental

## Reduced Neural Speech Tracking in Adolescents with Listening Difficulty: The Role of Talker Cues in Competing Speech Tasks

***Poster B69*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Background: An estimated 1-5% of children with clinically normal audiograms experience listening difficulty (LiD). This condition manifests as challenges in hearing and comprehending speech, particularly when multiple talkers speak simultaneously. These difficulties can, in turn, negatively affect language acquisition and cognitive development. A critical component for focusing on a target speaker among multiple talkers is the slow amplitude modulation, or amplitude envelope, of speech sounds. Speech amplitude envelope is integral to neural speech tracking, which represents the synchronization of cortical neural signals with the speech envelope. Neural speech tracking is quantified using inter-event phase coherence (IEPC) in the theta band neural signals, which occur following rapid increases in the amplitude envelope. During tasks involving competing speech, participants utilize different cues to segregate speech. Prior research has emphasized the role of spatial cues, which segregate speech based on location, and talker cues, which segregate speech by speaker identity. These cues represent auditory sensory and cognitive processing, respectively. Objective: This study aimed to contrast speech tracking between children with and without LiD, evaluate the influence of spatial and talker cues, and explore the association between speech tracking, cognitive performance, and parental reports of listening skills. Methods: We studied 14 adolescents with LiD and 15 typically developing (TD) controls using magnetoencephalography (MEG), behavioral tests, and questionnaires. The diagnosis of LiD was confirmed using parental reports of listening skills. During the MEG recording, participants listened to five stories, each lasting five minutes. One story was noise-free, while the remaining four with competing speech, where participants were instructed to concentrate on one speaker amongst three. Competing speech conditions varied based on the presence of talker and spatial cues. We compared IEPC across groups using 2D cluster-based permutation tests. We applied mixed-effect models to examine the effect of group, noise,

spatial cue, talker cue, and their interactions. Furthermore, the associations between theta IEPC, cognitive performance, and parental reports of listening skills were evaluated using linear regression models. Results: Both TD and LiD participants showed significant neural speech tracking in bilateral temporal sensors, diminished in competing speech conditions. The LiD group exhibited lower speech tracking than the TD group, indicating impaired speech envelope processing. Uniquely, only the LiD group improved speech tracking with talker cues, suggesting a heightened susceptibility to loss of these cues and echoing known cognitive processing challenges. Both groups significantly improved with the presence of both talker and spatial cues, hinting at a synergistic effect. Despite significant associations between speech tracking measures, listening, and cognitive skills in simple regression models, these associations were non-significant after controlling for group differences, suggesting these associations were due to the different listening and cognitive performances between the groups. Conclusions: This exploratory study demonstrated speech tracking in children with and without LiD. Our findings suggest that adolescents with LiD have lower speech tracking and may utilize different cues to segregate competing speech, indicative of potential impairments in cognitive speech processing.

Topic Areas: Speech Perception, Disorders: Developmental

## Statistical knowledge aids spoken word recognition with phonological tone in stutterers

***Poster B70*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Recent evidence has indicated that apart from disfluent production behavior, stutterers are also degraded in speech perception relative to typical, nonstuttering individuals. It is less known, however, of whether statistical learning plays a role in stutterers' abnormal speech perception. The current study recruited stutterers who spoke Mandarin Chinese and examined their abilities to track statistical regularities, namely syllable token frequency and syllable-tone co-occurrence probability, embedded in their native speech for spoken word recognition. Correspondingly, an auditory-perceptual gating experiment was designed. With close-matched age, working memory, gender ratio, and education level between the two groups, seventeen stutterers and 20 nonstuttering controls participated in this study. The auditory stimuli were 48 syllable-tone words varying in syllable frequency (high and low frequent syllables) and tone probability (more and less probable tones), determined using a spoken word corpus of Mandarin Chinese. Besides, these monosyllabic words were manipulated in acoustic length; that is, each word was segmented into eight successive gates, where stimuli in Gates 1 and 8 were the word onset and the complete word, but in Gates 2 through 7, their acoustic information of the rhyme gradually extended with the increment size fixed at 40 ms. Using Pinyin that specifies syllable and tone, participants needed to type the perceived words played from Block 1 (Gate 1) to Block 8 (Gate 8). Their responses were analyzed using mixed-effects models in terms of correct syllables, correct lexical tones, correct syllable-tone words, and correct-syllable-incorrect-tone errors, in order to comprehensively estimate their processing of segments and suprasegmentals. Results showed the differences that occurred between the two groups: stutterers had fewer correct responses to syllables, tones, and their combination as words than their fluent peers. Notwithstanding, stutterers' performance profiles patterned similarly to typical controls, as they had more accurate responses to high-frequency syllables, high-probability tones, and tone errors in all manners akin to those of nonstuttering controls. To conclude, this study corroborated that stuttering negatively affects speech perception. However, stutterers are capable of perceiving the words with phonological tones by using their statistical knowledge to track speech regularities in their native language. Their degraded speech perception is hence less likely a result of a faulty statistical learning mechanism. Combined our findings with those of previous studies that implied the effect of statistical information on stutterers' speech production, the link between perception and production can be supported. Moreover, future translational research may have a try to design an intervention program with a component relating to stimulus statistics, i.e., the materials may be chosen or separated by taking their statistical properties into account, in the hope of remediating stuttering.

Topic Areas: Speech Perception, Disorders: Developmental

## The Development of Excitation-Inhibition Balance relates to Speech Processing: Evidence from EEG

***Poster B71*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Sensory processing relies on the collective interactions of billions of neurons, which communicate by sending either excitatory or inhibitory signals (Wu et al., 2011). In healthy brains, excitation and inhibition are in check (E/I balance; Rubenstein & Merzenich, 2003), meaning that cortical excitation in response to a stimulus is followed by proportional inhibition, allowing for the effective encoding and interpretation of sensory information (Oswald et al., 2006). Here, we test the relevance of E/I balance for auditory processing of speech. To include a maximal range of E/I balance, we analyze electroencephalography (EEG) data from both healthy children and a group of children with autism, for which prior work, including our own (Plueckebaum et al., in revision), has observed E/I imbalance (Sohal & Rubenstein, 2019). We examined the relationship between E/I balance and auditory processing of naturalistic speech for a final sample of 64 non-autistic children matched by age, sex, and nonverbal-IQ to 58 autistic children between 6 and 17 years of age. We employed a recently introduced functional measure of E/I balance based on the amplitude and temporal autocorrelation of alpha oscillations in resting-state EEG recordings (Bruining et al., 2020). Auditory speech processing was quantified through EEG encoding models (temporal response functions, TRFs; Crosse et al., 2016) using the speech spectrogram as predictor. In addition to the neural measures, individual differences in general autism symptoms were assessed for all children using the Autism Spectrum Screening Questionnaire (ASSQ). We observed significant prediction accuracies to the spectral TRF model for non-autistic and autistic groups (both $p < .001$), which we employed as indicators of speech processing. We also found a significant relationship between the developmental trajectory of E/I balance and speech processing ($p = .048$). Specifically, we observed that better neural processing of speech was related to balanced E/I across childhood. In contrast,

lower spectral processing responses were linked to an increase in relative excitation and thus E/I imbalance in older children. Critically, we find that the relationship between speech processing and E/I balance was significantly moderated by individual differences in general autism symptoms ($p = .03$). Children with more pronounced autism symptoms displayed a stronger relationship between E/I imbalances and speech processing than children with less pronounced symptoms. Our results provide evidence for a relationship between E/I balance and auditory–sensory speech processing, highlighting the potential vulnerability of speech processing in autistic children to an E/I imbalance compared to their non-autistic counterparts. Our results support the proposal that E/I balance is crucial for the spectro–temporal response tuning of the auditory cortex and highlight the importance of understanding E/I balance in the neurobiology of language.

Topic Areas: Speech Perception, Disorders: Developmental

## Early neural encoding of acoustic-phonetic information is consistent across language ability

***Poster B72*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Speech is a complex signal. Even at the level of individual speech sounds (like the /g/ in “goal”), there is wide acoustic-phonetic variability across productions. In general, listeners are remarkably sensitive to this variability. The N100 ERP component reflects this sensitivity. Specifically, the amplitude of the N100 is graded with respect to voice-onset-time (VOT, a temporal cue for identifying stop consonants) such that the N100 amplitude linearly increases as VOT decreases. Individual differences in sensitivity to acoustic-phonetic information have been observed in behavior. For example, some listeners with language impairment (e.g., developmental language disorder, specific language impairment) show weaknesses in speech sound identification and discrimination, and some theories posit that these deficits may underlie the linguistic deficits associated with language impairment. However, an open question in this domain is whether individuals with weaker language ability (characteristic of language impairment) show differences in acoustic-phonetic cue encoding at the neural level. Therefore, the goal of this experiment was to examine the relationship between language ability and early neural encoding of acoustic-phonetic information. We used the N100 ERP component to investigate whether listeners with weaker language ability demonstrate diminished sensitivity in their encoding of VOT relative to listeners with stronger language ability. Listeners ($n = 77$) completed a battery of standardized assessments to measure their language ability, as well as a phonetic identification task while EEG was recorded. In the phonetic identification task, listeners categorized items from 9-step minimal pair continua (e.g., “goal”-“coal”, “gain”-“cane”). Our findings revealed a strong effect of VOT on the N100 component: as VOT increased, N100 amplitude decreased, consistent with prior research. However, there was no evidence to suggest that the encoding of VOT in the N100 varies with language ability. Moreover, Bayes Factor analyses provided moderate evidence for the null hypothesis (i.e., that there is no difference in the early neural encoding of VOT as a function of language ability), suggesting that listeners with weaker language ability may not show reduced sensitivity to acoustic-phonetic information during early neural encoding. In summary, this study provides insights into the neural processing of acoustic-phonetic cues in

individuals with varying language abilities. While listeners overall demonstrated the expected sensitivity to VOT in the N100 component, no differences were observed in the neural encoding of VOT based on language ability. These findings contribute to a better understanding of the relationship between language ability and acoustic-phonetic processing, indicating that reduced sensitivity at the neural level may not underlie the linguistic deficits observed in populations with language impairment.

Topic Areas: Speech Perception, Disorders: Developmental

## Can we learn foreign phonetic features better together than individually? An investigation of behavioral performance and brain activity

***Poster B73*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Xueqiao Li[1], Piia Astikainan[1]; [1]University of Jyväskylä

Learning phonetic features is essential in acquiring a foreign language as it forms the basis for effectively detecting, understanding, and using the language. Previous studies have found that infants can develop better phonological perception of foreign languages in a social situation compared to learning alone. This is probably because social learning could increase motivation and engagement during learning and direct attention to useful informational cues. Knowledge of social learning regarding adult learners is still lacking, particularly in the area of phonetic foreign language learning. In the present study, we investigate the effects of social phonetic learning of foreign language features in adult participants and the underlying mechanisms for possible social learning benefits. Here, social learning is explored by comparing the efficiency of phonetic learning between two groups: learning in pair (LPair) versus learning individually (LIndi). Native Finnish speakers, who have no prior exposure to tonal languages, are taught Mandarin Chinese tones for one hour per day over four consecutive days. Learning performance is tested with behavioral and brain activity measures using a pre/post design. Each learning session includes passive exposure to speech sounds, active training, and a listen-and-repeat task. To explore the mechanisms for possible social learning benefits, participants' subjective feelings about each learning session are recorded with questionnaires. Before and after the four learning sessions, participants' behavioral responses in discrimination and categorization tasks, as well as electrical brain responses (event-related potentials, ERPs) in ignore and attentive deviance detection tasks, are measured as the outcome of learning. Currently, data from fourteen participants (LPair: n = 7; LIndi: n = 7) have been collected. Based on an a priori sample size estimation, an additional 30 participants are still needed to detect a medium effect size (a group difference in ERPs). For the behavioral responses, response times for the discrimination and categorization tasks will be investigated. Additionally, the sensitivity to detect the pair of different tones and response bias will be explored for the discrimination task, while the categorical boundary and slope of the tones will be investigated for the categorization task. ERP responses to the speech sound in an ignore condition (mismatch negativity and P3a) and an attentive condition (N2b, P3b) will be compared between the groups. In general, we hypothesize that participants who learn in pairs will exhibit better learning outcomes than individual learners after the learning. Specifically, we expect the LPair group to have shorter response times and higher accuracies than the LIndi group in the discrimination task. For the categorization task, we anticipate changes in the categorical boundary and slope, which will likely resemble those observed in native Chinese speakers more closely within the LPair group compared to the LIndi group.

Moreover, we hypothesize that the LPair group compared to the LIndi group will show larger amplitudes of ERP responses related to change detection and attention shifting after the learning sessions. The results of our study could enhance the current understanding of social language learning in adults, thereby providing evidence-based guidance for effective second language acquisition.

Topic Areas: Speech Perception, Language Development/Acquisition

## Impact of moderate prematurity on early speech perception and language acquisition in infants, a longitudinal planned study

***Poster B74*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Each year, approximately 15 million infants are born prematurely, and in France, moderate preterm infants born between 32 and 36 weeks of amenorrhea account for 44 000 births (WHO, 2023; INSERM, 2023). Preterm birth has long-term negative effects on health, cognitive, and language development (Gervain, 2015). For instance, compared to full-term infants, moderate preterms have poorer neurodevelopmental outcomes by age two (de Jong et al., 2015) and present an impaired cortical encoding of speech sounds (Francois et al., 2021). However, while much research has been conducted on extreme preterm infants, only a few studies have focused on the consequences of moderate prematurity, the most significant part of preterm birth worldwide. Besides, prospective longitudinal assessments during the first two years of life are still rare. In this interdisciplinary study, we will longitudinally examine the impact of moderate prematurity on early speech perception and vocabulary acquisition during the first two years of life. We will use EEG recordings, behavioral and neurodevelopmental assessments performed at two days of life, 3, 6, 10, 18, and 24 months to investigate the relationship between early auditory perception and language learning abilities. The EEG recordings will include cortical and subcortical evoked potentials recorded simultaneously during a passive listening task (Bidelman, 2015). Our task will include blocks with a high stimulation rate (3.45 Hz) containing the syllable /oa/ and blocks with a low stimulation rate (1.47 Hz) containing the syllable /ba/ as the standard stimulus, as well as two deviant syllables (/da/ and /ga/). These EEG data will allow us to examine the auditory hierarchy of speech perception during early development. In addition, we will assess minimal-pair word-learning using eye-tracking measures to obtain crucial information on infants' associative learning skills. Finally, language development will be assessed using the Bayley Scale and the MacArthur-Bates Communicative Development Inventory. By combining neurophysiological measures, behavioral, and neurodevelopmental data, we will comprehensively examine the complex relationship between early speech perception and vocabulary acquisition and evaluate the impact of prematurity. We expect moderate preterm neonates to show lower amplitudes of cortical evoked potentials and longer latency compared to full-terms, and this pattern will be associated with delayed language development at age 2. Our study will have important implications for developing early interventions for moderate preterm infants by identifying early biomarkers of language delay.

Topic Areas: Speech Perception, Language Development/Acquisition

## Prosodic cues support acquisition of adjacent and nonadjacent regularities from continuous speech

***Poster B75*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In language acquisition, learners have to extract salient units from a continuous stream of speech. These units may be adjacent (e.g., in word-level segmentation) or nonadjacent (e.g., in syntax, the present continuous tense is _ing forms a nonadjacent regularity). Previous research suggests that regularities are tracked at both adjacent and nonadjacent levels ("statistical learning"), and familiar words also show word-level neural entrainment (Batterink & Paller, 2017; Smalle et al., 2022). Perceptual cues, such as pauses, prosodic cues or phonological similarities, facilitate learning; with nonadjacencies, they may be a prerequisite (Isbilen & Christiansen, 2022; Martinez-Alvarez et al., 2023). Here, we investigated how natural prosodic cues (i.e., pitch changes) in speech streams affect statistical learning of adjacent and nonadjacent regularities. In a series of online experiments, Finnish native participants (n=147) passively listened to structured speech streams containing meaningless CVCVCV triplets with both adjacent ("ABC") and nonadjacent ("AxC") regularities. The triplets matched Finnish phonotactics and had a phonologically balanced syllable distribution, corresponding to naturalistic speech. The experiments differed in prosody, which was either flat or had a "high-neutral-low" pitch structure for each triplet, typical for pragmatic emphasis in Finnish speech. Thus, without pitch cues, learning the triplets was only possible based on transitional probabilities between syllables, whereas the prosody structure also included pitch cues. A two-alternative forced-choice (2AFC) task probed learning of adjacent and nonadjacent regularities. To tease apart the learning of adjacent and nonadjacent regularities, nonadjacent regularities were presented in a triplet containing a novel middle syllable ("AyC") in the 2AFC task. They were pitted against foils with two familiar syllables and one novel syllable with a syllable transitional probability of 0 in the stream. Without prosody, participants' performance was above chance with adjacent regularities ($p < .001$) but not with nonadjacent regularities. With perceptual cues, i.e., prosody, participants' accuracy was above chance on both adjacent and nonadjacent regularities ($p < .001$). Prosody facilitated learning with both types of adjacencies ($p < .001$). Our results indicate that natural pitch changes in continuous speech support learning of statistical regularities. Our future studies will investigate how prosodic cues affect neural tracking of speech streams and brain mechanisms that support the acquisition of adjacent and nonadjacent regularities.

Topic Areas: Speech Perception, Language Development/Acquisition

## Neural Speech Encoding Mechanisms During the First Year of Infant Development: A Longitudinal EEG Study

***Poster B76*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language acquisition is a unique expertise that infants are able to master at very early stages of development. Language milestones are well depicted across literature for the first months of age in different populations and languages. However, neural mechanisms underlying these maturational processes are still poorly understood. Here, we use an auditory evoked potential termed frequency-following response (FFR) to unravel the developmental trajectory of the neural encoding of speech sounds during the first year of life. The FFR is generated by periodic sounds such as speech or music, and it allows assessing the tracking accuracy of complex sound features in the auditory pathway. It is sensitive to musical and language experience and it appears disrupted in children with speech or language impairments and neurodevelopmental disorders, which supports the aim of using this response as a possible biomarker for speech encoding impairment and literacy achievements. The FFR was elicited by a tailored two-vowel stimulus /oa/ that allows analyzing the neural encoding of the stimulus envelope and of its temporal fine structure. 41 healthy-term neonates were tested at birth and retested at the ages of 6 and 12 months. Results revealed a shortened neural lag for the first 6 months of development that stabilizes up to the age of 12 months, with a similar trend depicted for the maturation of the stimulus temporal fine structure encoding. Remarkably, no significantly different stimulus envelope encoding was observed across the three time-point measurements. This study adds new knowledge to the literature, describing the rapid maturation of the fine structure encoding abilities, already present at the early age of 6 months. It further contributes to characterize the neural developmental trajectory behind speech perception abilities during the very early stages of life. Results point to a sensitive developmental window in language acquisition occurring during the first 6 months of life, that may underlie the co-occurring critical milestones at that period. This study supports the FFR use to assess early abnormalities that could be associated to later language impairments. Funding: Project PID2021-122255NB-100 (MCIN/AEI/10.13039/501100011033/FEDER,UE), María de Maeztu Center of Excellence CEX2021-001159-M (MCIN/AEI/10.13039/501100011033), the 2021SGR-00356 Consolidated Research Group of the Catalan Government, and the ICREA Acadèmia Distinguished Professorship awarded to Carles Escera.

Topic Areas: Speech Perception, Language Development/Acquisition

## Cortical tracking of prosodic and statistical regularities in artificial speech

***Poster B77*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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During language acquisition, extracting statistical regularities is crucial for speech segmentation and word

learning. Recent work suggests an involvement of rhythmic brain activity in the learning of abstract statistical regularities. On the other hand, rhythmic activity has also been known to track acoustic patterns. Specifically, activity in the delta band has been found to track both prosodic and statistical cues. It remains unclear whether distinct neural circuits are involved in the tracking of prosodic and statistical rhythms and how they jointly impact learning. We employed an artificial lexicon of syllables in a frequency-tagging MEG experiment, and used a 2-by-2 design to orthogonally manipulate prosody (flat versus rhythmic) and syllable transitional probabilities (TPs; TP-uniform versus TP-rhythmic). Syllables were concatenated into isochronous streams (3.3 Hz), where low-TP events and/or prosodic boundaries delineated tri-syllabic chunks; in rhythmic conditions both types of events would occur isochronously as well (1.1 Hz). Each condition includes a learning phase and a test phase. In the learning phase, we exposed subjects to the streams. In the test phase, we presented pairs of trisyllabic artificial chunks and part-chunks (crossing over a chunk boundary) followed by a two-alternative forced choice (2-AFC) task to assess explicit learning. We collected behavioral and MEG data from 30 participants. Behavioral analyses were performed with binomial linear mixed effect models. We found a main effect of prosody, no effect of structure, nor an interaction between these factors. Post-hoc pairwise comparisons indicate learning in both TP-rhythmic and TP-uniform conditions when prosody was rhythmic, but not when prosody was flat. Since rhythmic prosody and TPs are known to constitute strong cues for chunking, we additionally investigated carry-over effects throughout the experiment depending on the presentation order of the four conditions, which was counterbalanced across participants. A model including a three-way interaction between the factors TP, prosody, and condition order as predictors showed improved fit compared to reduced models. Interestingly, we here found a greater facilitatory effect of prosody on learning when the TP-rhythmic condition with rhythmic prosody was presented in the first block, but not when it was presented in the last block. While it has been debated whether offline behavioral tasks are suitable to assess statistical learning in artificial language studies, neural tracking at the chunk rate has been considered a more sensitive metric. We are currently conducting the MEG analyses, and we are intending to present our results at the conference. In the learning phase, we expect high inter-trial phase coherence (ITPC) at the syllable rate (3.3 Hz) in all conditions, particularly in the auditory cortices. Additionally, we expect high ITPC at the chunk rate (1.1 Hz) in the right superior temporal gyrus for prosody conditions and in left fronto-temporal regions for TP-rhythmic conditions. In the test phase, we expect decreased M400 amplitudes in response to artificial chunks, relative to part-chunks, which would suggest reduced processing efforts for learned lexical items. This study can show that rhythmic processing of TPs and prosody is neurally dissociable and jointly impacts word learning.

Topic Areas: Speech Perception, Language Development/Acquisition

## Phase-Amplitude Coupling for the Integration of Predictive and Structural Cues during Language Comprehension

***Poster B78*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Humans excel at extracting meaning from speech despite the inherent physical variability of spoken language.

Despite the presence of masking background noise or while encountering new accents, speech is almost effortlessly comprehended. One mechanism underlying such robustness to noise and variability is for the brain to predict its sensory input and, to some extent, the linguistic content conveyed. Although prediction over a sequence of words is non-trivial, regularities exist. Word-level predictions can be computed from those regularities, over sequences, and over syntactic structures and categories, and also within words at the phonemic level and so forth down to acoustic information. But to extract meaning from a sentence, the brain must also interpret and process hierarchically organised phrases. The syntax must be jointly processed as the utterances are predicted for the listener to access the intended meaning. This study considered syntactic features reflecting operations working on nested phrases together with surface statistics based on word sequential predictability in order to describe cortical responses. We analysed magnetoencephalogram (MEG) signals, emphasising the role of cortical oscillations, particularly on phase and amplitude dynamics. Participants' MEG was recorded while they were asked to listen to audiobook stories in their native language. We used linear forward encoding models to model the brain response to different word features comprising rule-based -such as depth of syntactic trees and the number of closing branches- and statistical features -such as entropy and surprisal. The first result presents the joint contribution of statistical and syntactical word-level features. They demonstrate synergic and overlapping roles during speech processing, although with distinct temporal dynamics. But furthermore, by estimating temporal response functions in the complex domain, we could directly compute a metric for phase consistency and phase-amplitude coupling from continuous recordings while disentangling the contributions of different features. We found above chance delta-beta coupling linked to each linguistic word-level feature, with only a few eliciting a theta-gamma coupling after word onset. The entropy of a word, and the number of syntactic structures being integrated at that word (equivalently, the number of branches in a bottom-up constituency parser), resulted in a synchronous increase in the phase-amplitude relationship. This study offers new perspectives for analysing continuous signals in response to speech while providing theoretical insights into the mechanisms at play during listening.

Topic Areas: Speech Perception, Methods

## Explaining individual differences in noisy speech perception using multidimensional scaling of fMRI response patterns

***Poster B79** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Humans have the unique ability to decode the rapid stream of language elements that constitute speech. Although auditory noise in the environment interferes with speech perception, perceivers can partially compensate using visual information from the face of the talker. However, individuals vary greatly in their ability to understand noisy audiovisual and auditory-only speech. BOLD fMRI was used to examine the neural correlates of individual differences in noisy speech perception. Thirty-seven participants were presented with speech in five formats: audiovisual speech with and without added auditory noise; auditory-only speech with and without noise; and visual-only speech, and reported the intelligibility of the speech with a button press. An event-related design was used to sort noisy speech trials by their intelligibility. Individual-differences multidimensional scaling was applied to the fMRI response patterns to create representational space from the patterns of activity in superior temporal cortex evoked by speech. The distance in representational space between intelligible and unintelligible noisy speech served as a neural index of intelligibility; separate indices were calculated for audiovisual and auditory-only speech. For every participant, the neural intelligibility index was greater for audiovisual speech than auditory-only speech, matching the greater perceptual intelligibility of noisy audiovisual compared with auditory-only speech. The neural index also predicted individual differences. Participants with larger neural indices were better able to understand noisy speech, a relationship that held for both auditory-only and audiovisual speech. Individual differences multidimensional scaling sheds light on the neural mechanisms for the well-documented improvement in noisy speech perception when the face of the talker is visible; and on the substantial individual differences observed across healthy individuals in their ability to perceive noisy speech. This knowledge may help in the development of strategies for helping those with impaired speech perception.

Topic Areas: Speech Perception, Methods

## Rhythmic Auditory Stimulation of Cortical Tracking of Speech in Basque-Spanish Bilinguals

***Poster B80*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Long and short-term musical training leads to benefits in speech processing. Musical stimulation is proposed to influence auditory cortical tracking efficiency, the mechanism through which brain oscillations synchronize to the acoustic temporal structure of external stimuli, resulting in more efficient speech processing in individuals who have received music exposure. However, the precise features of musical stimulation that lead to these benefits are debated. Here, we show how the rhythm structure of the musical signal can guide the temporal dynamics of auditory oscillations phase-aligned to the speech envelope. We assessed this proposal by investigating the effects of prior exposure to rhythmic structure in musical sequences on cortical tracking of speech in Basque-Spanish bilingual adults. Our experimental design took advantage of participants' bilingual background, enabling the assessment of the effects that language-specific musical rhythms may have on cortical tracking of speech. Participants completed a listening task in Spanish and Basque. Each trial consisted of a melodic sequence immediately followed by a spoken sentence. Three experimental conditions were created by manipulating the beat structure of the melodic sequences: 1) Matching Regular, which reflected and matched the syllabic structure of the sentences, 2) Mis-matching Regular, which reflected a regular rhythm but did not match the syllabic structure of the sentences, and 3) Irregular, which followed an irregular rhythm. Cortical tracking of speech (speech-brain coherence) was calculated as the frequency-specific phase synchronization between the brain signal (recorded using electroencephalography) and the corresponding stimuli envelope weighted by their relative amplitude. In Experiment 1, participants (N=33) showed higher coherence of Spanish speech sequences in the delta band (~2 Hz) in the Matching Regular condition compared to Irregular and Mis-matching Regular conditions. In the theta band (~4 Hz), coherence

was higher for the Matching Regular condition compared to Mis-matching Regular. Surprisingly, no effects were observed in Basque. Further inspection of the stimuli suggested that the unexpected cross-linguistic findings in Experiment 1 may be due to the stimuli's more accurate representation of the prosodic structure of Spanish than Basque (while both are syllable-timed languages, Basque exhibits characteristics of both syllable- and stress-timed languages). To test this, Experiment 2 was conducted on a sample of 19 participants from Experiment 1, using stimuli adapted to the natural characteristics of Basque. Results showed higher coherence for Basque speech sequences, for both delta (~1.6 Hz) and theta (~3.6 Hz) bands, in the Matching Regular compared to Mis-matching Regular and Irregular conditions. Coherence was also higher in the Mis-matching Regular compared to the Irregular condition. Our results demonstrate a rhythm-to-speech benefit in cortical tracking of speech. Listeners benefitted from rhythmic scaffolding that matched the syllabic structure of the subsequent speech. While brain oscillators adapt to a wide range of rhythmic stimuli, the optimal matching between the rhythmic priming (Matching Regular condition) and the upcoming speech leads to a significant improvement of cortical tracking. These findings inform the relationship between the neurobiological mechanisms of cortical tracking and the rhythmic structure of speech and music.

Topic Areas: Speech Perception, Multilingualism

## Exploring the Effects of Anodal tDCS on Left Temporoparietal Cortex Function in Logopenic Variant Primary Progressive Aphasia (LvPPA): A Magnetoencephalography (MEG) Study

***Poster B81*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Logopenic variant primary progressive aphasia (lvPPA) is characterized by difficulties in language production, specifically in the phonological domain. Individuals with lvPPA face challenges in accessing and retrieving words from their mental lexicon, resulting in difficulties with naming, propositional speech, and impaired sentence comprehension due to phonological short-term memory deficits. Previous research has suggested that transcranial direct current stimulation (tDCS), a non-invasive brain stimulation technique, holds promise for improving language abilities in individuals with aphasia caused by stroke or neurodegenerative conditions. However, the precise neural mechanisms underlying this effect, particularly the impact of tDCS on language processing, remain incompletely understood. This study aimed to investigate the effects of anodal tDCS, which enhances cortical excitability, on the neural correlates of auditory word recognition using magnetoencephalography (MEG) in patients diagnosed with lvPPA. Four individuals with lvPPA underwent MEG scanning while performing an auditory word recognition task. MEG scans were conducted both before and after receiving either anodal or sham high-definition tDCS (HD-tDCS) over the left posterior parietal lobe in daily treatment sessions over two weeks, along with concurrent training on nonword repetition. The MEG task involved listening to 120 words and pressing a button when one of the five target words was recognized. Word presentation occurred in three blocks, each consisting of 40 distractor words and five target words. The distractor words were semantically and phonologically unrelated to the target words. The analysis focused on the event-related fields of the distractor responses. The source magnitudes of the regions adjacent to the stimulation sites in the left parietal lobe, as well as the laterality index (LI) of the temporoparietal network, were compared between the anodal and sham post-stimulation responses. MEG responses to word stimuli revealed consistent engagement of a left temporoparietal network in all patients, both before and after each two-week tDCS cycle. Following anodal stimulation, there was an increase in response magnitudes in the left parietal region compared to the baseline condition, ranging from approximately 20% to 50%. Conversely, only one out of the four participants exhibited increased response magnitudes in the same regions after the sham stimulation. In comparison to sham stimulation, anodal stimulation resulted in response magnitudes that were 10% to 70% higher in all four patients. When examining LI values within the temporoparietal network between the pre- and post-stimulation conditions, three out of four participants demonstrated increased (more left-lateralized) LI after anodal stimulation, while the same percentage exhibited decreased LI after the sham stimulation. Anodal stimulation also led to enhanced left hemispheric dominance, ranging from 9% to 16%, when compared to sham stimulation. These findings suggest that anodal stimulation has the potential to promote brain plasticity, leading to increased functional engagement in targeted regions during task performance. However, further research is needed to validate these findings using a larger sample of individuals with lvPPA. It is also important to determine whether the observed enhancement of cortical engagement in the left temporoparietal network, induced by anodal tDCS, translates into measurable improvements in behavioral performance on language tasks.

Topic Areas: Speech-Language Treatment, Computational Approaches

## tDCS-supported phonological therapy improved word retrieval in a patient with semantic variant of primary progressive aphasia (svPPA)

***Poster B82*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: Primary progressive aphasia (PPA) is a common form of presenile dementia and belongs to the frontotemporal dementias (FTD) [1]. Individuals affected by PPA suffer from a progredient language loss. Depending on the location of the cortical degeneration, different subtypes of PPA can be distinguished [2]. The semantic variant of PPA (svPPA) is typically caused by atrophy of the left temporal lobe. Persons affected by svPPA develop difficulties in language comprehension and production due to the loss of semantic knowledge [3]. To facilitate word retrieval in these patients, multimodal therapies that also focus on orthographic or phonological features are used in addition to semantic-based therapies [4]. Furthermore, there is evidence of facilitation of word retrieval in patients with semantic deficits following phonological component analysis (PCA) [5]. In the current study, we treated a 58-year-old female suffering from svPPA using the PCA with the aim of improving the patient's naming abilities by strengthening language networks. Additionally, we combined the PCA with anodal transcranial direct current stimulation (tDCS) over the left anterior temporal lobe to enhance a potential therapeutic effect. Methods: The patient trained in four intervention blocks, each consisting of a baseline test, 10 working days of practicing, and two intermediate tests approximately 3 and 13 days after the last training. Additionally, comprehensive diagnostic sessions on overall cognitive and language abilities were conducted one month before the PCA-tDCS intervention started and two months after it ended (pre- and post-test). Results: Using binomial logistic regression, we found that practicing predicted better naming performance during the two intermediate tests (Estimate = - .899, SE = .185, Z = - 4.85, p < .001). Additionally, the second testing time point (approx. 13 after the intervention) significantly predicted better naming skills of untrained items compared to baselines (Estimate = .389, SE = .184, Z = 2.1, p = .036). This pattern was interpreted as a generalization effect that may have occurred because of the combination of tDCS and therapy. The observed improvements remained stable for at least 14 days. Furthermore, the last baseline test predicted better naming skills when compared to the first baseline (Estimate = - 0.695 SE = .308, Z = - 2.26, p = .024). This indicates sustainability of improvements longer than 14 days. The pre- and post-test revealed stable language and cognitive abilities, with a trend of decreasing grammar skills, but also improved phonematic and semantic word fluency, as well as a trend toward better scores on the Boston Naming Test. Conclusion: To date, there are only a few therapeutic approaches for svPPA. Our findings suggest that PCA combined with tDCS could improve or maintain word retrieval in this progressive disease. References: [1] Bang, J., Spina, S. & Miller, B.L. (2015). The Lancet, 386(10004), 1672-1682. [2] Gorno-Tempini, M.L. et al. (2011). Neurology, 76(11), 1006-1014. [3] Reilly, J. & Peele, J.E. (2008). Semin Speech Lang, 29(1), 32-43. [4] Henry, M.L. et al. (2019). J Speech Lang Hear Res, 62, 2723-2749. [5] Leonard, C., Rochon, E. & Laird, L. (2008). Aphasiology, 22, 92-947.

Topic Areas: Speech-Language Treatment, Disorders: Acquired

## Executive Function Influence on Language Outcomes for People with Aphasia

***Poster B83*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction. In addition to prominent language deficits, over half of people with aphasia (PWA) present with cognitive deficits (Fonseca et al., 2016), which may compound the effect the primary language impairment has on their functional communication. Executive function (EF), thought to be comprised of initiation, inhibition, planning, problem solving, and cognitive flexibility (Baddeley & Hitch, 1974; Suchy, 2015), is often affected in PWA (Fridrikkson et al., 2006). EF is thought to be a reliable predictor of long-term rehabilitation outcomes (Kaye et al., 1990), where research shows stronger pre-treatment EF skills lead to better engagement in therapy and overall language outcomes (Gilmore et al., 2019; Helm-Estabrooks, 2002). Current research has not yet identified which of the many facets of EF have the strongest influence on language outcomes. Additionally, there is scant literature on treatment that includes the training of cognition in addition to language, though it seems likely that this is crucial in increasing language outcomes in PWA with impaired cognition. The purpose of this study is to identify whether baseline EF skills influence treatment outcomes. Hypotheses are as follows: (1) Intact EF skills will lead to better language outcomes (2) Participants receiving metacognitive-language treatment will achieve greater gains in language outcomes than those receiving language treatment only. Methods. Eight participants with chronic aphasia (mean TPO= 59.25 months) and without other neurological deficits participated in a single subject multiple baseline treatment study comparing the effects of a language-based treatment (M-MAT; Rose & Attard, 2011) to homegrown M-MAT Meta, which integrates metacognitive strategies into M-MAT. Outcome measures included: (1) Western Aphasia Battery-Revised (WAB-R; language outcome), (2) Tower of London (TOL; measure of planning, problem solving, and inhibition), and Wisconsin Card Sorting Test (WCST; measure of cognitive flexibility and ability to maintain set). Following analysis, participants were placed into either a treatment responder (WAB-R AQ + ≥ 5 points; Gilmore et al., 2019) or non-responder group. Trends of baseline EF scores from the subtests of the TOL and WCST were compared between responders and non-responders. Results. Four of the eight participants demonstrated a significant increase in language outcomes (WAB-R > 5), and three of the four were those who received M-MAT Meta. Pre-treatment scores on the TOL revealed severe problem solving, planning, and inhibition impairments for three of the four participants (SS < 65); their performance on the WCST ranged from mild-severe (SS 55-85). Similar to the responders, the non-responders presented with severely impaired problem solving and planning skills (SS<65), as well as variable cognitive flexibility skills (SS 74-95). Inhibition was within normal limits for three out of the four non-responders. Conclusion. All eight participants presented with an initial EF impairment in at least one area assessed. Though EF profiles were similar between the two groups, participants receiving M-MAT Meta achieved and maintained language gains over and above those who received M-MAT. Given this, rather than focusing on how baseline EF skills influence language-focused treatment response, we should apply a treatment appropriate for the executive function and language impairments.

Topic Areas: Speech-Language Treatment, Disorders: Acquired

## Neuromodulation as a Therapeutic Approach: Addressing Phonological Errors in Naming and Word Finding in Logopenic Variant of Primary Progressive Aphasia

***Poster B84*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The logopenic variant of primary progressive aphasia (lvPPA) is characterized by impaired single-word retrieval, diminished phrasal repetition, compromised comprehension of complex sentences, and phonological speech errors (e.g., saying "cap" instead of "tap"). These phonological errors are thought to stem from deficits in phonological working memory, which can be attributed to atrophy in the temporo-parietal regions. However, the exact characteristics and underlying pathology of these phonological errors in lvPPA patients remain unclear, with the impact of temporal lobe degeneration often being overlooked. Temporal regions store subphonemic representations for consonant place and manner of articulation, which are activated during speech production. Consequently, temporal degeneration may lead to a systematic impairment in the retrieval of subphonemic characteristics in lvPPA speech, a hypothesis yet to be thoroughly investigated. Targeting these subphonemic characteristics could be critical in mitigating the progression of speech impairment associated with lvPPA. Neuromodulation, using transcranial direct-current stimulation (tDCS), may enhance the weakened connections to these subphonemic representations by stimulating intact brain regions involved in phonological processes. This makes neuromodulation a potentially promising treatment approach for lvPPA. This study primarily aimed to specify the subphonemic characteristics of lvPPA speech errors and to evaluate the effectiveness of neuromodulation as a therapeutic approach. A double-blind, sham-controlled, crossover design was employed, involving ten treatment sessions of either active or sham high-definition tDCS (HD-tDCS) paired with modified constraint-induced language therapy (mCILT). Participants' speech was recorded during an object-naming task from the Western Aphasia Battery (WAB) before treatment (baseline), after 12 weeks of sham HD-tDCS combined with mCILT, and after 12 weeks of active HD-tDCS combined with mCILT. Preliminary findings from a small sample size (n = 8) indicated that patients' phonological accuracy for consonant place and manner of articulation was lower at baseline compared to their accuracy for consonant voicing and vowel characteristics. However, patients' phonological accuracy improved after active HD-tDCS combined with mCILT, extending to place and manner of articulation, consonant voicing, and vowel characteristics such as height, frontness, and tenseness. Additionally, there was a marked decrease in the number of revisions made by patients in their speech following active HD-tDCS combined with mCILT. These results suggest that neuromodulation may effectively preserve and restore specific language domains in lvPPA patients, thereby enhancing their quality of life and potentially presenting new directions in the treatment of this condition.

Topic Areas: Speech-Language Treatment, Disorders: Acquired

## Anomia Pre-habilitation in Temporal Lobe Epilepsy Surgery: A Pilot Study

***Poster B85*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The surgical treatment of drug-resistant Left Temporal Lobe Epilepsy (LTLE) carries a risk of increasing cognitive deficits, notably verbal memory impairments and word-finding difficulties (anomia) that negatively impact personal, social, and occupational activities. An emerging approach in various surgery domains is to propose pre-habilitation programs to strengthen the patient's functional abilities before a surgical intervention, to help them cope better with its consequences. We explored the potential benefits of a cognitive pre-habilitation program on word-finding abilities. Fifteen LTLE patients were invited to participate in a speech and language therapy program that was adapted to the specificity of their difficulties. The program combined a psycho-educational face to face approach with daily, self-administered language training sessions driven by an online app. This language pre-habilitation was based on theoretical considerations from the fields of neuropsychology, cognitive neuroscience, and re-adaptation sciences, to select the ingredients thought to be most active for LTLE patients. The data summarizing word production performance before and after the intervention were analyzed using a generalized linear mixed effects model. We found a significant effect of the interaction between the factors “time” (i.e., rehabilitation program weeks) and “training” (i.e., trained vs untrained items) on the rate of correct responses. Further analysis confirmed a significant effect

from the beginning of the pre-habilitation phase. The effect was limited to trained items, suggesting the specificity of the intervention. We also observed encouraging results about the protective effect of the program on naming performance after LTLE surgery. Namely, the trained items showed a slight and non-significant performance increase after surgery compared to baseline, whereas untrained items showed a significant decline in the same comparison. We conclude that untrained items, despite their higher accuracy in the baseline phase, were less protected from post-surgical decline than trained items. Looking forward, we hypothesize that brain plasticity could have been induced by the pre-habilitation program; a reinforcement of the functional networks may have increased the cognitive reserve of the patients when faced with the surgical procedure. Our study lays the groundwork for more detailed and powerful examinations of the protective effect of pre-habilitation on language skills in LTLE.

Topic Areas: Speech-Language Treatment, Language Production

## Toward an implanted language neuroprosthesis for severe aphasia

***Poster B86*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Individuals with persistent severe aphasia after stroke typically have limited rehabilitation options. Because further conventional speech therapy is of limited value in this setting, novel therapeutic approaches are needed. This study explored the potential of an implanted neuroprosthesis for decoding lexical semantic targets from neural activity. Prior brain-computer interfaces (BCIs) proposed as communication assistance devices have largely focused on decoding motor articulation of speech, which is only useful in conditions of paralysis where pre-articulatory phonological skills are preserved, such as ALS. Despite impressive advances in this technology, this approach is not applicable to individuals with severe phonological deficits, such as those with stroke-induced aphasia. Here we propose an alternative approach, decoding neural activity associated with lexical-semantic retrieval rather than motor planning. We performed electrocorticographic (ECoG) recordings during an awake craniotomy on a single patient engaged in picture naming and auditory definition naming tasks (151 total trials). Raw ECoG signals were filtered to high gamma power (70-200Hz) and entered into a machine learning model. The model employed several convolutional layers to capture spatial patterns in the ECoG signals followed by transformer layers to efficiently map interactions between electrodes. To leverage more data, the model was first pretrained as an autoencoder on a large corpus of signals recorded from implanted sEEG electrodes, training it on general patterns of intracranial electrical activity. Subsequently, the model was trained on the patient's ECoG data to predict individual lexical concepts. We attempted to predict the vector representation of each word in the experiential model space described by Binder et al. (Cogn Neuropsychol, 2016). We chose to train the model to map ECoG signals onto a continuous semantic space (rather than onto discrete word tokens) to force the model to attend to semantic (rather than phonological) features, and to enable the ability to perform zero-shot learning (i.e., predicting a word that was not part of the training set). Training continued until performance plateaued, and accuracy was tested using rank-accuracy of the predicted vector out of all potential vectors on a reserved sample, replicated 16 times to establish reproducibility. The model performed significantly above chance on the held back sample (average rank accuracy of 54%, $p<0.05$). We anticipate higher accuracy levels with a greater number of trials. Our study illustrates the successful implementation of a machine learning model that is able to decode word meanings from individual trials using ECoG data. Despite not yet attaining practical accuracy levels, this result affirms the feasibility of this approach.

Topic Areas: Speech-Language Treatment, Meaning: Lexical Semantics

## Tracking each variable of speech inference in the human brain with MEG decoding

***Poster B87*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language is central to human cognition: it allows individuals to share and accumulate knowledge and it structures their social interactions. Yet, the biological and computational bases of language functions remain largely unknown. To tackle this issue, we combine magneto-encephalography recordings of healthy participants with state-of-the-art deep learning models of speech and language to understand how the human brain recognizes words from a sequence of phonemes. For this, we decode, at each time samples, the phonetic and the lexical features from a linear combination of MEG sensors. We then study these decoded representations within a formal inferential model originally theorized in decision making: namely sequential evidence accumulation. Per this mathematical framework, each phoneme and word can be hierarchically modeled as pieces of evidence that incrementally specify the meaning of a sentence. We decode these phonemic and semantic activations in the brain through linear mapping, building temporal generalization matrices. Large Language Models are typically optimized to predict the next token (word or phoneme) based on an embedded context. Regarding neural data, we expect our results to show a hierarchical predictive coding architecture, whereby the brain generates a hierarchy of predictions. To test whether the language representations of the brain and of AI systems both follow the predictions of this inferential framework, we correlate the decoded representations with the stimulus posterior as approximated with Large Language Models (GPT-3, EnCodec). During natural speech processing, we can decode phonemic activations occurring around 200ms after the start of each phoneme, as well as word activations occurring around 400ms after the start of each word. Both temporal generalization (TG) matrices associated to these phonemic and word activations have oblong shapes, though the TG matrix associated to words has a later and thicker figure. This reveals a later and longer retention period of word representations over phonemic representations, coherent with a potential hierarchical processing of language. We can also decode basal expectancies as well as conditional expectancies of phonemes – the latter is approximated with Large Language Models. Moreover, we evaluate in which measures the decoded word and phonemic representations vary with the levels of expectancy of these words and phonemes, may it be basal or conditional. By providing an experimentally-approved formal framework modelling language processing in the human brain, the present interdisciplinary project sheds light on how the human brain combines words into meaning, and in which measures this human process can be compared and contrasted to latent processes of Large Language Models. By highlighting the similarities and differences between brains and modern deep neural networks, the present results promise to help bridge the disciplines of AI and neuroscience.

Topic Areas: Speech-Language Treatment, Speech Perception

## Convergent Resting State fMRI and EEG Evidence of Speech-Language Therapy and tDCS Impacts on Brain Network Connectivity for an Individual with Stroke Aphasia

***Poster B88*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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INTRODUCTION: Recent studies suggest that transcranial direct current stimulation (tDCS) combined with speech-language therapy (SLT) may enhance treatment outcomes in individuals with aphasia. However, recent reviews also highlight the inconsistent impact of tDCS on treatment outcomes in individuals with aphasia. This variability in results could be explained by our lack of understanding of how tDCS combined with SLT modulates residual brain networks to impact behavioral performance. The aim of the present study was to investigate changes in conversational performance and brain network functional connectivity (FC), following intensive tDCS and SLT. Multiple imaging modalities (i.e., fMRI, EEG) were used to provide converging evidence. METHOD: The participant, P1 (right-handed male, aged 49.84) was 71.74 months post-stroke onset. P1's WAB-R Aphasia Quotient was 65.8. P1 received 40 minutes of SLT, in the form of computer-based script practice. tDCS (2mA) was concurrently administered with the SLT for the first 20 minutes. MRI-guided neuronavigation was used to place the 'target' cathodal tDCS electrode above right angular gyrus (rAG) and the 'return' anodal electrode above center supraorbital area. P1 received 15 sessions of tDCS/SLT over 3 weeks. Resting-state fMRI data was collected pre- and post-intervention. Seed-based correlation was used to assess connectivity with AG-associated regions; e.g., default mode network (DMN). Graph analysis was used to evaluate changes in brain network properties such as intra-hemispheric FC (IHC). These properties were compared to 18 age/sex-matched healthy controls. Resting-state (rs)EEG responses were also recorded with eyes open for 3 minutes with a 64-channel system before and after treatment, on days 1, 5, 10, and 15. EEG data was analyzed in source space, with signals extracted from 4 regions of interest (left/right inferior frontal gyrus (l/rIFG), l/rAG). In order to assess changes in left- and right-hemisphere FC, a coherence analysis was performed between lIFG/lAG signals and between rIFG/rAG signals, respectively. RESULTS: The primary behavioral measure was the pre- to post-treatment change in accuracy of script-related words during the simulated conversation. Performance improved from baseline to immediately post-treatment (106.4% increase). 8/9 resting-state fMRI graph measures were found to change towards those of controls after treatment. In particular, left IHC (evaluated as the proportion of 95th-percentile to total-number-of intra-hemispheric FC edges), increased from .030 to .041, vs. the .053 healthy control mean (95% CI: .051-.056). Concurrently, right IHC decreased from .101 to .088, vs. the .066 healthy control mean (95% CI: .062-.070). Within-DMN FC also increased post-intervention. Our EEG analysis also indicated left-hemisphere FC increases post-treatment, and right-hemisphere FC decreases post-treatment. CONCLUSION: Our results suggest that cathodal tDCS applied to rAG combined with SLT increases left-hemisphere FC while decreasing right-hemisphere FC. Further, FC patterns approaching those of healthy controls may result in improvement in behavioral performance in individuals with aphasia. Results are also in line with previous brain stimulation studies indicating that left-hemisphere connectivity increases improve speech/language task performance. rsEEG results indicate ongoing impact of treatment sessions on residual brain FC. Future research is needed to further understand the differential impact of tDCS and SLT on functional network connectivity and behavioral performance.

Topic Areas: Speech-Language Treatment,

## Using Machine learning to localize Area Spt without an Spt localizer.

***Poster B89*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In the field of cognitive neuroscience of language, reliable identification of functional regions of interest is crucial for obtaining comparable findings across research studies, laboratories, and neuroimaging parameters and pipelines. In the early 2000s, numerous groups used fMRI to localize functionally specific regions of the brain thought to underlie specific "cognitive processes". Through a series of fMRI investigations focused on mapping regions jointly involved in speech perception, speech production, and verbal short-term memory, Buchsbaum et al. (2001) and Hickok et al. (2003) targeted a functional region at the posterior end of the left Sylvian fissure (Area Spt - Sylvian-parietal-temporal). This area was hypothesized to act as a bridge or interface between the perception and production of speech. Over a decade later, Glasser et al. (2016) used large-scale multimodal mapping of neuroimaging data from the Human Connectome Project to partition the entire cerebral cortex into 360 regions. One of these regions, the perisylvian language area (PSL), was anatomically co-located with the functionally-defined area Spt. Here, we present results from 15 research subjects scanned with fMRI, who underwent a 10-minute resting state scan, viewed 20 minutes of movies, and performed the classic Spt localizer (auditory-verbal short-term memory). We then trained machine learning models with spatial priors to identify the boundaries of Spt using functional connectivity patterns from the movie and resting state data. Preliminary results indicate that Spt can be localized using connectivity data derived from as little as 5 minutes of resting state data, with prediction accuracy increasing with more training data. We also examined the extent to which a group-defined PSL ROI overlapped with funcitonally-defined Spt. The results suggest rough agreement in the group-averaged data, but with significant variability across subjects. These data open up the possibility of localizing Spt in individual subjects without an explicit "Spt localizer"--and without falling back on an approximate group parcellation--thereby enabling analysis of Spt responses in a variety of historical, openly shared, or resting state-only fMRI datasets.

Topic Areas: Computational Approaches, Multisensory or Sensorimotor Integration

## Convolutional networks can be used to model the functional modulation of MEG responses during reading

***Poster B90*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Reading elicits a series of evoked responses along the left ventral stream. In MEG, notable ones are the Type I, Type II, and N400m. The location, timing, and functional behavior of these responses to different stimuli tell the story of a processing pipeline starting with basic visual analysis (Type I) to letter detection (Type II) to lexical analysis (N400m). In this study, we sought to understand this pipeline better by implementing it as a computational model. In contrast to classic models of reading, ours starts with raw pixels, which is required if one wants to reproduce all three aforementioned evoked responses. By presenting the same stimuli to both human and model, we evaluated the model's accuracy both qualitatively (response patterns to experimental contrasts) and quantitatively (correlation with MEG evoked response amplitudes). Our results show how a basic VGG11 architecture trained on ImageNet succeeds in simulating the Type I response but fails to simulate the Type II and N400m. In subsequent models where we introduced noisy activations on the units, expanded the vocabulary size, and introduced language statistics into the training set, we obtained our final model that accurately simulated all three MEG evoked responses.

Topic Areas: Computational Approaches, Reading

## Driving and suppressing the human language network using large language models

***Poster B91*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Reading and understanding this sentence engages a set of left-lateralized frontal and temporal brain regions. These interconnected areas, the ‘language network’, support both comprehension and production (Menenti et al., 2011; Hu, Small et al., 2022) and are highly selective for language relative to diverse non-linguistic input (Fedorenko et al., 2011). However, the precise representations and computations underlying comprehension remain unknown. Enabled by progress in artificial intelligence, large language models (LLMs) have emerged as today’s most accurate models of language processing in the brain (Schrimpf et al., 2021; Goldstein et al., 2022). Despite LLMs currently being the most quantitatively accurate models of language processing, there has been no attempt to test whether LLMs can causally control neural responses to language. We asked whether LLMs are accurate enough to identify novel sentences to drive (or suppress) brain activity in new participants. We first developed an encoding model to predict brain responses in the left hemisphere (LH) language network to arbitrary new sentences. We acquired BOLD responses from 5 participants who each read a set of 1,000 diverse, corpus-extracted sentences. The model takes as input representations from GPT2-XL (previously identified as the most brain-aligned language model; Schrimpf et al., 2021) and was trained, via ridge regression, to predict the average LH language network’s BOLD response. This model explained 68% of the variance when assessed on held-out sentences from the n=1,000 sentence set. We then evaluated this model by a) identifying novel sentences (across ~1.8M sentences) that are predicted to activate the language network to a maximal (or minimal) extent (250 drive and 250 suppress sentences), and b) collecting brain responses to these sentences in 3 new participants, who read the 500 new sentences along with the original set of n=1,000 sentences. The drive sentences yielded significantly higher responses than the baseline sentences (mean BOLD increase of 86%, $\beta$=0.27, t=9.72, p<.0001), and the suppress sentences yielded lower responses than the baseline sentences (decrease of 98%, $\beta$= -0.29, t=-10.44, p<.0001). Hence, these model-selected sentences can indeed drive and suppress activity of human language areas in new individuals. We then asked: what makes drive sentences elicit strong responses? What stimulus properties is the language network most responsive to? We collected a diverse set of linguistic and semantic norms on the 1,500 sentences used in this study (across n=2,700 independent participants using web-based platforms). A systematic analysis of the model-selected sentences revealed that surprisal and well-formedness of linguistic input are key determinants of response strength in the language network. Sentences in the mid-range of the well-formedness scale elicited stronger responses than sentences on the lower and higher ends of the scales, indicating that the language network responds strongly to sentences that are 'normal' enough to engage it, yet complex enough to tax it. In summary, these results establish the ability of model-selected sentences to noninvasively control neural activity in higher-level cortical areas, like the language network. Furthermore, we demonstrate that brain responses to model-selected sentences can provide valuable, assumption-neutral insights into the computations underlying language processing.

Topic Areas: Computational Approaches, Reading

## Contextual Facilitation in Language Comprehension: Insights from a Unified Predictive Coding Framework

***Poster B92*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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A central question in psycholinguistics is how form is mapped onto meaning during incremental language comprehension. Critically, when provided with constraining contextual information, this mapping process is often facilitated, resulting in both faster behavioral responses and reductions in evoked neural activity. However, the underlying sources of these neural and behavioral facilitation effects and their relationship to each other remains an open question. In previous modeling work, we simulated various contextual effects on the N400 using predictive coding principles. In the predictive coding framework, each hierarchical level of the cortex contains two kinds of units:1) state units, whose activity encodes beliefs about the state of the world, and 2) error units, which update these beliefs by signaling inconsistencies in representations between cortical levels . By passing predictions and prediction error between layers, these state and error units can extract high-level structure from low-level sensory information. Importantly, the summed activity of lexical and semantic error units in this model captured key properties of the N400 response, including its sensitivity to a wide range of contextual factors. Here, we shift our focus to the activity in the state units, and show that the same model accurately captures behavioral facilitation effects from the same set of contextual manipulations, including word repetition, semantic priming, lexical predictability, anticipatory semantic overlap and the null effect of constraint. Our model encodes three hierarchical levels of linguistic representation: orthographic, lexical, and semantic, each with its own state units. Over time, the model converges to the correct lexical state that can accurately explain the bottom-up orthographic input. We operationalize behavioral response times as the duration (number of iterations) it takes for the activity of the most active lexical state unit to surpass a predefined threshold. To simulate word-pair priming, we presented word-pairs that were either repetitions (LIME–LIME), semantic associates (SOUR–LIME) or unrelated (BANK–LIME). To simulate lexical predictability, anticipatory semantic overlap and the null effect of constraint, the higher-level state units associated with each word were clamped to activations proportional to their predictability (cloze), before presenting any bottom-up input. Across three simulations, the bottom-up input was either identical to this top-down prediction, was semantically related, or was unrelated. Results:Similar to human readers, responses were faster for repeated and primed words. We also observed a graded reduction in response times as a function of word predictability, with no additional effect of constraint. Finally, responses were faster when the unpredicted input was semantically related to the modal prediction. Discussion:Predictive coding offers a biologically-motivated and parsimonious account of both neural and behavioral patterns in language comprehension. Our model shows that the same contextual manipulations that attenuate error unit activity (the N400) also cause lexical state units to converge more rapidly, resulting in faster behavioral responses. Importantly, because these two outcomes are tied to distinct sub-components of the model, this model predicts that some contextual manipulations (e.g. form priming) may lead to dissociations between behavior and the N400. Exploring these dissociations empirically in future work would constitute a strong test of the model.

Topic Areas: Computational Approaches, Reading

## Impact of model size and fine-tuning techniques on LLMs' resemblance to the human brain

***Poster B93*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction, Prior studies comparing GPT2 with the human brain have suggested shared computational principles between the two systems (e.g., Caucheteux & King, 2022; Goldstein et al., 2022; Schrimpf et al., 2021). Yet current LLMs such as ChatGPT are orders of magnitude larger, with novel fine-tuning techniques that enable improved contextual understanding and human-like few-shot learning. Consequently, it becomes imperative to investigate whether these latest language models exhibit enhanced human-like language comprehension at the neural level, and how model size and fine-tuning techniques affect the model's resemblance to the human brain. Methods. We used the openly available Reading Brain dataset (Li et al., 2022), which includes concurrent eye-tracking and fMRI BOLD signals during naturalistic reading of 5 English articles. The subjects included 52 native English speakers (L1) and 56 non-native learners of English (L2). For each subject, we used the eye fixation time points to extract the fMRI signals within a left-lateralized language mask time-locked to each word and constructed an fMRI data matrix for each sentence. We also extracted the saccade matrix for every sentence and we compared the fMRI and saccade patterns with the attention patterns of LLMs. To assess the effect of varying model size and fine-tuning techniques, we included GPT2 (Radford et al., 2019) with 774M parameters and the LLaMA family (Touvron et al., 2023; Taori et al., 2023; Chiang et al., 2023) with 7B, 13B and 30B parameters. The LLaMA models also contain two different fine-tuning techniques: the instruction-tuned model (Alpaca-LoRA) and the conversation-tuned one (Vicuna). We fed the 5 English articles used in the fMRI experiment into these models sentence by sentence and obtained the attention patterns in each layer and each attention head. Then we used linear regression to predict each subject's fMRI and eye movement data using the models' attention patterns at each layer. We obtained the regression scores at each layer for each subject, and compared their performance for L1 and L2 at the group level using two-sample t-tests with 1000 permutations. Results. Our regression results revealed a significant improvement in the regression score for both L1 and L2 speakers as the model size goes up from 774M to 30B. However, instruction or conversation fine-tuning did not significantly improve the model fit to either L1 or L2 speakers' neural and behavioral patterns. Conclusion. Compared to their predecessors, current LLMs better capture the human behavioral and neural patterns during language comprehension with increased parameter size. The trending fine-tuning techniques with human feedback seem to not improve the model fit to human comprehension patterns, suggesting that the current training techniques of LLMs may encourage comprehension strategies that differ from natural reading in humans.

Topic Areas: Computational Approaches, Reading

## Phonemic decoding of speech articulation using stereo-electroencephalography

***Poster B94*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Aditya Singh[1], Tessy Thomas[1], Xavier Scherschligt[1], Nitin Tandon[1]; [1]UT Health

Recent research has shown that brain-computer interfaces (BCIs) can be used to decode speech from neural activity, with the goal of aiding patients with speech impairments, such as dysarthria or aphasia. Stereo-electroencephalography (sEEG) has emerged as a means of achieving widespread coverage across multiple regions of the language network with minimal surgical risks. In this study, we employed the articulation of tongue twisters to demonstrate the use of sEEG to map and decode speech. This also provides novels ways to evince unique neural signatures of the speech network, going beyond extracranial localization and surface-based measures derived from subdural grid arrays, contributing to a refinement of existing language models. 25 patients, with sEEG electrodes implanted for seizure onset localization, participated in a tongue twister production task. Each tongue twister comprised four words with matched phonological onsets, systematically increasing articulatory complexity (e.g. just rum rug jump). Patients silently read the words, followed by two rounds of reading aloud and two rounds of memory-based production. Phoneme decoding was performed using linear classification models trained on broadband gamma activity (BGA: 70-150 Hz) recorded from the sEEG electrodes during reading and memory trials. The training and testing samples consisted of a 600ms BGA-window centered at the onset of articulation for each phoneme, and accuracy was evaluated using 10-fold cross-validation. Covert trials were separately decoded using an encoder-decoder model with a connectionist temporal classification loss function. Decoding was performed either during articulation or a pre-articulatory period to evaluate the predictive properties encoded in the latent neural information. We achieved remarkable decoding accuracies, with a peak accuracy of 25.2% during the articulatory window and 22.6% during the pre-articulatory window in the best-performing patient (chance accuracy at 7.7%). Across all 25 patients, the average accuracy was 13.3% +/- 4.4% during articulation, and 11.6% +/- 5% during pre-articulatory periods, surpassing chance accuracy of 5.1% +/- 1%. Notably, these decoding results consistently outperformed those obtained through ECoG and MEA-based decoding studies using similar linear models,

while still being considerably safer in terms of intra-operative neural trauma. Our findings revealed activation in posterior middle temporal gyrus, dorsal frontal cortex, inferior frontal gyrus, and superior parietal cortex. Moreover, we observed distinct separation in the latent articulatory space for manner and place of articulation, particularly within superior temporal gyrus and sensorimotor cortex. These regions have been associated with predictive encoding and monitoring of articulation, notably emphasized during tasks which have a larger stress on generating phonologically correct sounds when given stimuli with higher phonological load and lexical bias. Spatial decoding patterns from pre-articulatory models validated these predictive encoding sites, highlighting the presence of information-rich electrodes sparsely distributed across frontal and parietal regions, including deep sulcal sites inaccessible to subdural grids.This study significantly contributes to the development of more precise and high-fidelity assistive communication devices for individuals affected by neurodegenerative disorders that impact speech articulation and production. Furthermore, our sEEG findings refine models of the distributed speech network derived solely from extracranial neuroimaging measures, enhancing our understanding of the underlying neurobiology of language.

Topic Areas: Computational Approaches, Speech Motor Control

## A deep hierarchy of predictions enables on-line meaning extraction in a computational model of human speech comprehension

***Poster B95*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Understanding speech requires mapping fleeting and often ambiguous soundwaves to meaning. While humans are known to exploit their capacity of contextualization to facilitate this process, how internal contextual knowledge is deployed on-line by the brain remains an open question. Here, we present a model that extracts multiple levels of information from continuous speech online. The model applies both linguistic and nonlinguistic knowledge to speech processing, by periodically generating top-down predictions and incorporating bottom-up incoming evidence in a nested temporal hierarchy. We show that a nonlinguistic context level provides semantic predictions informed by sensory inputs, which are crucial for disambiguating multiple meanings of the same word. The explicit knowledge hierarchy of the model enables a more holistic account of magnetoencephalography (MEG) responses to speech containing semantically ambiguous words, compared to using lexical predictions generated by a neural-network language model (GPT-2). We also show that hierarchical predictions reduce peripheral processing via minimizing uncertainty and prediction error. With this proof-of-concept model we demonstrate that the deployment of hierarchical predictions is a possible strategy for the brain to dynamically utilize structured knowledge and make sense of the speech input. We discuss preliminary results from a MEG study that uses this model to guide the interpretation of neural information passing during speech comprehension under different tasks.

Topic Areas: Computational Approaches, Speech Perception

# Improving presurgical language mapping by a method for optimally sorting independent components of resting-state fMRI

***Poster B96*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: Pre-operative language mapping is an important component of presurgical planning of resectable brain lesions in the vicinity of eloquent areas. Many advances have been conducted in the last few decades towards the development and implementation of resting-state independent component analysis (ICA) for presurgical mapping in clinical practice. Particularly, as an alternative to task-based functional magnetic resonance imaging (fMRI) and the gold standard electrical cortical stimulation. More recently, resting-state fMRI has been used since it is a simpler technique and does not require the patient to cooperate in complex cognitive tasks. However, the methods for resting-state fMRI analysis are not yet robust or of practical usage. This work proposes a method for optimally sorting independent components (ICs) resulting from ICA so that components representing language resting-state networks take the first places in the component order. Methods: We recruited 20 healthy, right-handed volunteers and acquired both resting-state fMRI and task-based fMRI using three linguistic paradigms: object naming, verbal responsive naming, and verb generation. Task data was processed using general linear model (GLM) analysis while resting-state networks were extracted using ICA. Furthermore, it was developed an automated sorting procedure for the resting-state extracted ICs based on three characteristics: spatial similarity with the Neurosynth “language” probability map, ratio of low/high frequency and IC reliability over several bootstrapping folds. Results: Task-related activation consistent with the language network was identified at the individual and group-level. Furthermore, the proposed algorithm is shown to sort ICs with a guarantee that the resting-state language maps appear among the first five with an accuracy of 75%. When considering a symmetric language probability map which allows to be taken into account, in the algorithm, not only individuals who have left hemispheric dominance but also right and atypical language hemispheric dominance, the resting-state language maps appear among the first five sorted with a decreased accuracy of 60%. Overall, there was a good overlay between the sorted ICs of relevance and the task subject-specific language maps. The Dice coefficient measured between task and rest maps was found to be significantly higher when determined within language regions of interest rather than whole-brain analysis. Comparison between task and resting-state language maps showed that resting-state networks were more specific, reporting more activation in language-specific critical areas with fewer extraneous non-language activations when compared to task-related activation maps. However, resting-state networks were less sensitive than task language maps. Conclusion: Our findings suggest that optimally sorting components can contribute to making ICA usage viable in the clinical context since language components are more likely to be presented first, efficiently reducing the time spent in clinical evaluation. We expect that sorting components can become an alternative reliable method for presurgical planning in patients who cannot follow a task-fMRI protocol. However, further research is required to validate the sorting method proposed in a cohort of patients with brain lesions.

Topic Areas: Computational Approaches,

## A Comprehensive Analysis of the Neural Fits of Sentence Embedding Model Classes

***Poster B97*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In the past few years, neural fits based on associations between brain activity patterns and pre-trained language models have been increasingly used to validate hypotheses about language processing. However, there remain unanswered questions about what intrinsic properties of language processing these neural fits reflect. Here, we examine to which degree the neural fits differ across brain networks, language models and neural fit approaches, namely neural encoding and Representational Similarity Analysis (RSA). We employ parallel sentence and functional magnetic resonance imaging (fMRI) data from Pereira et al. (2018) that comprise short paragraphs about 96 different concepts. Based on four model classes representing linguistic hypotheses about sentence processing, we perform a comprehensive analysis of their fits to four different brain networks. Specifically, we focus on the language, task-positive and vision networks as well as the default mode network (DMN) that are predefined in the open access dataset. We apply a total of 12 sentence embedding models belonging to four different classes: masked language modeling, pragmatic coherence, semantic comparison and contrastive learning. Next, we calculate neural fits for each brain network and sentence embedding model combination using neural encoding and RSA. We implement neural encoding by adding a linear mapping model on top of the output of the sentence embedding model to predict the fMRI features. Then, we evaluate the prediction performance using pairwise accuracy, a metric based on comparisons of distances within pairs of predicted and ground truth fMRI features. For RSA, we use the Spearman's rank correlation between the representational dissimilarity matrices (RDMs) of a given sentence embedding model and brain network. Overall, GPT-2, SkipThoughts, and S-RoBERTa yielded the strongest correlations, in particular with the language network: $r=0.067$ ($p<0.001$), $r=0.082$ ($p<0.001$), and $r=0.051$ ($p<0.001$). For neural encoding, GPT-3, S-T5 and SkipThoughts resulted in the highest pairwise accuracy scores. Moreover, contrastive learning-based models resulted in overall low neural fits. Furthermore, our findings demonstrate that neural fits vary across models that represent the same linguistic hypothesis but are based on different model sizes and training data (e.g., GPT-2 and GPT-3) and neural fit approaches (RSA versus neural encoding). Notably, we show that the embedding size (i.e., the dimensionality of a sentence embedding) and model performances are correlated to each other in the context of neural encoding. These findings indicate that the high neural fit of large language models such as GPT-3 based on neural encoding is substantially influenced by its embedding size (alongside other possible factors such as model architecture and training data) rather than the inherent properties of its representational space, as reflected by its low neural fit based on RSA. In conclusion, the embedding model class does not significantly impact the resulting neural fit, as models from different classes such as GPT-2 and S-RoBERTa demonstrate comparable performance, while the embedding size proves to be one of the determining factors.

Topic Areas: Computational Approaches,

# Deep neural networks for sound classification reveal representations of natural sounds from intracerebral responses in human auditory cortex

***Poster B98*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The human auditory system is extremely adept at parsing auditory scenes into individual components, analyzing their constituent acoustic features, and sorting those components into sound categories. Many studies have attempted to explain the underlying neural representations that facilitate this transformation from a continuous and variable acoustic signal to category-level endpoints. However, this work has largely focused on using human-defined stimulus features, or in some cases using matrix decomposition techniques that explain neural responses to a set of sounds as a weighted sum across a latent low-dimensional stimulus space. Both approaches fall short in capturing the rich, complex stimulus transformations that must exist to solve the sound categorization problem. Meanwhile, recent machine learning advances have produced novel deep neural network (DNN) models that solve this exact problem, with relatively few constraints on the specific stimulus transformations that the models can use. Assuming that the models have naturally identified an optimal set of stimulus features to categorize sounds, and that the stimulus representations within the model grow increasingly complex and abstract with increasing layer depth, we can view it as a data-driven feature extractor with representations spanning the range from low-level acoustics to abstract category-level descriptions. Guided by this framework, we built encoding models to predict neural responses in auditory cortex using layer activations within a sound categorization DNN as input features, which we refer to as DNN-derived encoding models. Neural data was recorded via stereoelectroencephalography (sEEG) in 16 patient-participants while they listened to a set of 165 two-second clips of natural sounds from categories including speech, non-speech vocalizations, music, and environmental sounds. We were able to predict neural responses with state-of-the-art accuracy; furthermore, the best predictions came from shallower DNN layers for supratemporal plane (STP) channels and deeper layers for channels in superior temporal gyrus and superior temporal sulcus (STG/S). DNN-derived encoding models consistently outperformed spectrotemporal receptive field models, suggesting that all channels, including those in posteromedial Heschl's gyrus, encoded more complex representations than simple spectrotemporal tuning. Furthermore, a measure of the category encoding strength for human vocalizations (as determined by a separate analysis) was highly positively correlated with the best DNN layer across channels, demonstrating that channels traditionally described as voice category-selective were most closely associated with deep DNN layers. We then used the DNN-derived encoding models to estimate integration windows by identifying the shortest stimulus inputs that did not appreciably change the predicted neural responses; a clear anatomical segregation emerged, with integration windows of ~85-185 ms for STP channels and ~245-335 ms in STG/S. These results further elucidate the functional properties within subregions of auditory cortex: STP encodes acoustic properties (albeit with higher complexity than spectrotemporal tuning) at short timescales, while STG/S integrates over longer timescales to encode higher order stimulus transformations more akin to voice category selectivity.

Topic Areas: Computational Approaches,

## Does language influence thought? A look at past research and thoughts for the future.

***Poster B99*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Tally McCormick Miller[1], Friedemann Pulvermüller[2]; [1]Freie Universität Berlin

The idea that our language may influence our thought has persisted throughout history. Recent empirical evidence seems to point towards a conclusion: linguistic relativity effects have been seen among an ever-growing research body of empirical evidence. But how convincing are these arguments, especially if some notable skeptics remain unconvinced? Recent research into the causal effects that language has on perception has been growing exponentially in recent decades. Much of this research strongly suggests the presence of linguistic influences and interactions onto a variety of cognitive domains. However, we have yet to decipher one of the key interplays of the complicated, functional interconnectedness of language, categorization, and perception. The current state of research falls short of demonstrating the extent of the effects that language can have on our perception and has thus far not investigated if said effects can be attributed to cross-modal effects outside the domain of language, or if it is indeed something specific to language itself. Evidence of how language may shape our cognitive representation of world knowledge has been accumulating for decades (e.g. von Humboldt 1836, Whorf 1940, Thierry, Athanasopoulos et al. 2009, Boutonnet, Dering et al. 2013, Maier, Glage et al. 2014, Li, Casaponsa et al. 2019, Vanek, Soskuthy et al. 2021). Often, the focus is on how language creates individual categories, such as how we divide the spectrum of perceivable light into individual color words (Boroditsky 2000). Previous studies testing possible effects of new or known verbal labels on perception have spanned various sensory domains, including vision (Winawer, Witthoft et al. 2007, Thierry, Athanasopoulos et al. 2009, Zhou, Mo et al. 2010, Boutonnet, Dering et al. 2013, Maier, Glage et al. 2014, Athanasopoulos, Bylund et al. 2015), sound (Dolscheid, Shayan et al. 2013) and touch (Miller, Schmidt et al. 2018, Schmidt, Miller et al. 2019). It has been well argued that attributing language effects to the results attained by group comparisons is problematic due to possible confounds such as, but not limited to, differences in cultural-specific experiences or previous knowledge, which cannot be excluded when comparing groups (Freundlieb, Ridder et al. 2012). The vast majority of research, however, continues to focused entirely on intercultural differences, in that they compare native speakers of two different languages and look for group differences (e.g. Boroditsky 2001, Winawer, Witthoft et al. 2007, Boutonnet, Dering et al. 2013, Athanasopoulos, Bylund et al. 2015, Li, Casaponsa et al. 2019). Fewer studies divide participants into groups which undergo differences in their linguistic trainings and exposure (Zhou, Mo et al. 2010, Maier, Glage et al. 2014, Vanek, Soskuthy et al. 2021). But only a handful of research is able to avoid group differences and cultural confounds by using within-subject manipulation in order to test for differences (Miller, Schmidt et al. 2018, Schmidt, Miller et al. 2019). I propose an overview of what has been done, and what is lacking, in order to determine whether language can affect the nature of our perception, as well as examine putative extents and limitations of these mechanisms.

Topic Areas: Language Development/Acquisition, History of the Neurobiology of Language

## Appearance of dancing in early development predicts language development

***Poster B100*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Dancing appears early in development. Dancing is “physical movement that forms rhythmic patterns and spaces”(Kuni, 1973). Previous study analyzed the development of infants' body movements longitudinally and reported an increase in the frequency of spontaneous dancing accompanied by rhythmic movements at around 9 months of age, with a range of simple to complex rhythms (Mazokopaki & Kugiumutzaki, 2009). Why do infants dance? The timing of the appearance of dancing coincides with the prelinguistic stage of language development. During the prelinguistic period, infants begin canonical babbling. This canonical babbling has rhythmic properties, and the expression of canonical babbling can be considered sensorimotor learning aimed at producing speech (Doupe & Kuhl, 1999). In fact, delayed appearance of canonical babbling has been reported to predict delayed subsequent language development (Whitehurst et al., 1991). Findings from research on language development suggest that the appearance of dancing in infancy may be based on the development of rhythmic movements that are shared with language development. In other words, dancing promotes the learning of rhythmic movements and is thought to play an important role in the development of language. Therefore, in this study, we examined the developmental relationship between dance and language in early development. The study was conducted between 2015 and 2023 and involved 79 infants and their parents who were surveyed when their infant was 9, 12, 18, and 24 months of age. The study consisted of questionnaires for parents and a developmental test for infants. For the parent questionnaires, we administered a dancing questionnaire when the infant reached 9 and 12 months, and then at 24 months we administered the Japanese version of the MacArthur Communicative Development Inventory (CDI). In addition, we conducted the Kyoto Scale of Psychological Development (K-test) to infants at all ages to assess development in three domains: postural and motor development, cognitive and adaptive development, and language and social development. A cumulative link mixed model was used to examine the effect of dancing at 9 months of age on language development at 24 months of age. As results, there were two main findings in this study. First, the appearance of dancing at 9 months of age had a significant effect on the developmental quotients in language and social development of the K-test in at 24 months of age. Second, the appearance of dancing at 9 months of age had also significant effects on the vocabulary score and sentence complexity score at 24 months of age. This supports our hypothesis that dancing in early development promotes the learning of rhythmic movements and plays an important role in the development of language.

Topic Areas: Language Development/Acquisition, Language Production

## Speaker familiarity modulates neural signatures of lexical-semantic processing in monolingual infants

***Poster B101*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Developmental language studies have shown evidence of a lexical-semantic network in infants as young as 18-24 months (Wojcik, 2018). Other studies have shown that familiar voices may facilitate infant word comprehension in a picture-word paradigm (Parise & Csibra, 2012). However, little is known about whether voice familiarity could influence lexical-semantic processing of spoken words in the infant brain. We recorded the brain activity of thirty 18-month-old French-learning infants using electroencephalography (EEG) while they listened to auditory recordings of words spoken by one voice with which they were familiar, and one voice with which they were not familiar. Infants were familiarized with one voice for the seven days leading up to the experiment, through a procedure in which parents presented their children with audio-recordings of stories spoken by one of the two possible voices. Stimuli were presented in a semantic priming paradigm, with audio-recordings of 20 words played in both taxonomically related and unrelated pairs. All infants heard related and unrelated pairs spoken by a familiar and an unfamiliar voice. We examined event-related potentials (ERPs) to determine whether the familiar voice facilitated access to the lexical-semantic network for 18-month-old infants. In particular, we measured the N400 - a negative-going ERP at around 300-500 ms post target word onset that is commonly observed for semantic incongruences, thereby indicating access to the lexical-semantic network (Kutas & Federmeier, 2011; Junge et al., 2021). We expected to observe a larger N400 effect (greater amplitudes for unrelated than related word pairs) for familiar as opposed to unfamiliar voices. Our results showed an N400 effect over the left hemisphere, only for the familiar voice. Additionally, for unfamiliar voices, we observed a congruence effect - that is, more negativity for related than for unrelated target words. The N400 effect was obtained only for familiar voices, providing favourable evidence for our hypothesis that familiar voices facilitate access to the lexical-semantic network. The congruence effect that we found for unfamiliar voices has been observed in previous studies with younger infants (Friedrich & Friederici, 2005) and in infants with a familial risk for dyslexia (Von Koss Torkildsen, 2007). This suggests that it might be a less mature neural signature of lexical-semantic activation than the N400. We are currently conducting an experiment with 14-month-olds to explore whether voice familiarity facilitates word comprehension in even younger infants.

Topic Areas: Language Development/Acquisition, Meaning: Lexical Semantics

## Age of Acquisition and The Embodiment of Language

***Poster B102*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Background/Introduction: Theories of language embodiment typically propose that language and action are inter-related. Age of Acquisition (AoA) effects refer to the findings that words, phrases, and concepts learned early in life (i.e., before approximately 7 years old) are recognised and responded to more quickly than stimuli learned after this period (Brysbaert et al., 2000). However, AoA is a factor that does not appear to have been considered in many language embodiment studies; thus, whether or not AoA influences motor activity during language processing is not entirely clear. Additionally, the degree (if any) to which participant age attenuates the semantic processing of motor-related language remains an open question. Method: Using samples of younger adults (aged 18-44, N = 40) and older adults (aged 50-65, N = 40), the current experiment tested the effect of AoA on motor responses to motor-related language while also controlling for word frequency. Participants in both groups undertook a lexical decision task (LDT) – requiring a hand response to real words and no response to pseudo words. Words were grouped via AoA (early: learned before aged 7 years old vs. late: learned after aged 7 years old), Hand Relatedness (hand related vs. non-hand related), and Frequency (high frequency vs. low frequency), and response times (RTs) were the outcome variable. Results: For the younger sample, a significant interaction effect was found between AoA and Hand Relatedness; hand-related language learned early in life (early AoA) elicited quicker hand responses than non-hand related language learned early. However, hand-related language learned late in life (late AoA) elicited slower hand responses than non-hand related language learned late in life. With the older adult sample, a large significant main effect for AoA was found, but no significant interaction between AoA and Hand Relatedness was found. Discussion/conclusion: In relation to younger adults (i.e., aged 18-44), embodied language effects may only apply to early learned language (i.e., learned before approximately 7 years old). Moreover, this effect appears to be attenuated by participants` age, as the result was not replicated with older adults (i.e., aged 50-65). Taken together, the findings suggest that embodied effects could be related to factors such as AoA and to the age of participants. Accordingly, future research should aim to control for both factors.

Topic Areas: Language Development/Acquisition, Meaning: Lexical Semantics

## Cognitive and environmental factors during school-aged development and their relation to electrophysiological signatures of spoken sentence comprehension.

***Poster B103*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Julie Schneider[1], Jacob Momsen[2,3]; [1]Louisiana State University, [2]University of California San Diego, [3]San Diego State University

Real-time language comprehension is a fast-paced, complex task that is contingent upon the ability to readily retrieve and integrate phonological, semantic, syntactic, and pragmatic information instantaneously. The development of adult-like sentence comprehension skills is prolonged, continuing through age 12 or later (Schneider et al., 2016, 2018; Atchley et al., 2006; Friederici & Hahne, 2001); the trajectory of which is influenced by general language abilities, working memory, and a child’s home environment (e.g., Schneider et al., 2023; Pexman & Yap, 2018; Troyer & Borovsky, 2017; Boudewyn et al., 2013; Brauer & Friederici, 2007). It remains unknown though how these cognitive and environmental factors constrain the neural processes underlying sentence comprehension during the school years. In the current study we address this question by examining how individual differences in general language ability, working memory, and home environment relate to the engagement of neural processes which are critical for real-time language comprehension among 68 school-aged children (ages 8-12 years; M = 11.02, SD = 2.01, 33 females). Children’s EEG was recorded as they listened to 160 semantically correct and incorrect naturally paced sentences and completed an acceptability judgment task. All sentences included an inanimate noun paired with a modal verb and action verb (i.e., Outside in the garden, the hose can spray water on the flowers; Schneider & Maguire, 2018). General language ability was measured using the CELF-5 Core Language Score (Wiig, Semel & Secord, 2013), working memory with the Digit Span (Blackburn & Benton, 1957) and home environment with the Confusion, Hubbub, and Order Scale (CHAOS; Matheny et al., 1995). EEG data was epoched from 1000 msec before to 2000 msec after the target verb onset (spray in the above example). Trials with incorrect responses on the acceptability judgment task were removed from the analysis. Time-frequency representations (TFRs) associated with target verb processing (200-800 msec post word onset) were calculated using a single taper Hanning window across a frequency range of 2-30 Hz. TFRs were then decibel corrected using a 500 msec window prior to the onset of the target verb. An independent samples cluster-based regression permutation test was performed to identify subject-level relationships between EEG associated with sentence processing and metrics related to three individual differences measures: general language ability, working memory and home environment. The results of our cluster-based regression permutation test indicate working memory, but not general language ability or home environment, is related to neural engagement during processing of semantically correct sentences in school-aged children. Children with higher working memory scores were more likely to engage theta at widespread midline electrodes (4.8-9.0 Hz; Cluster-level $t = 521.93$, $p = 0.02$) and lower beta at bilateral frontocentral electrodes (Cluster-level $t = 366.98$, $p = 0.04$). Increases in theta and beta are thought to underlie different aspects of semantic retrieval and integration (Schneider et al., 2016; Schneider & Maguire, 2018). These findings indicate domain-general cognitive skills, above and beyond language ability and home environment, are associated with specific neural indices critical for spoken sentence comprehension during middle to late childhood.

Topic Areas: Language Development/Acquisition, Meaning: Lexical Semantics

## Functional correlates of word learning and inflection generalisation

***Poster B104*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Kshipra Gurunandan[1,2], Lydia Vinals[1], Matthew H. Davis[1]; [1]University of Cambridge, [2]BCBL Basque Center on Cognition, Brain and Language

Naturalistic word learning in languages such as English often involves acquisition of quasi-regular systems consisting largely of systematic, regular forms (for example, in the case of past-tenses: work–worked, live–lived) along with a smaller number of high frequency irregulars (e.g. bring–brought, keep–kept). In the current study, we will examine the neural correlates of morphological learning and generalisation of quasi-regular inflectional morphology in the framework of a Complementary Learning Systems (CLS) account of lexical acquisition (Davis and Gaskell, 2009). The CLS account posits a two-stage learning process in which rapid initial familiarisation is followed by slow lexical consolidation, underpinned by complementary systems in the hippocampus and the neocortex. Differences in the encoding schemes of these two systems may have particular implications for learning of regular and irregular forms: hippocampal sparse encoding and pattern separation may be well-suited for mapping of exceptional irregular forms, while a distributed neocortical representational scheme may better capture systematically regular forms. These differences predict distinct patterns of generalisation for regular and irregular forms before and after lexical consolidation. In a dataset from Vinals-Castonguay (2018), twenty-two adult participants aged 18–34 (mean age = 23, SD = 4, 14 female) were trained and tested in an artificial language learning paradigm in 3 sessions over a 9-day period. On day 1, participants learned novel names for professions (e.g. gleet, shiln), followed by training with separate sets of gender-marked plural affixes (e.g. -aff, -opp; gleetaff, shilnopp) on days 8 and 9. The plurals varied in their phonological consistency (diverse, ambiguous or consistent), and their type and token frequency (high or low). Training sessions involved word-repetition and picture naming with feedback, and testing sessions consisted of picture naming and 2-alternative forced choice (AFC) tasks. On day 9, testing involved generalisation to previously unseen words (plural elicitation and 3AFC tasks), followed by fMRI scanning during a 4AFC task to compare neural correlates of the plurals that were learned 24h prior versus just before scanning. In our re-analyses, we will test behavioural changes in generalisation of regular and irregular forms before and after lexical consolidation, predicting differences indicative of overnight changes in their underlying representations. We will perform three types of fMRI analyses: ROI analyses to examine hippocampal and neocortical contributions to encoding of regular and irregular forms, Representational Similarity Analysis (RSA) to examine effects of initial learning and consolidation-related changes in neural representations of the newly-learned words, and Psychophysiological Interactions (PPI) analysis to examine changes in hippocampal-neocortical connectivity and neocortical-neocortical connectivity. Based on the CLS model, we predict greater hippocampal involvement in encoding of irregular forms versus greater neocortical involvement for regular forms; contrasting patterns of changes in representational similarity for regular and irregular forms before and after consolidation; and post-consolidation weakening of hippocampal-neocortical connectivity and strengthening of neocortical-neocortical connectivity. These results will shed new light on the long-term memory processes underlying learning and consolidation of novel linguistic forms with varying structural and statistical properties.

Topic Areas: Language Development/Acquisition, Morphology

## The Rule Learning of Phonological-Based Linguistic Categories: an fMRI Study

***Poster B105** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Diego Elisandro Dardon[1], Chunlin Liu[1], Motoaki Sugiura[1], Hyeonjeong Jeong[1]; [1]Tohoku University

Learning a second language requires the mastery of various grammatical rules, such as word order or nominal classification. Previous studies in grammatical rule learning have identified the left inferior frontal gyrus (IFG) and the adjacent motor area important for learning (Friederici & Opitz, 2003; Hauser et al., 2012). However, these studies focused on formal rules without semantic/phonological content, neglecting more typologically diverse rules that do integrate semantic/phonological information with formal patterns. This focus can lead to biased models of L2 learning while missing out on neurocognitive consequences of linguistic typology. In this study, we investigated the learning of sound-based nominal classification systems, grammatical rules that combine formal properties with phonological information to categorize the natural world. Since learning these rules is impossible without access to phonology to generalize correct categories, we predicted left IFG activation but novel activation in areas related to phonological processing particularly the left superior temporal gyrus and supplementary motor area (Nevat et al., 2017). Participants were 21 healthy, right-handed Japanese native speakers (Age 18-33, 10 females). We created a semi-artificial language with 72 concrete Japanese nouns divided into phonological categories commonly found typologically (Aikhenvald, 2000). The categories were divided according to a noun`s vowel ending (e.g., -a, -o, and -u). The target grammar rule was agreement between a noun`s ending and an agreeing demonstrative (e.g, sofa he; miso mi). Participants were scanned as they learned the semi-artificial language over 3 learning phases.

During each learning phase, participants listened to 18 randomized correct noun-demonstrative combinations (learning condition) with each noun-demonstrative combination including a picture of the noun to prevent ambiguity. They heard the same 18 noun-demonstrative combinations but with the sound in reverse and a mosaic picture (control condition). After each learning phase, participants performed an offline grammatical judgment task, a behavioral indicator of learning. A paired-samples t-test was conducted on behavioral test scores between the first and last test phases. There was a statistically significant increase in scores between the first test ($M = 11.33$, $SD = 3.82$) and last test ($M = 13.61$, $SD = 4.51$), $t(20) = -3.21$, $p = .004$ (two-tailed) indicating learning took place over time. For the fMRI analysis, the contrast of interest was Learning Phase 1(-Control 1) vs Learning Phase 3(- Control 3) to find activation associated with learning as evidenced by the behavioral data. The statistical threshold for the voxel-wise analysis was $p < 0.001$ (uncorrected) for cluster formation and corrected to family-wise error ($p < 0.05$) using cluster size. fMRI analysis of the contrast Learning Phase 1(-Control 1) vs Learning Phase 3(-Control 3) revealed significant activation in the left STG. For the same contrast, activation in the left IFG was significant after small volume correction ($p < .05$). The findings indicate that both regions associated with formal rule learning and those associated with the underlying information categories are crucial for successfully learning linguistically diverse rules. These results significantly contribute to our understanding of the neurobiological mechanisms of L2 grammar acquisition, specifically in relation to linguistic typology.

Topic Areas: Language Development/Acquisition, Phonology

## Effects of early language exposure on speech category and speaker identification learning in international adoptees

***Poster B106*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Stephanie Deschamps[1], Kevin Sitek[2], Jen-Kai Chen[1], Bharath Chandrasekaran[2], Shari Baum[1], Denise Klein[1]; [1]McGill University, [2]University of Pittsburgh

International adoptees (IA) often experience early but discontinued exposure to their original birth language prior to being adopted and acquiring the language of their new adopted family. Previous research with IA from China has shown that early but discontinued exposure to their birth language, Chinese, can result in maintained neural traces of Chinese phonology despite having no functional knowledge of the language at time of testing (Pierce et al., 2014). Furthermore, evidence is emerging that listeners more accurately identify voices when they can understand the language being spoken. This advantage is believed to depend on listeners' knowledge of the phonology of the language (Perrachione & Wong, 2007). Here, we build on this work by examining in what ways IA can leverage their early language representations established during infancy to exhibit a re-learning advantage for the perception of their birth language in adulthood. We recruited 3 groups of adult participants: 1) IA from China, who were exposed to Chinese lexical tones during infancy before being adopted into French-speaking families (subsequently discontinuing their birth language for French), 2) French monolinguals (FM) without prior exposure to Chinese tones, and 3) French-Chinese bilinguals. To investigate whether the maintained neural traces of IA's original birth language provide them with an advantage in the learning of Chinese phonology, we compared the behavioural and fMRI responses of all 3 groups of participants during a Chinese lexical tone categorization task. Participants were asked to categorize auditory stimuli that consisted of monosyllables produced using 4 different lexical tones. Participants received minimal visual feedback after each trial. To explore whether IA's early experience with Chinese provides them with an advantage in the identification of speakers of their birth language, we compared the behavioural and fMRI responses of the 3 groups during a speaker categorization task. Here, participants were asked to identify 4 male speakers of Chinese producing full sentences, rather than tones in isolation, while receiving trial-by-trial minimal visual feedback. We hypothesized that the IA group would perform more similarly to the French-Chinese bilinguals than to the FM across both tasks. Linear mixed effect modelling of the behavioural data of both tasks did not reveal any global differences between the performances of the IA and the FM group, suggesting no general advantage of early exposure to Chinese phonology during learning. However, preliminary examination of behavioral performance on tone 4 combined with neuroimaging data during the lexical tone categorization task revealed different BOLD activation patterns in the IA and FM groups, suggesting differences in underlying tone learning strategies. Additional analyses are underway to more closely investigate these activation differences. Future directions for the dataset include applying drift diffusion models to identify differences in underlying decision-making processes and evidence accumulation strategies across the three groups. The behavioural and neural activation results will be discussed in the context of theories of language development, the sensitive period hypothesis, and neuroplasticity.

Topic Areas: Language Development/Acquisition, Phonology

## Statistical language learning with and without awareness

***Poster B107*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Babies, children and adults use statistical learning (SL), i.e., automatic tracking of transitional probabilities, in detecting boundaries between repeating words (Saffran et al., 1996; Isbilen & Christiansen, 2022). Natural speech has a melody, i.e., prosody, which can also affect SL (Toro et al., 2009; Martinez-Alvarez et al., 2023). Prosody is exaggerated in infant-directed speech compared to adult-directed speech (Ma et al., 2020). Adults typically become aware of learned words in SL experiments using speech sequences without prosodic cues (Batterink et al. 2015). It remains unresolved how prosody (e.g., pitch changes) affects acquisition of implicit or explicit linguistic knowledge from continuous speech streams in adults. We tested, in three online experiments of 30 Finnish-speaking adults each, the effect of pitch (fundamental frequency, F0) changes on SL of trisyllabic word-forms (e.g. lu-vi-ra). In Experiment 1, with familiar prosody, the first syllable was the highest and the last one the lowest in F0, which is a typical pattern in Finnish language. In Experiment 2, the prosody was reversed, the first syllable being lowest and the last one highest, resulting in a structure that was unnatural to the listeners. In Experiment 3, F0 varied randomly in each triplet. All experiments included also neutral speech streams of another set of word-forms with constant F0. After exposure to the 4-minute syllable streams, learning was tested using a two-alternative forced choice (2AFC) task. Awareness of newly learned word-forms was assessed with confidence ratings (from “I guessed” to “I remembered”; see Batterink et al., 2015). In experiment 1, 2AFC accuracy was higher in the familiar prosody than the neutral condition. Familiar

prosody specifically enhanced implicit learning of statistical regularities, but had no effect on explicit learning. In Experiments 2 and 3, the unfamiliar rising prosodic structure or random prosodic cues had no effect on accuracy relative to the neutral condition. Our results suggest that familiar pitch changes improve adult SL, and it especially enhances implicit extraction of linguistic patterns from continuous speech without awareness. However, pitch changes that are unfamiliar with respect to the listener's native language do not affect SL. Since SL has been shown to be associated with increased neural entrainment to repeating words and decreased neural entrainment to syllables (Batterink & Paller, 2017), our current EEG experiments aim to investigate how prosody affects these changes in neural entrainment during SL. In addition, we aim to investigate motor contributions to SL (Assaneo et al., 2019) with and without prosody.

Topic Areas: Language Development/Acquisition, Prosody

## The Influence of ASL Fluency and Age of Acquisition on Perceptual Reasoning Skills in American Sign Language Users

***Poster B109*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Melody Schwenk[1], Lorna C Quandt[1]; [1]Gallaudet University

Background: A significant research gap exists in understanding the influence of ASL fluency and age of acquisition (AoA) on perceptual reasoning skills in the Deaf and Hard-of-Hearing (DHH+) population. Research has been examining the relationship between ASL fluency, AoA, and mental rotation in DHH+ people, finding a positive correlation between ASL fluency, mental rotation abilities, and perspective taking abilities (Kubicek & Quandt, 2021; Secora & Emmorey, 2020). We designed a study using the Block Design (BD) subtest of the The Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV). The WAIS-IV has been criticized for its limited validity and accuracy in assessing cognitive capacity for individuals who primarily use American Sign Language (ASL), as it was exclusively normed for English speakers. Our research aims to investigate the impact of ASL fluency, AoA, and performance on a block design task in ASL users, focusing on perceptual reasoning skills. Methods: The study included three parzticipant groups: Deaf signers (n=22), Hard of Hearing signers (n=6), and hearing signers (n=12). Participants completed the Vandenberg-Kuse Mental Rotation Test, ASL Comprehension Test as a measure of ASL fluency , and Block Design task. Results: Results from multiple regression analyses looking at the relationship between VKMRT, Block Design, AoA, and ASL fluency, show that participants' perceptual reasoning skills are significantly predicted by age of acquisition and ASLCT scores. To demonstrate this, we looked at VKMRT as a predictor of BD scores and found a significant positive relationship ($\beta = 0.394$, $p < .001$). Further, findings indicated that participants with earlier age of ASL acquisition had higher BD scores ($\beta = 0.584$, $p = 0.026$), suggesting that individuals who acquired sign language at a younger age demonstrated better perceptual reasoning skills. Similarly, higher ASL fluency scores were associated with higher block design scores ($\beta = 1.115$, $p = 0.025$). Moreover, the interaction effects between hearing status and the other predictors revealed interesting patterns. The interaction term between being Deaf and age of acquisition showed a significant negative relationship with BDSS scores ($\beta = -1.03293$, $p = 0.0494$). This suggests that the impact of age of ASL acquisition on perceptual reasoning skills may vary depending on hearing status. Conclusion: Our study reveals that early exposure and higher ASL fluency are linked to improved performance on the block design task in DHH+ people. These findings have significant implications

for the importance of supporting ASL acquisition and proficiency. Furthermore, by using neuroscience techniques to investigate the neural underpinnings related to these behavioral findings, future research can provide a deeper understanding of the mechanisms through which ASL influences perception and cognition. While acknowledging the limitations of small sample sizes in ASL research, such studies offer valuable insights into how knowing ASL may impact perception and cognition. These results lay the groundwork for future research, advancing our understanding of ASL acquisition, as well as age of acquisition, and their impact on ASL users.

Topic Areas: Signed Language and Gesture, Control, Selection, and Executive Processes

## Effects of Sign Language Brokering on Working Memory Capacity

***Poster B110*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Joseph Palagano[1], Lorna C. Quandt[1]; [1]Gallaudet University

Sign Language Brokering (SLB) is a form of intercultural mediation that occurs when a bilingual-bimodal child mediates communication between two adults who are less able to communicate directly due to asymmetries in language modality (Napier, 2021; Weisskirch, 2017). For sign language brokers, translanguaging through brokering requires ample attention and memory, as SLBs must retain information spanning: languages, modalities, cultures, and emotions. Research on spoken language brokering suggests that long-term language brokering has cognitive and socio-emotional effects (i.e., increased text comprehension, higher conceptual convergence, adult-level decision-making, and better academic performance; López & Vaid, 2016; Dorner et al., 2008; McQuillan & Tse, 1995). These behavioral effects suggest underlying modifications of executive functions, such as working memory, due to distinct language experiences. Bilingualism has long been suggested to afford individuals with distinct neurocognitive adaptations, particularly within executive functions (Bialystok, 2017). However, meta-reviews have rarely found consistent effects of bilingualism on executive functions, likely due to statistical preference for broadband patterns muting the more idiosyncratic variations between bilingual individuals and sub-groups (Marian & Shook, 2012; DeLuca et al., 2019; Lehtonen et al., 2023). In our proposed study, we ask whether sign language brokering, given the cognitive demand and speed needed to maintain the natural flow of multimodal conversation, affords idiosyncratic cognitive benefits such as differential patterns in verbal and visuospatial working memory. To test this, we seek to recruit hearing children of deaf adults who have experience acting as sign language brokers (N=20) and non-brokering bilinguals (N=20) matched on language proficiency and non-verbal I.Q. We will assess their working memory capacity (WMC) by utilizing the Listening Span Task (Daneman & Carpenter, 1980) and a novel Multimodal Span Task (MST). We will build upon the traditional span task by assessing working memory capacity in the primed and target languages across modalities. During the MST, participants will be tasked with attending to consecutive sentences in either English or American Sign Language (ASL). They will be instructed to make syntactic judgments about the sentences while reporting the sentence-final word/sign translational equivalence (i.e., if the sentence is shown in English, the participant would be asked to report the signed equivalent to the final word/sign in every sentence). While performing the modified listening span task described above, we will record electroencephalography (EEG) with a 64-channel BrainVision cap positioned to fit the 10-20 system (Jasper, 1958). Our analysis will focus on frontotemporal midline regions, which are functionally associated with syntactic compositionality and language efficacy and become stronger while participants engage with high working memory demands. (Quandt & Kubicek, 2018; Pavlov & Kotchoubey, 2020; Mollica et al., 2020; Inguscio et al., 2021). We will also focus on theta and alpha oscillations within the left anterior temporal regions and right prefrontal cortical areas, which play a role in visuospatial attentional, short-term encoding, and maintenance processes (Gjini et al., 2007; Muthukrishnan et al., 2020). This process will differentiate neural correlates of WMC between sign language brokers and matched bilinguals to help detangle the role of bilingual cognitive processes in executive function development.

Topic Areas: Signed Language and Gesture, Control, Selection, and Executive Processes

## Neural dynamics of high-level linguistic predictions during natural audiovisual discourse processing

***Poster B111*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In natural environments, language is typically multimodal, encompassing both auditory and visual cues. When listening to connected speech, listeners also process the visual input provided by the speaker's gestures and facial movements. Previous studies have demonstrated that co-speech gestures can impact the neural processing of words, whether they are presented in isolation or embedded in sentences. Furthermore, the brain leverages visual speech cues to enhance linguistic comprehension when accompanied by gestures. However, most of these studies have employed non-naturalistic linguistic stimuli and time-locked neural measures (e.g. ERPs). In this study, we want to investigate the impact of observing the speaker's co-speech gestures and visual speech on the neural processing of spontaneous speech, with a particular focus on high-level linguistic representations. Recent research has indicated that during discourse comprehension, the brain continuously generates predictions based on the preceding linguistic context. A question we seek to address is how predictions regarding the meaning and syntactic category of upcoming words are modulated by the visual cues received from the speaker, and what are the corresponding cortico-anatomical correlates of these effects. To achieve this, we will analyze magnetoencephalographic neural activity from a sample of 30 participants presented with spontaneous speech. The recordings consist of 80 audiovisual retellings of cartoons (1 minute each), delivered by five different speakers. The continuous neural tracking of linguistic predictions will be performed with the encoding model of the multivariate temporal response function (mTRF), to predict the recorded neural data using the features of interest, namely lexico-semantic surprisal and part-of-speech (PoS) surprisal. We use GPT-2, a deep-learning model, to compute the lexico-semantic surprisal of each word, considering all the preceding words in the retelling. Subsequently, PoS surprisal is computed based on these values. The experimental conditions include four audiovisual (AV), four visual-only (VO) and one auditory-only (AO) conditions. The AV and VO conditions involve full body-face presentation, mouth occlusion, dots depicting the speaker's movements, and random dynamic dots. Participants are instructed to answer a comprehension question following each presentation. This is the first study using this methodology to investigate multimodal spontaneous speech comprehension. However, based on previous research, we predict that the TRFs of lexico-semantic surprisal will exhibit higher prediction accuracy in the AV conditions compared to the AO condition (except AV random dots). Within the AV presentations, we anticipate that the tracking of semantic surprisal will be more effective when gestures are accompanied by visual speech, compared to seeing the speaker with a mask. Regarding the neural tracking of PoS surprisal, we hypothesize that the highest accuracy will be observed in the AV presentations, depending on the syntactic category. We further anticipate that the neural source locations will exhibit activations in multimodal integration areas in AV compared to AO presentations. Moreover, cortical areas associated with lexico-semantic surprisal are expected to show more widespread activation across the scalp compared to PoS surprisal, which may predominantly activate temporal areas. These results will have significant implications for the neurobiology of multimodal communication and enhance our understanding of situated language comprehension.

Topic Areas: Signed Language and Gesture, Meaning: Discourse and Pragmatics

## Investigating Embodied Cognition in Deaf ASL Users: EEG and Virtual Reality for STEM Education

***Poster B112*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Carly Leannah[1], Lorna Quandt[1]; [1]Gallaudet University

It has been shown that hands-on physical learning experiences with science lead to increased activation in the sensorimotor regions, indicating an embodied understanding of scientific concepts (Kontra et al., 2015). Recent research in Immersive Virtual Reality (IVR) suggests it can enhance learning through gamified experiences, increased presence, and self-efficacy. However, little is known about the learning experience in IVR for individuals who are deaf or hard of hearing (DHH) and have extensive familiarity with American Sign Language (ASL), an embodied language. ASL is a manual language that utilizes the visuospatial modality, making it an embodied language that engages sensorimotor cortex regions (Emmorey et al., 2014). DHH ASL users have been found to have earlier and more robust sensorimotor responses when processing human movement compared to hearing non-signers (Quandt et al., 2021). Building on this work, our study aims to explore how DHH learners understand and process STEM content during IVR educational activities. Our experiment will explore the behavioral and neural impacts of two types of technological learning experiences: 1) immersive, interactive VR, and 2) passive video-watching. We will compare learning outcomes before and after the two experiences. Learning outcomes will be assessed through knowledge retention, transfer, and motivation measures. Additionally, we will identify the neural correlates of immersive learning among DHH ASL users using EEG time-frequency analysis focusing on frontal midline theta power and sensorimotor mu rhythm desynchronization before and after each type of learning. Increased desynchronization in the IVR condition would indicate heightened engagement and embodiment of the learning content. To achieve our research goals, we will recruit 30 individuals aged 18-40 who are DHH and fluent in ASL. Participants will be divided into two groups: one experiencing a 20-minute chemistry reaction-balancing activity in IVR (N=15) and the other engaging in passive video watching of the same content (N=15). Pre- and post-learning assessments will be conducted to measure learning outcomes, and EEG data will be collected before and after the learning experience. The experiment will involve 120 stimulus trials consisting of alphanumerical and picture molecular equations, some learned during the IVR activity and others unfamiliar. Participants will indicate whether the equation is correct or incorrect. Through EEG analyses, we will compare the impact of different learning environments on sensorimotor neural processing, shedding light on embodied learning processes. There is limited research on how lifelong experience and fluency in an embodied signed language, such as ASL, affect cognitive processes during different learning contexts. Studying how DHH learners, a unique group with an embodied language, embody concepts by measuring their theta oscillations and sensorimotor mu rhythms will allow us to investigate their performance in hands-on STEM learning. This research will provide insights into comparisons between IVR and video learning for embodied learning of STEM content. Link to references: https://docs.google.com/document/d/1xUZNZPoDn8JZiIuCH_ETh1jjiVw93nkRHihaW9MwYbs/edit?usp=sharing

Topic Areas: Signed Language and Gesture, Multisensory or Sensorimotor Integration

## Multisensory enhancement of cortical speech tracking by co-speech gesture kinematics

***Poster B113*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The McGurk effect indicates visual processing of articulatory information impacts how speech sounds are heard and suggests the processing of spoken language is fundamentally a multimodal affair. However, the observable activity that accompanies speech also involves coordinated movements across the entire body. Compared to the way articulatory activity can influence speech perception, the relationship between co-speech gesture and speech acoustics is less transparent. The present study aims to establish whether biological motion in co-speech gestures influences neural signatures of speech tracking. Specifically, we test whether continuous speech is processed independently from information in the co-speech gestures, or whether biological motion information in co-speech gestures can enhance the processing of continuous speech. EEG was recorded from 13 English-speaking adults while they observed clips of unscripted discourse containing either original audio and visual content (Congruent), recombined audiovisual content from unrelated discourse segments (Incongruent), visual content without sound (Video Only), or audio paired with a still-frame of the speaker (Audio Only). Decoder models were trained on the EEG across conditions to predict the broadband envelope of the speech signal. A leave-one-out cross-validation procedure was performed to render a decoding score, viz. the Pearson correlation coefficient for the predicted and actual speech envelope in each clip in each of the four conditions. Linear mixed effects regression models with random intercept terms for subject and item were used to predict decoding scores from experimental condition. This analysis revealed that the neural representation of the speech envelope was more precise when speech was paired with congruent gestures relative to a listening-only condition ($\beta = 0.02$; $SE=0.007$; $p<0.05$). Alternatively, performance of decoders trained on incongruent speech-gesture pairings did not differ from those trained in the Audio Only condition. As expected, speech reconstruction success was also poorer when gestures were presented in silence ($\beta = -0.05$; $SE=0.007$; $p<0.001$). To assess whether congruent gestures lead to multisensory enhancement of speech-tracking, reconstruction performance was compared between additive decoder models trained on both unimodal conditions and those trained on trials in the Congruent condition. This analysis revealed the additive model trained on Audio Only and Video Only trials performed worse than decoder models trained on congruent speech gesture pairings ($\beta = -0.03$; $SE=0.007$; $p<0.001$). This result indicates the presence of congruent gestures led to a non-linear enhancement of speech envelope tracking relative to unimodal processing of speech and co-speech gesture information alone. Extant work on audiovisual speech processing indicates that visual articulatory information from the face enhances the cortical representation of continuous speech via non-linear multisensory enhancement of speech encoding. Our results point to an analogous super-additive enhancement of the cortical representation of speech when speech is paired with congruent co-speech gestures. This suggests visual information about the talker's movements affects the fidelity of speech tracking in the auditory cortex. The temporal coherence between co-speech gesture kinematics and continuous speech may result in the two signals being perceptually bound to form a multisensory representation that allows visuospatial information conveyed in biological motion to influence the perceptual uptake of speech.

Topic Areas: Signed Language and Gesture, Multisensory or Sensorimotor Integration

## Cross-modal effects of pseudo-sign articulation (overt and covert) on the premotor cortex: an adaptation fMRI study

***Poster B114*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

Stephen McCullough[1], Karen Emmorey[1]; [1]SDSU

Tian and Poeppel (2013) found that both overt and covert speech enhanced activation in auditory cortex: overt speaking and imagined speaking both increased the neural response to the same (subsequently presented) auditory syllable. In contrast, auditory imagery (imagine hearing the syllable) and actually hearing the syllable both suppressed the neural response to the heard syllable probe (a repetition priming effect). We investigated whether similar effects occur in visual-manual language: American Sign Language (ASL) with 13 deaf participants. We created grayscale videos of a right hand producing eight different pseudosign syllables (probes) and 24 scrambled videos (adaptors) with a transparent square cue (gray for overt; black for covert production) and one of eight different pictographs, corresponding to each pseudosign. Prior to scanning, deaf signers learned the association between each pseudosign and pictograph. Participants also learned to articulate the pseudosigns overtly or covertly, depending on the color of square cue. The fMRI study consisted of four event-related fMRI adaptation scans and two blocked-design functional localizers. The localizer scans always followed the adaptation scans. The first localizer identified the cortical regions involved in viewing hand and foot motor actions (VIEW-LOC). The stimuli for VIEW-LOC consisted of a randomized order of 20s blocks showing videos of pseudosigns, foot motor actions, and scrambled videos without the square cue. We instructed participants to pay attention to the stimuli during the run. The second localizer identified the regions involved in producing hand motor actions (PROD-LOC). The PROD-LOC stimuli consisted of a randomized order of 20s hand or foot blocks showing scrambled videos with pictograph cues, and participants produced either hand or foot motor actions corresponding to the pictographs (learned prior to scanning). For the event-related fMRI adaptation scans, participants viewed a total of 256 trials of video pairs (2s each) separated by 1s. The first video (adaptor) was always selected randomly from four categories: overt articulation, covert articulation, visual imagery, or visual presentation. The second probe was always a video of a pseudosign that was either the same pseudosign or a different pseudosign from the adaptor stimulus. We use the neural activation clusters identified in both VIEW-LOC and PROD-LOC as areas of investigation for our whole-brain analysis of BOLD responses acquired from the adaptation scans. Surprisingly, the localizers did not reveal any overlap in the brain regions for viewing and producing pseudosigns. The whole-brain analysis ($p = .01$) of neural adaptation showed strong adaptation effects in the supplementary motor area (SMA) for the overt and covert articulation, and for visual imagery adaptors, but not for the visual adaptor. SMA was also localized using the hand condition of the production localizer. Moreover, the production localizer identified hand regions (precentral gyrus and middle frontal gyrus) that also overlapped with the clusters of adaptation effects for overt and covert articulation. Of all adaptation effects observed, the ones from covert articulation were the strongest and most widespread. Overall, our results reveal distinct patterns of neural adaptation for internally versus externally generated signing compared to those found for speech.

Topic Areas: Signed Language and Gesture, Multisensory or Sensorimotor Integration

## Linking movement and cognition through the hierarchical buildup of internal modeling.

***Poster B115*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Movement and cognition have traditionally been investigated separately, hypothesized to rely on different mechanisms. More recently, networks of simpler motor reflexes have been proposed as precursors of more complex cognitive functions (Friston, 2011; Pezzulo et al., 2021). In particular, there are theories that propose recycling motor control processes for cognitive processing, such as predictive coding orinternal modeling (Ito, 2008). While the brain loci network associated with the control of movement is known to include the cerebellum and primary sensory and motor cortex, the hierarchical buildup of internal modeling would suppose a shift towards more prefrontal and parieto-temporal regions. In this study we were interested in observing this shift within individuals. We acquired the fMRI data of 20 participants performing recurrent movements of different body parts (tongue and hand) with two conditions: movement alone and monitored movement. In the movement alone condition participants were instructed to perform specific and paced movements with either the hand or the tongue. In the monitored movement condition, they received the additional instruction not to touch the bed of the fMRI or the walls of their mouth. The monitored movement condition was used to maximize the cognitive involvement in the task. Finally, in a baseline condition, participants were instructed not to move while looking at the same fixation cross as in the other conditions. Averaging activations of mouth and hand movements served to investigate movement monitoring control that generalizes across body parts. Examining activations of hand and mouth separately served to explore precursors of gestural and verbal motor acts respectively. The data was analysed using factorial GLM contrasting movement alone and monitored movement with the baseline fixation both across hand and tongue and for each body part separately. To investigate commonalities across the contrasts of movement alone (MV) and monitored movement (MN) we subsequently masked the MV contrast inclusively with the MN contrast. Similarly, to investigate specificities of each contrast, we masked MN exclusively with MV, and MV exclusively with MN. The results revealed that both movement and monitored movement conditions activate a network of primary motor, parietal and cerebellar regions. Additionally, the exclusive masking procedure revealed additional activations for more prefrontal regions such as BA10, BA9, BA8 and BA45 for monitored movement. These findings are consistent with the hierarchical shift proposed by models of internal modeling and support the hypothesis that the mechanism may have emerged gradually during evolution. Interestingly, mouth monitored movement loci were mostly found left-lateralised, while right-hand monitored movement activations were found bilateral. In contrast, movement alone resulted in more bilateral activations for the tongue and, not surprisingly, in left lateralized activations for right hand movement.

Topic Areas: Control, Selection, and Executive Processes, Speech Motor Control

## Examining genetic effects on reading related traits through polygenic scores in two independent datasets

***Poster B116*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Reading relies on several foundational skills, including manipulating speech sounds, rapid and efficient access to lexical representations and orthographic knowledge. However, the extent to which these skills explain reading performance varies across developmental stages and languages. Genetic factors are also known to influence reading and underlying cognitive processes. How the environmental and genetic factors interact to influence reading outcomes is still largely unknown. Polygenic scores (PGS) are individual-level predictors derived from the sum of effect alleles at a single nucleotide polymorphism (SNP), weighted by the regression coefficient describing each SNP's level of association with a trait of interest. PGSes can also be used to study the genetic relationship between two traits by making predictions across traits. In this study, we use two large datasets of children to explore the extent to which polygenic scores explain variability in reading and related traits. The first is the longitudinal Adolescent Brain Cognitive Development dataset, for which we use a subset of the baseline data (age range 9-10, English) of N=4,080 from European ancestry. The second is the COEDUCA-BCBL dataset, a cross-sectional sample of children (primary grade 2 to secondary grade 2: ages 6.2-16) with a comprehensive assessment of reading-related traits (in Spanish, N>1,200) (Sanchez-Morán et al. 2018), from which we have derived principal components that relate to phonological and orthographic aspects of reading. We first computed PGSes for both datasets using GWAS summary statistics for dyslexia (Doust et al. 2022), reading (Eising et al. 2022), cognitive performance (Lee et al. 2018) and cortical surface area (Smith et al. 2021). Next, we investigated the proportion of variance explained (%adjusted R2) by each of the PGSes in reading in the two target datasets, and in components related to phonological and orthographic processing in the COEDUCA-BCBL dataset through linear mixed-effect models after accounting for covariates (age, sex, grade and genetic PCs). We adjusted for multiple comparisons within datasets using FDR. Our results show that the best PGS predicting reading outcomes is different in these two datasets. The PGS of cognitive performance explains 5.08% of reading accuracy in English (ABCD) and 1.11% in Spanish (COEDUCA-BCBL), while the PGS of dyslexia explains 2.86% for reading efficiency in Spanish and 4.1% in English. In the Spanish database, where a much in depth characterization of reading-related measures in available, reading-related components show a differential pattern of effects across the PGSes. For instance, the PGS of dyslexia explains 1.7% of the variability in the phonological access component and 1.2% of orthographic component related to letter position while no one of the PGSes significantly predicts phoneme awareness accuracy. In addition, phonological short-term memory component is best predicted by the PGS of cognitive performance (2.37%) and variability in the orthographic component is predicted by the PGS of cortical surface area (1.3%). This work provides a validation of the PGS as indices for reading in two general population datasets, and further allows us to disentangle the extent to which reading-related traits have different genetic weight profiles.

Topic Areas: Genetics, Reading

## Functional identification of language-responsive channels in individual participants in MEG investigations

***Poster B117*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Making meaningful inferences about the functional architecture of the language system requires the ability to refer to the same neural units across individuals and studies. Traditional neuromaging approaches often align and average brains together in a common space. However, lateral frontal and temporal cortex, where the language system resides, is characterized by high structural and functional inter-individual variability. This variability reduces the sensitivity and functional resolution of group-averaging analyses. A solution inspired by other fields of cognitive neuroscience (e.g., vision) is to identify language areas functionally in each individual brain using a 'localizer' task (e.g., a language comprehension task) This approach has proven productive in fMRI (Fedorenko et al., 2010)., yielding a number of discoveries about the language system, and has been successfully extended to intracranial recording investigations (Fedorenko et al., 2016). Here, we apply this approach to MEG using a whole-head 306 channel (102 magnetometers, 204 planar gradiometers) Triux system (Elekta Neuromag). Across two experiments (one in Dutch speakers, n=19; one in English speakers, n=23), we examined neural responses while participants read sentences and performed a control condition (reading nonword sequences). For every word or nonword (MEG signal epoched between 0-350ms after (non)word presentation), we grouped each pair of planar gradiometers into a single effective gradiometer derived as their Euclidean norm (Chetail et al., 2018) and averaged the norm values across the epoch. First, we examined the Spearman correlation in the size of the sentence effect (percent signal change for the sentence condition relative to the baseline) across all channels within each participant across odd- and even-numbered trials, compared to the correlations between different participants (Wilcoxon rank sum test). This analysis demonstrated that the neural response to language was spatially consistent at the individual level in both the English and Dutch datasets (English: mean rho: 0.51 within participant, 0.14 between participants, $P<0.001$; Dutch: mean rho: 0.59 within participant, 0.20 between participants, $P<0.001$). Second, we used the data from the odd-numbered trials to define sensors of interest (SOIs) in each participant. SOIs were defined as the 10% sensors with the highest increase in percentage signal change in the sentence condition relative to the baseline. In the even-numbered trials, we then examined the effect size for the sentence condition in these SOIs relative to the effect size for the nonwords condition using a signed rank test. The language-responsive

SOIs were, as expected, significantly less responsive to the nonwords condition (English: $P = 0.017$; Dutch: $P < 0.001$). Finally, when we defined the SOIs based on the group-level map for the odd-numbered trials, the effect size for the sentence condition in the even-numbered trials was significantly smaller compared to the analyses that take inter-individual differences into account (English & Dutch: $P<0.001$). Thus, as in fMRI, functional localization yields benefits in MEG and thus opens the door to probing fine-grained distinctions in space and time in future MEG investigations of language processing.

Topic Areas: Methods, Reading

## Layer-resolved FMRI activation and connectivity of the left inferior frontal cortex during reading

***Poster B118*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Layer-resolved FMRI is becoming established as a feasible measure of bottom-up and top-down signal contributions to BOLD activation within brain regions (Lawrence et al., 2018). This method supports the direct measurement of these signals by exploiting high spatial resolution FMRI and neuroanatomical information (Koopmans et al.,2010). While previous research has focused primarily on sensory cortices, new research is emerging which focuses on questions in cognitive neuroscience (Finn et al.,2019; Sharoh et al.,2019), as this method transitions from proof-of-concept research to a new role as a methodological tool in application focused brain imaging. Although connectivity of cortical layers is a goal of the field, developments in this area have been limited. This abstract describes results which demonstrate simultaneous bottom-up and top-down connectivity from a portion of BA 44 to regions hierarchically inferior and superior to it. These results were obtained in the context of a word-reading experiment. A network of left hemisphere regions which includes posterior STG (TPJ), BA 44 and (pre-)motor cortex are believed to support acoustic-phonetic processing and articulation. While the connections between these regions have been extensively studied and are known to be supported by the SLF III (Giampiccolo&Duffau,2022), much is unknown concerning connections between BA 44 and (pre-)motor cortex, as well as the network dynamics these regions exhibit under different conditions. METHODS: Submillimeter FMRI data were acquired on a 7T scanner during a reading experiment. We exploited the tendency of the articulatory system to exhibit a BOLD response in some contexts during silent reading (Hagoort et al., 1999). Items were presented individually and displayed for 800ms. We manipulated lexicality (real/pseudo) and length (long/short) of the stimulus items to interrogate relative differences in the contribution of lower and higher order regions to the BOLD signal in BA 44. The grey matter volume in this region was partitioned into three equivolume bins (Waehnert et al.,2014), and the signal from each of the bins was extracted using a spatial GLM (van Mourik et al.,2019). The signal in each of these depth-bins was analyzed to determine the relative bottom-up and top-down contribution to BA 44 for each of the task conditions. Furthermore, a layer-dependent GPPI (Sharoh et al.,2019)--a type of task-based connectivity

analysis--was performed to map bottom-up and top-down signal through BA 44 as it traveled through the left hemisphere network. RESULTS AND DISCUSSION: The layer-dependent activation results within BA 44 demonstrated that reading real-words compared to pseudo-words resulted in reduced bottom-up input to to this region. Bottom-up input was additionally observed to decrease for long compared to short real-words. We furthermore determined that bottom-up signal propagated from posterior STG through BA 44 and to orofacial motor cortex, whereas top-down signal propagated from motor cortex to BA 44, and likely back to posterior STG. This finding does not preclude the existence of other connections throughout this network. This result demonstrates that layer-dependent connectivity analysis can be used to directly map BOLD signal changes related to top-down and bottom-up signal sources through an interacting network during word reading.

Topic Areas: Methods, Reading

## The predictive brain in typical and impaired reading: an fMRI study of context effects and statistical learning in reading.

***Poster B120** in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The predictive brain has become a key concept in language research and prediction is a dominant theoretical framework for understanding how the brain works. Psycholinguistic and neuroimaging research highlights the importance of anticipatory mechanisms in language comprehension, language production, and reading. In addition, a growing number of studies have used statistical learning (SL) paradigms to investigate whether SL abilities can explain inter-individual differences in language processing and reading abilities. The aim of the present study was to focus specifically on the neural network underlying predictive processes and to understand whether making semantic and syntactic predictions in reading relies on domain-general SL abilities and whether people with reading impairments (i.e., dyslexia) show deficits in these domains. To investigate a possible relationship between linguistic prediction and SL abilities in normal and impaired reading, we conducted an fMRI study with a serial reaction time (SRT) task and a predictive reading task in which 50 participants (25 typical readers and 25 dyslexic students) had to read aloud the same target words (e.g., mouse) either in a context of semantically related or unrelated words (cat – dog – rabbit – mouse vs. table – green – flower – mouse) or in the context of syntactically correct or incorrect sentences (she – likes – this – mouse vs. this – likes – she – mouse). We predicted that good readers should be good predictors in both linguistic (reading aloud) and non-linguistic (SRT) domains. It was an open question whether dyslexic students should be better predictors in order to compensate for their lower-level orthographic deficits, or whether they should be worse predictors, as suggested by some previous studies showing SL deficits in dyslexia. As very few neuroimaging studies have focused on semantic versus syntactic prediction, we wanted to dissociate the neural network underlying these predictive processes. It was also of interest to compare the neural underpinnings of linguistic and non-linguistic predictions in both typical and dyslexic readers. Preliminary results of the univariate analysis showed no differences between control and dyslexic participants in our predictive tasks. We also found an overlap between areas involved in the SRT task and the neural networks of semantic and syntactic prediction (specifically in the precentral gyrus and the postcentral gyrus). These results will be discussed in the context of current compensatory theories of dyslexia, the neural basis of reading and statistical learning, and the role of prediction in language processing.

Topic Areas: Reading, Disorders: Developmental

## The structural covariance of reading-related brain regions in adults and children with typical reading skills and developmental dyslexia

***Poster B121*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Reading is a fundamental skill in our society, however, approximately 5-10% of the population suffer from developmental dyslexia (DD), a specific learning disorder characterized by significant impairments in reading performance. Understanding the neural underpinnings of DD is a crucial step toward the development of targeted interventions. Here, we investigated structural covariance (SC) of key regions within the brain's reading network in adults and children with typical reading skills as well as DD. SC analyses provide insights into how structural brain measures, such as grey matter volume, co-vary across the brain and are likely to reflect both structural and functional connectivity information. For typical-reading adults (N=134), we conducted seed-based whole-brain SC analyses on grey matter volume for six key brain regions of the reading network: the anterior/lexical Visual Word Form Area (VWFA_lex) as well as the posterior/perceptual Visual Word Form Area (VWFA_per), the left Superior Temporal Gyrus (STG), the left Inferior Frontal Gyrus (IFG), the left Precentral Gyrus (PCG), and the left Inferior Parietal Lobule (IPL). Additionally, we compared SC matrices for five of these key regions between typical-reading adults (N=134) and children (N=110) as well as between children with typical reading skills (N=110) and DD (N=68). Finally, seed-based SC analyses were performed using the two VWFA subregions as seeds for both groups of children. In typical-reading adults, all key reading regions except for the PCG, exhibited significant associations with spatially distinct areas across the brain, which partially included key reading-related regions. Specifically, the VWFA_per seed demonstrated significant associations with brain regions in the left occipital cortex, while the VWFA_lex seed was found to be associated with the left STG and left IFG. Furthermore, associations between the IPL and IFG were observed. When comparing SC matrices between typical-reading adults and children, no significant differences were found. However, comparisons between children with and without DD revealed a significant difference between the corresponding SC matrices. Post-hoc analyses indicated that this difference was primarily driven by significantly stronger associations between the left IPL and the other reading-related brain regions in typical-reading children as compared to the children with DD. Finally, seed-based SC analyses of the two VWFA seeds demonstrated that, in children with DD, VWFA subregions were exclusively associated with the ventral occipitotemporal cortex. In contrast, in typical-reading children, VWFA_lex showed significant associations with the STG and insula, while VWFA_per demonstrated associations with the right IPL. For the first time, we

showed the SC of reading-related brain regions across different ages and reading skills. Our findings suggest that the organization of grey matter volume in reading-related brain regions may, partially, be explained by reading processes. Moreover, they provide additional evidence for the functional and structural division of the VWFA into a lexical and a perceptual part. Finally, the study highlights the importance of the IPL for fluent reading. Overall, our findings offer valuable insights into the organization of grey matter volume in reading-related brain regions and underscore the need to consider these complex interactions when investigating the neurobiology of reading and developmental dyslexia.

Topic Areas: Reading, Disorders: Developmental

## Influence of enhanced perceptual features on development of neural specialization for Arabic print in early readers

***Poster B122*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Introduction: Arabic is the most widely spoken Semitic language in the world and is spoken by more than 250 million people as their first language in the Middle East (Watson, 2007). Despite its wide usage, learning to read in Arabic remains difficult for many. The complexity of Arabic orthography, along with other reasons, makes it challenging for reading learners. This has led to many efforts to improve reading instruction in the Middle East. To improve Arabic reading fluency, a textbook (IQRA) was designed to enhance the visual characteristics of Arabic, and thus, help children recognize the Arabic orthography (Wilson et al., 2020). 345 first year pupils in the UAE were tested to evaluate IQRA training effects. The students were able to accurately identify more letters compared to a matched control. However, it is unknown whether improvement is associated with accelerated development of the brain's reading network, which develops over a long trajectory. Thus, the goal of this study was to measure brain responses to Arabic print in early readers enrolled in IQRA instruction. We hypothesized that we would observe a greater N1 amplitude in IQRA children compared to a matching-control group. Methods: EEG responses were collected from 49 first grade children in the UAE (N = 27 IQRA treatment, N = 22 control) at the end of the school year. Children viewed images on a screen and completed a vigilance task in which they pressed a button when a picture of a cat appeared (10% of trials). A test block consisted of common objects while the researcher provided instruction and feedback, followed by test blocks containing connected Arabic words and disconnected Arabic false font strings. Children also completed letter identification and fluency tests. Results: At the O1 electrode, there was a marginally significant group difference in the P1 response to Arabic words such that control children exhibited a stronger response ($t(40) = 1.73$, $p = 0.046$) but no difference in the response to Arabic false font strings ($p = 0.16$). With respect to the N1 response to words, a significant difference was observed in electrode M1 ($t (40) = 2.29$, $p = 0.014$) such that IQRA children exhibited a stronger response than control children. Behavioral measures of word identification revealed a slight improvement for IQRA children compared to their peers in control classrooms. Discussion: Overall, the study aimed to evaluating whether one year of participation in the IQRA curriculum would improve neural responses to Arabic words in first grade children. EEG responses suggest improved familiarity with Arabic in IQRA children as well as increased print-specific response, though the latter finding did not survive correction for multiple comparisons. These findings suggest a modest effect of the IQRA curriculum on neural responses to print in young readers. Future work is needed to understand the long-term impact of IQRA on the reading brain

Topic Areas: Reading, Disorders: Developmental

## Auditory cortex anatomy is related to reading skills and is similar among family members

***Poster B123*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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The development of high-level cognitive skills depends on a complex interplay between genetic and environmental factors, and is related to brain structural and functional indices. In the context of brain-behavior relationships, inter-individual variability in both language and music skills has been repeatedly associated with the structure of the auditory cortex, and in particular with the shape, size and asymmetry of the transverse temporal gyrus(i) (TTG) (Benner et al., 2017; Turker et al., 2021). For example, TTG anatomy has been associated with reading skills and pre-reading abilities (Altarelli et al., 2014; Kuhl et al., 2020; Sutherland et al., 2012). TTG shows high variability in shape and size, some individuals having one single gyrus (also referred to as Heschl's gyrus, HG), others presenting duplications (with a common stem or fully separated) or multiplication of TTG. Past studies have established moderate to high heritability of TTG morphology (Eyler et al., 2012; Grasby et al., 2020), but its anatomy has been also shown to be related to experiential variables, such as bilingualism (Ressel et al., 2012). Both genetic and environmental influences on children's cognition, behavior, and brain can to some to degree be traced back to familial and parental factors. Given the importance of the TTG for a large array of high-level cognitive skills, including reading, studying its anatomical characteristics across different family members and generations can give us a better understanding of familial transmission of brain structure and the associated phenotypes. Here, using a unique MRI dataset of parents and children (135 individuals from 36 families), we ask whether the anatomy of the auditory cortex is related to reading measures across different families, and whether there are intergenerational effects on TTG anatomy. Furthermore, we ask whether auditory regions of family members are similar overall, or whether there are specific markers showing more familial overlap than others. For this, we performed detailed, automatic segmentations of HG and of additional TTG(s) when present, extracting volume, surface area, thickness and shape of the gyri. We tested for relationships between these and reading skill, and assessed their degree of familial similarity and intergenerational transmission effects. We found that volume and area of all identified TTGs combined was positively related to reading scores, both in children and adults. With respect to intergenerational similarities in the structure of the auditory cortex, we identified similarities in HG anatomy for mother-child pairs, and in the lateralization of all TTG for father-child pairs. Mothers' HG was similar to children's HG in terms of cortical thickness and shape; fathers' TTG-lateralization was similar to children's TTG-lateralization of cortical surface area. Both the HG and TTG-lateralization findings were significantly more likely for parent-child dyads than for unrelated adult-child pairs, demonstrating that the observed effects were not due to generic similarities of the investigated brain regions across individuals. Our results suggest intergenerational transmission of specific structural features of the auditory cortex; these may arise from genetics and/or from shared environment.

Topic Areas: Reading, Genetics

## The visual word form area engages in processing Braille in expert visual readers

***Poster B124*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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In the ventral occipito-temporal cortex (vOTC) reside numerous areas specialized to identify different categories of stimuli. Among them, the visual word form area (VWFA) and its preferential response to written words have been subject of a great corpus of studies, given its link to expertise and language acquisition. What drives this selectivity for orthographic material remains debated. One prominent account suggests that VWFA's preference builds on the intrinsic selectivity for low-level features shared among most orthographic systems, like specific line junctions (e.g. T, L, Y). Alternatively, the VWFA could be sensitive to any alphabetic material, irrespective of these specific low-level features. We present evidence showing that VWFA in processing visual Braille in expert readers, a script developed for touch that does not share some low-level characteristic of classical alphabets like line junctions. In a first functional localizer experiment, we presented different intact and scrambled stimuli. We show that, in expert visual Braille readers only, the region of vOTC showing preferential activity for roman-based French word over scrambled stimuli, also showed preferential response to Braille words over scrambled Braille stimuli. To unfold the representation of different linguistic components in individually localized VWFA, in a second experiment, we presented to the participants stimuli with four decreasing levels of linguistic properties: real words, pseudo-words, non-words, and a fake-script condition, for both Braille and roman-based alphabets. Multivariate analyses on patterns of activity from VWFA revealed that the differences between words and word-like stimuli show a dissimilarity pattern within Braille stimuli that resembles the one within roman-based French. These results indicate that typical visual features of scripts are not mandatory characteristics in the activation of VWFA for linguistic material. Rather, linguistic information itself, invariant across scripts, seems to play an important role in determining the response of VWFA.

Topic Areas: Reading, Language Development/Acquisition

## The functional differences of brain networks in different hierarchical language structures of children's natural reading

***Poster B125*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Language exhibits a distinct hierarchical structure, and proficient reading relies on the efficient recognition of words, their integration into coherent sentences, and the extraction of meaning from the text (Fedorenko et al.,2019). When children engage in reading, they construct various psychological representations that align with the hierarchical organization of language (Perfetti & Adlof, 2012). Previous research discussed that functional differences in connection patterns of overlapping regions in reading words and sentences (Aboud et al., 2019), but have not revealed the mechanistic changes in children's reading different language units from the perspective of natural reading. Consequently, it is important to investigate the neural mechanisms underlying children's reading through a fine-grained experimental design, which may uncover the development of the hierarchical characteristics of reading networks. Our study included a total of 34 typically developing children (23 males, 11.82 ± 1.13 yrs). All participants were native Mandarin speakers. We tested children’s verbal fluency and reading comprehension abilities. In the natural reading experiment, participants read the presented stories sentence by sentence. Our study combines children's natural reading with a child-friendly reading rate of approximately 18 words per screen, with an average word presentation of 200-400 milliseconds, and each block length of approximately 1 minute (Wang et al., 2015; Zhou et al., 2021). Here we used functional magnetic resonance imaging (fMRI) to examine brain activity of children during reading pseudowords, reading shuffled words, reading shuffled sentences, and reading intact stories in the natural reading paradigm. We used conjunction and ANOVA analysis to obtain the overlapping regions across 4 condition and dominant brain regions in each contrast. Then, we used a generalized psychophysiological interaction (gPPI) analysis (McLaren et al., 2012) to examine functional connectivity for the dominant seed regions in each contrast. Firstly, we found that bilateral frontal and occipital lobes overlapping regions across four conditions, while distinct functional differences were identified in the temporal lobes. Results revealed that the left middle temporal gyrus (MTG) is specific to word level processing, while the bilateral angular gyrus and the left precuneus are specific to sentence level processing. The right temporal lobe is involved in both word level processing and sentence level processing. The activation values of the dominant regions in sentence processing were related to children's verbal fluency and reading comprehension ability. The gPPI results showed that children exhibited stronger functional connectivity between the bilateral angular gyrus with contralateral MTG during sentence reading compared to word reading. The functional connections between the left angular gyrus and the right MTG ($r=0.432$, $p=0.025$) were positively correlated with children's reading comprehension. The present study elucidated the neural mechanisms underlying children's reading of different language units within the framework of natural reading. We found that there is a transition from median to posterior in temporal lobe from word processing to sentence processing, which determines children's individual differences at a high-level reading. Additionally, the connection between the bilateral angular gyrus and the contralateral middle temporal gyrus may indicate an integration mechanism that operates across hemispheres.

Topic Areas: Reading, Language Development/Acquisition

## Essential neural differences in the recognition between words and objects

***Poster B126*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Visually recognizing objects in the environment is usually critical for the survival and reproduction of all animals. It enables an animal to respond adaptively to sources of food, conspecifics, and possible threats. About 4000 years ago, the human being evolved a new ability of milestone, visual word recognition. This new ability allows people to record and disseminate information across vast expanses of space and time, which has facilitated the gradual accumulation of scientific, technological, and historical knowledge, transcending generations and spanning continents. A relevant scientific issue is what are the neural differences between recognizing a word and an object. The new word system fine-tunes the pre-existing neural circuit of object recognition (neuronal recycling hypothesis), or develops a new neural circuit outside the pre-existing object recognition (cultural determination hypothesis). Previous studies have provided some elegant findings for this issue. However, these studies have not matched well in stimuli materials or task demands between words and objects. For instance, they used dissimilar-appearing words and objects or different tasks. To overcome these limitations, the present study developed a set of pictorial pictographs as stimuli. Each of the stimuli can be recognized as a Chinese character or an object by a Chinese literate person. Thus, the stimuli were rigorously matched in form, phonology, and semantics between the two types of recognition stimuli. Moreover, each type of stimuli was performed for four functional MRI tasks: the decision for realness, phonology, semantics, and color (baseline), which were used to investigate the modulation of task demands between the two recognition processes. We observed that significant differences of brain activity intensity between word and object recognition occurred in bilateral inferior parietal lobule (IPL) and bilateral anterior cingulate cortex (ACC). Compared to object recognition, word recognition elicited stronger activation in bilateral IPL, and weaker negative activation in bilateral ACC. Interestingly, the differences in activity intensity for word-object processing were not consistently observed across all tasks in the four brain regions (the left IPL: realness and phonological tasks; the right IPL: realness task; the left ACC: all the three language tasks; and the right ACC: realness and semantic tasks). Functional connectivity analyses further revealed that the left IPL exhibited greater connectivity strength with the right inferior temporal cortex (involved in visual processing) in word recognition than object recognition, suggesting a potential role in form-to-sound transformation during word processing. The right ACC exhibited greater connectivity strength with visual cortices (e.g., bilateral ventral occipitotemporal cortex) and semantic areas (e.g., the left inferior and middle frontal gyri) in word recognition than object recognition. The effects were particularly obvious in realness and semantic tasks, which indicated the involvement of the right ACC in semantic control. These findings demonstrate that the neural circuit of word recognition builds upon the pre-existing neural circuit of object recognition, with adaptive adjustments in the IPL and ACC areas. This provides supporting evidence for the neuronal recycling hypothesis, and refines the neuroanatomical interrelationships between word and object recognition processes.

Topic Areas: Reading, Language Development/Acquisition

## Novel visual word learning tracked with FPVS-EEG

***Poster B127*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Reading is one of the most important human skills and has been studied for years with different techniques.

EEG frequency tagging with electroencephalography (EEG) recordings proved efficient to measure the neural basis of visual word recognition. Here we investigate the emergence of novel neural representations for written words in 32 adults (21 females; age mean=21.78; range=17-32 years old) who were tested with EEG before and after learning 32 rare French words according to two different methods. Half of the words were provided with orthographic and phonological information only, while the other half were also provided with explicit semantic information. Participants were tested twice at one-week interval. During the first session, cognitive and language abilities were assessed, and a lexical decision task was performed. In the second session, they were capped with a 64 Biosemi system (EEG) for two EEG recordings (pre- and post-learning), and a post-test lexical decision task was performed. Novel words were taught by blocs of 8, through different short learning tasks (matching, typing, etc.), and were counterbalanced so that they were either learned with orthography + phonology only (OP hereafter) or orthography + phonology + semantic (OPS hereafter). We used fast periodic visual stimulation (FPVS) coupled with EEG to measure selective neural responses to words. Base stimuli (pseudowords) were displayed at 10Hz during 1 min, and periodic deviant stimuli (words) occured every fifth stimulus (at 10Hz/5 thus 2Hz). Responses to deviant stimuli at 2Hz indicate that words have been automatically discriminated from pseudowords. Here we contrasted 4 sequence types displaying words (learned words OP, learned words OPS, unknown words, and known words) among respectively matched pseudowords. Every condition was repeated 4 times for a total of 16 sequences of 60 seconds. EEG results show a significant learning effect ($p<0.001$), with larger word-selective responses over the left occipital-temporal cortex at post-test with both methods, while no pre/post difference was seen for control conditions (known and unknown words). Contrary to our hypothesis, larger amplitudes were found with the OP method than with the OPS method ($p=0.036$). These results reveal that discrimination of learned word among pseudowords was stronger when learnt with the orthographic method. Moreover, behavioral lexical decision data reveal that the new lexical trace of the learned words induced significant increases in reaction times both for novel words' lexical neighbors and for 1-letter close pseudowords, suggesting competition effects arising with new lexicalizations. Those effects were stronger for OP words, as in EEG responses. This might indicate that the semantic method, implemented here by simultaneous image and word presentation during learning, drags the participant's attention away from the orthographic form. This suggestion is supported by the fact that participants spent more time for the OPS than the OP learning. Our findings open new perspectives to track novel word learning using EEG.

Topic Areas: Reading, Language Development/Acquisition

## From shared representations to individual variations in non-native speakers: shared activity patterns predict naturalistic reading performance

***Poster B128*** *in Poster Session B, Tuesday, October 24, 3:30 - 5:15 pm CEST, Espace Vieux-Port*

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Learning a second language is an important part of daily life for many people. As second language learning plays a significant role in education and work, it is essential to understand the neural underpinnings of second language reading. Despite similar neural mechanisms involved in first and second language reading at the level of single words or sentences, it remains unclear how non-native speakers successfully comprehend real-world texts in naturalistic settings. In this study, we propose to examine whether the neural activities in non-native speakers are aligned to each other and also aligned to native speakers during naturalistic science-text reading comprehension. We then compare the degree of alignment to other assessments of linguistic abilities. We recruited 56 Chinese-English speakers as non-native speakers and 52 native English speakers as native speakers to silently read scientific texts in English. Using a fixation-related fMRI paradigm, we simultaneously recorded participants' eye movements and neural activity during reading. We hypothesized that shared patterns of neural activity among participants will be detected in brain regions involved in reading comprehension due to similar language background and efficiency. By leveraging the spatial intersubject correlation (pISC) framework, we measured the shared activity patterns among non-native speakers and between non-native and native speakers. Finally, we adopted intersubject representation similarity analysis and constructed multiple regression models to examine the effect of linguistic abilities on pISC. We found strong pISC in non-native speakers in brain regions including language and default-mode network (DMN) regions, multiple-demand (MD) regions, and visual regions. The alignment among non-native speakers in those brain regions was correlated with reading performance. Further, a subject-by-subject vocabulary size matrix, where non-native subjects with similar vocabulary size were more similar, was positively correlated with the alignment in DMN, MD, and visual regions, suggesting stronger alignment in non-native speakers with similar vocabulary size. In addition to the alignment among non-native speakers, we found significant alignment between non-native and native speakers in DMN, language, MD and visual regions, which was also positively correlated with reading performance. Finally, the regression models comprising vocabulary size, general reading ability, and their interaction term significantly predicted neural alignment in the right language and left DMN regions, indicating that linguistic abilities jointly predict the alignment of brain activity patterns in non-native speakers to those of native speakers. To conclude, by leveraging a naturalistic reading paradigm, our study provides novel fMRI evidence about the neural underpinnings of naturalistic scientific reading comprehension in non-native speakers. Specifically, non-native speakers engaged distributed lower- and higher-order brain regions during naturalistic reading comprehension, revealed by exhibiting shared activity among non-native speakers and between non-native and native speakers, both of which predict reading performance. Further, individual linguistic abilities significantly impacted shared spatial representations in language and DMN brain regions, respectively. Our findings thus provide the first systematic data in this respect to shed light on how shared activity patterns can capture naturalistic language comprehension and how individual variations impact shared representations in second language reading.

Topic Areas: Reading, Language Development/Acquisition


# Poster Session C

## Differences in brain activation, lexical processing, and language interference in Bilingual children with and without Developmental language disorder (DLD)

***Poster C1*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Objective: This study aimed to investigate lexical processing and language interference in bilingual children with and without Developmental Language Disorder (DLD) using electroencephalography (EEG). Methods: Participants were 36 DLD Spanish-English bilinguals, ages 7 to 10 and 32 Typically developed (TD) matched grouped on gender and age. Participants were recruited from 5 Bilingual schools in Chile in 2021. Lexical processing abilities were measured using a “Lexical Decision task”, and participants were presented with 80 stimuli containing 40 non-words, 20 Spanish words, and 20 English words. Spanish words did not include any item with special characters such as /ñ/ and accents in words like más (more) or música (music). All stimuli had between 5 to 7 characters (MEAN=6.12, SD=0.74). The second task was a Stroop task, for this, bilinguals add the complexity of being able to perform the Stroop task in both of their languages. Cognitive function, inhibitory control and Language interference were examined with this task. The task had 4 different conditions for language interference. English and Spanish word colours were used for congruent (same colour name and ink colour) and incongruent (different ink colour) conditions. It is important to mention that only congruent/incongruent conditions were “recorded”, and priming was only used as a distractor. EEG and behavioural data were recorded while participants were doing both tasks. Results: For the lexical decision task, a visual inspection of grand averages showed a centro-parietal negative ongoing ERP component in the 350-500 ms interval which was visible for non-words for both groups. This N400 component was not present for Spanish and English words. A linear mixed-effect model was done, and an interaction of type of word and group was made (type*group). This showed a significant effect on type of word, meaning that Non-Words were the hardest ones to be categorised for both groups ($F(2,30) = 52.23$, $p < .001$). There was no significant interaction between groups. The same analysis was made for the Stroop task. A three-way interaction was done with language*group*congruency. Results show significant results between language and congruency ($F(2,79) = 10.4$; $p<.001$), which means that incongruent condition for Spanish and English was the hardest to

categorise. An N400 was visible for both groups' incongruent condition in Spanish and English. This could be explained because an incongruent condition creates conflict between the word and the colour, requiring increased cognitive control to resolve the conflict and resulting in longer responses for incongruent conditions. Conclusion: Contrary to initial expectations, the results of this study revealed no significant differences in lexical processing and language interference between bilingual children with and without DLD. Both groups demonstrated similar performance in the lexical decision and Stroop task, suggesting that lexical processing abilities were comparable irrespective of DLD status. These findings challenge previous assumptions regarding the impact of DLD on lexical processing and language interference in bilingual children. Finally, this study provides novel insights into the differences in brain activation, lexical processing, and language interference in bilingual children with and without DLD.

Topic Areas: Disorders: Developmental, Language Development/Acquisition

## Comparing cortical alpha/beta oscillations in language production and episodic memory retrieval: an EEG study

***Poster C2*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language production involves retrieving concepts/lexical items from semantic memory, while episodic memory retrieval requires recalling details from past events. Semantic and episodic memory, both part of declarative memory, have traditionally been examined separately. Previous electrophysiological studies have consistently associated alpha-beta desynchronization with conceptual/lexical retrieval in language production and with successful episodic memory retrieval. However, it remains elusive whether the alpha-beta oscillations observed in language and memory tasks are functionally similar and can potentially index the same neuronal computations. In this ongoing EEG study, we compare conceptual/lexical retrieval in language production with episodic memory retrieval within participants. We attempt to draw a direct comparison between the alpha-beta oscillations in the language and memory tasks by comparing their oscillatory and spatial characteristics. Under our working definitions, the neural underpinning of a shared neuronal computation should be highly similar with respect to oscillatory characteristics and active brain regions. Our paradigm combines a context-driven word production task and an episodic-memory retrieval task. Participants listen to context sentences, which can either be constrained or unconstrained. After a brief retrieval period, participants are then presented with a target picture. They are instructed to name the picture and memorize it. In the constrained condition, conceptual/lexical retrieval can occur before picture presentation. Subsequently, a memory task requires participants to make old/new judgments on target or foil words, indicating whether they previously encountered the word as a picture. We computed time-frequency representations (TFR) for frequencies from 4 to 30 Hz on the two tasks and performed non-parametric cluster-based permutation tests. For the production task, we tested the contrast between constrained and unconstrained conditions. The contrast was set between correctly recognized old items and correctly rejected foils for the episodic-memory task. Within-task findings replicate the alpha-beta desynchronization effects in the language and memory tasks. In the production task, we identified a significant power decrease for the constrained compared to unconstrained conditions. This effect was most prominent in the 5-26 Hz frequency range, spanning from 0.8s to 0.3s before picture onset, in left posterior electrodes. In the episodic-memory task, a power decrease was evident for correctly recognized old items compared to correctly rejected foils. The effect was salient in the 5-21 Hz frequency range, from 0.6s to 1.5s after word onset. To further establish the similarity of these two desynchronization effects, we will compare the peak frequency within predefined electrodes in sensor space. For each participant, we will compute peak frequencies for both tasks from the left central and posterior electrodes where the alpha-beta effect was most salient in previous language studies. A Bayesian paired sample t-test will be used to evaluate whether the peak frequencies between tasks are similar. By extending the analyses to source space, we will furthermore gain insight into the spatial localization of both task effects. We hypothesize that a Bayesian t-test shows strong evidence in favor of the null hypothesis, indicating comparable peak frequencies in language and memory effects, pointing to the observed alpha-beta oscillations reflecting a shared neuronal computation.

Topic Areas: Language Production, Meaning: Discourse and Pragmatics

## Neural correlates of auditory naming to definition and environmental sounds: investigating common and task specific activation

***Poster C3*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The neural bases of conceptual-to-lexical retrieval processes during language production tasks are debated. Many studies have pointed to the involvement of ventral anterior temporal regions in accessing conceptual knowledge but most have employed picture naming tasks. Auditory naming tasks have been less frequently used, despite their importance for understanding the extent to which conceptual processing may differ when no visual input is present. We therefore investigated conceptual-to-lexical retrieval with fMRI using two auditory paradigms, requiring names to be retrieved from either verbal definitions or environmental sounds. 14 healthy participants (recruitment still in progress, target 25 participants) completed the two continuous auditory naming tasks while fMRI data were acquired (continuous multi-band EPI acquisition; TR = 1s). To isolate conceptual-to-lexical retrieval processes from articulatory/motor processes, participants first listened to the auditory input and had to delay their verbal production until a visual cue appeared. Experimental trials in each task were contrasted with control trials, in which the participant listened to scrambled sentences (definition naming) or white noise (sound naming) and were required to respond with a single word (“noise”). A conjunction analysis at the whole-brain level showed BOLD signal increase common to both tasks in the left precentral gyrus, left posterior inferior temporal / fusiform gyrus, bilateral superior temporal gyrus, left lingual gyrus, left thalamus, right cerebellum and left supplementary motor cortex. We also found BOLD signal decreases common to both tasks in the right angular gyrus, precuneus and middle frontal gyrus. Task-specific activations were observed for definition naming in the left anterior middle temporal gyrus (MTG) and superior temporal sulcus (STS), posterior inferior temporal gyrus, bilateral cerebellum, left superior frontal gyrus, superior occipital gyrus, and bilateral superior parietal lobule, and for sound naming in the bilateral auditory cortex, bilateral supplementary motor cortex, left thalamus and right precentral gyrus. We did not observe any significant common or specific activation in ventral anterior temporal regions although task-specific activation was observed in the left anterior MTG/STS for definition naming. Our findings confirm that auditory naming of verbal and non-verbal stimuli activates a similar left perisylvian network of regions to picture naming tasks. While naming to definition involved a wider network of left-lateralized regions, including the anterior MTG and STS associated with conceptual preparation, naming environmental sounds recruited a more bilateral auditory network, supporting different pathways depending on the input type and a likely richer activation of conceptual representations for naming to definition. While preliminary, these results raise questions about a common anterior temporal region for processing “cross-modal” conceptual representations during spoken word production.

Topic Areas: Language Production, Meaning: Lexical Semantics

## Can a 15-word picture description checklist differentiate various subtypes of Primary Progressive Aphasia and Parkinson-plus disorders?

***Poster C4*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Picture description tasks are widely used in the assessment of aphasias. Connected speech samples are quick and easy to elicit, but analyses including full transcription are time-consuming, inconsistently conducted, and impractical for non-specialist settings. There is a pressing need for a simple, evidence-based analysis of connected speech that is clinically useful and easy to apply. Using connected speech samples of the Boston Diagnostic Aphasia Examination ‘cookie theft’ and Mini Linguistic Aphasia Examination (MLSE) ‘beach’ pictures from people with primary progressive aphasia (n=27 PPA), progressive supranuclear palsy (n=10 PSP), corticobasal syndrome (n=13 CBS), and healthy controls, we assessed the differences in quantitative language output and the psycholinguistic properties of words produced by patients and controls using a principal component analysis (PCA) to understand and simplify the covariance in the quantifiable (e.g., word count, timing) and lexico-semantic (e.g., frequency, semantic diversity) word properties of connected speech. We then optimised a 15-word checklist for the two pictures and tested the outputs of the least absolute shrinkage and selection operator (LASSO) models with out-of-sample predictive validity testing (26 PPA, 2 PSP, and 6 CBS). As an exploratory analysis, we examined the associations between whole-brain grey matter intensity and PCA-generated principal component scores using t-contrasts with clusters extracted using a threshold of $p < 0.001$ uncorrected for multiple comparisons. We found that the total language output was significantly reduced in patients with the non-fluent variant of PPA (nfvPPA), PSP, and CBS relative to those with the semantic variant of PPA (svPPA) and controls. Qualitative differences in word properties were found for patients with the logopenic variant of PPA (lvPPA) and svPPA with a disproportionately greater use of words that were more frequent and semantically diverse. Using our 15-word checklists, the LASSO models showed excellent accuracy for within-sample k-fold (over 95%) and out-of-sample validation between patients and

controls (over 90%), and moderately good (59% - 70%) differentiation between primary motor (nfvPPA, PSP, CBS) and temporal/lexico-semantic groups (svPPA, lvPPA). When supplementing the LASSO models with the Addenbrooke's Cognitive Examination – Revised and MLSE sub-scores along with the target words, diagnostic accuracy improved for svPPA versus lvPPA, which highlights the need for further language testing to capture these groups' primary areas of impairment (e.g., semantic versus phonology/working memory) despite similar overall word usage. Results from our voxel-based morphometry (VBM) analyses revealed significant correlations between grey matter intensities in (i) the bilateral frontal lobe and language output, (ii) left frontal and superior temporal regions and articulatory variety, (iii) bilateral temporal, insula, and the right limbic lobe and phonology, and (iv) bilateral cingulate gyri, right caudate and putamen and age of acquisition. To conclude, we propose that (1) our word checklist is a suitable screening test to identify people with progressive aphasia, and (2) further specialist assessment is likely to be needed for some groups (e.g., svPPA and lvPPA) for accurate diagnoses.

Topic Areas: Language Production, Meaning: Lexical Semantics

## How aging affects the neural basis of phonological neighborhood density and frequency

***Poster C5*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Although many aspects of language remain stable with age, aging is associated with declines in language production. For example, compared to younger adults, older adults experience more tip-of-the-tongue states, show decreased speed and accuracy in naming objects, increased errors in spoken and written production, and more pauses and fillers in speech, all of which indicate age-related increases in retrieval difficulty. Although these behavioral effects are commonly observed, prior work from our lab suggests that the neural sensitivity to phonological features is stable across adulthood (Diaz et al., 2021). Prior work has demonstrated that words with small phonological neighborhoods and words that have a lower lexical frequency are produced more slowly by adults of all ages. Moreover, older adults may be particularly vulnerable to retrieval deficits with words that have particular characteristics such as sparse phonological neighborhoods or low lexical frequency (Gertel et al., 2020). But no studies have examined these lexical factors in combination, or with neuroimaging techniques (i.e., functional Magnetic Resonance Imaging (fMRI). In the present fMRI picture naming study, we investigated the influence of phonological neighborhood density (PND) and lexical frequency on the behavioral and neural bases of word retrieval across the lifespan (current N = 75, anticipated N = 90, ages 20-89). We will present behavioral and fMRI activation findings and discuss the implications these results have for cognitive and neural theories of aging.

Topic Areas: Language Production, Meaning: Lexical Semantics

## Multilevel Pre-activation of Lexical Features During Prediction-Driven Naming; an ERP study

***Poster C6*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Successful lexical predictions can pre-activate the meaning and various features of the upcoming word (Gao et al., 2022). However, the underlying process of prediction is unknown. The current ERP study uses a novel self-generated predictive naming task to decipher the content and the precise timing of prediction and how it influences the processing of features of the upcoming word. Participants (N=30, in progress) read 480 sets of prime target word pairs that are semantically related (e.g., circus - CLOWN) or unrelated (e.g., trim - CLOWN). There are also 125 filler sets of word-pseudoword pairs (e.g., cartoon - CRECKED). Participants were asked to verbally name one word that came into mind immediately after seeing the prime word and before seeing the target word. Based on the relation between named words and target words, we compared the N400 across four conditions: match named related to target (e.g., seeing “circus” as the prime, naming and seeing “CLOWN” as the target), mismatch named related to target (e.g., seeing “circus” as the prime, naming “elephant”, and seeing “CLOWN” as the target), mismatch named unrelated to target (e.g., seeing “circus” as the prime, naming “elephant”, and seeing “TABLE” as the target), no response. Our hypothesis is that when the same words were named predictively, participants would have pre-activated the word and its semantic features and form-level features, making processing of the word effortless. We found that: 1) the mean N400 amplitude was the most positive when the same target word was named, suggesting a main effect of predictive naming accuracy; 2) the mean amplitude of the N400 was significant more negative when a related alternate word to the target was named (p<.001), suggesting an effect of semantic priming; 3) the mean amplitude of the N400 reduced even more for mismatch named unrelated trials and for the no response trials (p<.001). Moreover, we examined the pre-activation of semantic features (e.g., semantic concreteness), form-level feature (e.g., orthographic / phonological neighborhood size; word length). So far, we found a significant effect of semantic concreteness (i.e., abstract words eliciting less negative N400 responses than concrete words since there is less semantic information to be processed) for both match named related trials (p<.05) and mismatch named unrelated trials (p<.05). However, there was no difference in the mean amplitude of N400 between abstract vs. concrete words for the mismatch named related trials. This suggests that semantic priming facilitated lexical processing, but there is no evidence that concreteness has been pre-activated by predictively naming the same word. For the next step, we will analyze the form-level features to see whether correct prediction can pre-activate these features. If so, we would not see any N400 difference between word with large vs. small orthographic/phonological neighborhood sizes, or between long vs. short words. Finally, we plan to decode the time period after the naming response but prior to the target onset to examine the exact timing and content of pre-activation.

Topic Areas: Language Production, Meaning: Lexical Semantics

## Speech monitoring activations in the midcingulate cortex depend on cingulate sulcal morphology.

***Poster C7*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Lydia DOROKHOVA[1], Jean-Luc Anton[1], Julien Sein[1], Bruno Nazarian[1], Valérie Chanoine[1], Pascal Belin[1], Kep

Kee Loh[2], Elin Runnqvist[1]; [1]Aix Marseille Université, [2]McGill University

Self-monitoring of speech recruits the midcingulate cortex (MCC) region in the human brain (Runnqvist et al., 2021). This region shows substantial interindividual variations in sulcal morphology: while everyone has a cingulate sulcus (CgS) in both hemispheres, some individuals also have a paracingulate sulcus (PCgS) in one or both hemispheres. Critically, cingulate sulcal morphology has been demonstrated to influence both anatomical and functional organisation in the MCC region. When a PCgS is present, BA32 occupies the paracingulate gyrus (Vogt et al., 1995), and likewise, functional activations associated with mouth movements and vocal feedback monitoring are also found on the paracingulate gyrus (e.g., Loh et al; 2018, 2020). Here, we wanted to investigate whether functional activations associated with speech error monitoring are influenced by whether or not a PCgS is present. Such an influence would support the hypothesis that simpler feedback control circuitry used for movements and basic vocalizations has been recycled to sustain the optimizing of language production. 24 participants performed a speech production task designed to induce errors (Runnqvist et al., 2021) in an event-related fMRI protocol. By contrasting the BOLD activation in trials where participants commit a speech error with trials where participants make a correct production, this paradigm could reveal the neural activations associated with monitoring of overt speech errors. To determine if there was an influence of cingulate sulcal morphology on activations associated to speech errors, we first classified each participant hemispheres into three groups based on their cingulate sulcal morphology: 1) Prominent – a prominent paracingulate sulcus that runs dorsal and parallel to the cingulate sulcus, 2) Absent – only a cingulate sulcus, and 3) Emerging – short sulcal segments above the cingulate sulcus. Next, we averaged the BOLD contrast corresponding to error trials minus correct trials across hemispheres in each of the three cingulate morphology groups. We observed that patterns of activation in the MCC region differ between the three groups: In the PCgS Absent group, two significant activation peaks were observed in the MCC, within the cingulate sulcus: An anterior peak at the level of the posterior limit of the genu and a posterior one at the level of the anterior commissure. In the PCgS Prominent group, two significant peaks were also observed in the MCC, an anterior one in the cingulate sulcus, and a posterior one in the paracingulate sulcus. Notably, the two peaks were found at the same anterior-posterior position as the two peaks in the PCgS Absent group. The emerging PCgS group showed a pattern of activation that looked like a combination of the other two groups. Our results underscore the importance of considering individual cingulate sulcal morphology when localising speech monitoring activations in the MCC. Importantly, we also revealed potential anatomical landmarks for localising speech monitoring cortical regions in individual brains which are highly valuable for neurosurgical interventions and for further functional investigations. Finally, these findings suggest an evolutionary link from the control of basic movement and vocalizations to that of language production.

Topic Areas: Language Production,

## Localizing component processes of picture naming using MEG recordings of covert picture-word interference and overt naming

***Poster C8** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Picture naming is a fundamental laboratory task for language production. Several variations of picture-naming tasks have been used to investigate behavioral and neurological factors underlying naming abilities. The picture-word interference (PWI) task is a crucial paradigm investigating the latency and brain activation related to the two main stages of word retrieval – semantic selection and phonological activation. In manipulating the semantic and phonological relations between distractor words and target pictures, the PWI task can create interference and facilitation at distinct stages of the naming process. However, despite the fast-paced nature of naming, relatively little research has been conducted with high temporal resolution recordings on PWI, compared to the rich literature on hemodynamic responses. Moreover, since vocal responses unavoidably create movement artifacts in all neuroimaging modalities, covert picture-naming designs without the need for vocal output are of high interest in the field. This preliminary study used magnetoencephalography (MEG) on three different covert and overt picture naming paradigms. The study aims to (1) further understand the MEG signals behind semantic interference and phonological facilitation induced by PWI, both locally and interhemispherically, and (2) compare brain activation patterns of covert and overt naming to examine the validity of covert naming tasks in measuring word retrieval processes. Aside from the traditional overt picture naming, we included two covert picture naming tasks. One was a covert PWI task where participants were instructed to ignore the audio distractor word and focus on judging whether the target picture name ends in a target sound assigned for the block by pressing yes/no buttons. The design of the covert PWI task was previously validated to elicit both semantic interference and phonological facilitation in a 4-experiment behavioural study on young healthy adults (Wei et al, 2022). The other covert naming task asked participants to judge whether the target picture name begins with the target sound assigned for the block by pressing yes/no buttons. The incentive for validating the beginning sound matching design was for the ease of future application on aphasic patients with difficulty understanding task instructions. Thirty young healthy adults (age: 22.73 ± 4.36; 20 female) were recruited for the MEG study. With the exploratory nature of this study, we anticipate evoked and induced power modulations in the left temporal and frontal regions during semantic interference and phonological facilitation. Although most of the brain activations observed in previous literature using an overt design of PWI tend to be left lateralized, right hemisphere involvement has also been reported. Therefore, connectivity between the left and right homologous activation, if any, will be explored to reveal the potential transcallosal facilitation and/or inhibition during our covert PWI task. Furthermore, if covert naming can be validated for revealing processes of word retrieval, we expect to see comparable brain activation patterns during the covert naming paradigms with those of overt naming. If not, the differences between paradigms will be further explored and discussed.

Topic Areas: Language Production,

## An ALE meta-analysis of the functional correlates of word and pseudoword repetition.

***Poster C9*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Verbal repetition abilities are of utmost importance, playing a vital role in various advanced linguistic functions, including language acquisition and language recovery after a stroke. Although repeating back a verbal sequence appears to be a straightforward task, it actually requires the involvement of several intricate subprocesses to successfully achieve it. Nevertheless, our understanding of the brain regions involved in repetition remains limited, though the repetition of known and unknown stimuli seems to rely on distinct processing pathways1,2. Objectives: The primary aim of this study is to determine the precise brain regions engaged in verbal repetition among neurotypical adults. First, we examine the neural correlates associated with repetition as a general linguistic process. Additionally, we conducted separate analyses to disentangle the pattern of activation associated with the repetition of stimuli with semantic content (words) and without (pseudowords). Lastly, our objective was to investigate the varying roles played by the right and left hemispheres of the brain in repetition processes. Methods: A systematic literature search on four databases was conducted. Twenty-three articles including 25 independent experiments were found to fulfill the inclusion criteria. Three main activation likelihood estimation (ALE) meta-analyses were conducted. The first analysis included all the detected studies (ALE 1: general repetition; n = 25), pooling together varying forms of verbal repetition. After, two complementary analyses were added to capture brain regions involved in the repetition of different stimuli: ALE 2 included only contrasts containing word repetition (n = 17); while ALE 3 included only those contrasts tapping pseudoword repetition (n = 10). Lastly, laterality indices were computed to assess the contribution of the left and right hemispheres in the three ALE activation maps. Results: Left hemispheric perisylvian areas, namely the superior temporal gyrus and premotor area, were engaged in all processes. However, pseudoword repetition was associated with greater activation in the temporal and premotor areas compared to word repetition, and with a left-ward activation pattern in the inferior frontal gyrus (IFG); while word repetition revealed greater activation in the left medial frontal cortex and right temporal areas. Repetition of stimuli with semantic content was associated with a more symmetrical activation of the IFG. On a hemispheric level, both repetition processes showed symmetrical brain activation. Conclusions: This is the first meta-analysis exploring the overlap between functional studies employing different verbal repetition tasks. These consistent activation patterns across experiments can be integrated into current models of language processing. References: 1Yoo, S., Chung, J. Y., Jeon, H. A., Lee, K. M., Kim, Y. B., & Cho, Z. H. (2012). Dual routes for verbal repetition: Articulation-based and acoustic–phonetic codes for pseudoword and word repetition, respectively. Brain and language, 122(1), 1-10., 2Saur, D., Kreher, B. W., Schnell, S., Kümmerer, D., Kellmeyer, P., Vry, M. S., ... & Weiller, C. (2008). Ventral and dorsal pathways for language. Proceedings of the national academy of Sciences, 105(46), 18035-18040.

Topic Areas: Language Production,

## Addressee gaze direction and response timing signal upcoming response preference: evidence from behavioral and EEG experiments

***Poster C10*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speaker gaze is a prominent visual signal in face-to-face communication. Data from corpus analyses suggests that an addressee's gaze direction may also be an early signal foreshadowing the extent to which a response aligns with the content of the question. Conversation analysis has shown that interactants prefer aligned over non-aligned responses, such as accepting an offer. A recent corpus study showed that dispreferred responses are more often preceded by gaze aversions (Kendrick & Holler, 2017), possibly to allow the questioner to reformulate the phrasing of their question in order to conform to the norms of preference organization in conversation. Psycholinguistic research has examined response timing as an additional early indicator of the upcoming response, with "yes" responses being associated with shorter gap times compared to "no" responses. Evidence from EEG indicates that interlocuters may be sensitive to these differences in gap times, with dispreferred (no) responses eliciting an N400 after short gaps but not long gaps (Bögels et al., 2015). The current research combines these two factors to examine how they influence perception of the upcoming responses in two experiments (online behavioral, EEG). Participants will be presented with 240 animated videos that represent short conversation fragments between two (photorealistic) avatars. The participants view the conversation from an over-the-shoulder perspective, as if they are standing behind one avatar (Questioner), facing the other (Responder). Participants are instructed to listen carefully to the conversation while observing the Responder at the center of the screen. At the end of each fragment, the Questioner asks a polar question. The question is followed by a pause (Short: 333 ms, Long: 1000 ms), during which the Responder either averts their gaze, or keeps it directed at the Questioner. After the pause, the Responder responds to the question with either "yes" or "no". In the online behavioral experiment, the video ends before a response is given, and participants are asked to indicate on a scale from 1 to 6 what response they expect, where 1 indicates most likely No, and 6 indicates most likely Yes. We expect questions followed by long gaps and gaze aversions to receive lower scores compared to questions where the avatars maintain direct gaze, indicating that participants anticipate a "no" response. In the EEG experiment, participants will passively watch the conversations while their brain activity is measured with EEG. To monitor attention, 20% of clips will be followed by a comprehension question. Our analyses will focus on the N400 amplitude, measured as the difference between No and Yes responses. We hypothesize that both gap duration and gaze will modulate N400 response, with larger N400 amplitudes to responses with short gaps and direct gaze. We additionally explore whether gap duration and gaze direction influence the N400 interactively or additively. Data collection for the behavioral experiment is set to launch in June, for the EEG experiment in September. We anticipate to present results from the behavioral study as well has preliminary findings from the first batch of EEG participants at the 2023 meeting.

Topic Areas: Meaning: Discourse and Pragmatics, Multisensory or Sensorimotor Integration

## ERP subsequent memory effect for spoken narratives: Effects of contrast focus accent on memory for alternatives

***Poster C11*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Linguistic focus indicates that alternatives are relevant for interpretation (Krifka, 2008). The utterance "I think we'll have [CHAMPAGNE]" with the bird." – with capital letters indicating contrastive focus accent – informs us about the drink chosen but also implies that there might have been other drinks on offer, like sherry, white wine, port wine ... (The example (and the drinks menu) is taken from the sketch "Dinner for One" which is traditionally shown on German TV on New Year's Eve.) Listeners remember alternatives better when focus is produced with a contrastive accent, improving both recognition (Fraundorf et al., 2010) and recall (Koch & Spalek, 2021, Tjuka et al., 2020). We investigated the underlying mechanisms with the subsequent memory effect (SME) paradigm. Usually, SMEs are observed in the study phase of memory tasks where participants learn lists of words. In event-related potential (ERP) studies, words that are later remembered are associated with more positive going ERP activity (300-800 ms post stimulus onset) during encoding than words that are later forgotten. Here, we investigated whether the SME elicited by contrastive focus predicts later recall of alternatives. Methods: 49 native young German adults participated. The data of participants who contributed five or more observations per design cell were analysed (n = 31). Eighty spoken narratives were presented. First, three items were mentioned. One of these was later repeated with contrastive or neutral focus accent. ERPs were computed time-locked to the onset of the focused word (ex. (1), trigger = +; n.b. original stimuli were presented in German): (1) Felix examined peas, beans and onions in his garden. He tended his garden regularly. He watered the +peas/+PEAS. After ten narratives, recall questions were given (ex. (2)): (2) Which pieces of vegetable grew in the garden? In critical trials (n = 64), participants had to recall the three items. We tested for a SME on a focused word when one vs. two of its alternatives were remembered and for an interaction with the focus condition. Cases where 0 alternatives were remembered, were not included, because they occurred only infrequently. Results: An ANOVA with RECALL (1, 2 alternatives), FOCUS (contrastive vs. neutral), HEMISPHERE (left vs. right), and REGION (anterior vs. posterior) yielded a significant interaction of HEMISPHERE, FOCUS and RECALL. Follow-up analyses revealed an interaction of FOCUS and RECALL in the left hemisphere, in the form of an SME for contrastive, but not neutral focus. Discussion: Brain activity during a focused word predicts memory performance for focus alternatives when the focus is produced with a contrastive accent: The ERP measured at the focused element is indicative of the number of remembered alternatives. We believe that contrastive accent makes alternatives more salient, retrospectively increasing their representation strength - presumably by strengthening memory consolidation at a post-encoding stage (Anderson et al., 2006). References: Anderson et al. (2006). PNAS, 103(5). Fraundorf et al. (2010). JML, 63(3). Koch & Spalek (2021). Memory & Cognition, 49(7). Krifka (2008). Acta Linguistica Hungarica, 55(3-4). Tjuka et al. (2020). Laboratory Phonology, 11(1).

Topic Areas: Meaning: Discourse and Pragmatics, Prosody

## Transcranial Direct Current Stimulation of the Superior Parietal Cortex Modulates Reference Processing

***Poster C12*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Reference tracking is the ability to keep up with who/what is being referred to across sentences. The repeated name penalty (RNP) is the cognitive processing delay caused by the use of a repeated name in situations where a pronoun would suffice (Gordon et al., 1993). For example, sentences with repeated names (e.g., Bill) are read slower than sentences with a pronoun (e.g., he) when referring to a previously mentioned salient referent (Almor & Nair, 2007; Gordon et al., 1993). MRI studies found that the RNP is associated with bilateral activation in the superior parietal cortex (SPC), a brain region recruited for spatial tracking of visual stimuli (Almor et al., 2009; Conder et al., 2017). This suggests that the SPC is involved in consolidating multiple linguistic references. However, models of sentence processing rarely include these parietal regions, highlighting instead the left inferior frontal gyrus (IFG) as a core node in the syntactic network (e.g., Den Ouden et al., 2012). To test whether either area plays a causal role in the RNP, the present study compared the effects of cathodal high-definition transcranial direct current stimulation (HD-tDCS) of the left IFG and bilateral SPC on the RNP. Method. 85 students participated; 14 were excluded due to missing data or self-reported absence of stimulation sensation. All were right-handed native English speakers with normal/corrected-to-normal vision and no language disorders. The study had a 2x2x2x3 factorial design, with three within-participant factors: block (stimulation, post-stimulation), reference form (name, pronoun) and antecedent salience (salient, non-salient); and one between-participant factor: stimulation type (IFG, SPC, Sham). In the IFG and SPC conditions, stimulation of -2 milliamps was applied for 20 minutes; in Sham, stimulation only occurred during the first and final minute. The reading task included 96 three-sentence discourses followed by comprehension questions. Half of the critical trials were completed while receiving stimulation (stimulation block); the remaining critical trials followed stimulation (post-stimulation block). Results. Log transformed reading times of critical sentences were analyzed using linear mixed-effects models. There was a 3-way interaction for block, reference form, and salience approaching significance, $\beta$=.01, SE=.005, t=1.948, p=.052, suggesting that the RNP was modulated by stimulation. Post-hoc comparisons further revealed that stimulation affected the RNP only in the SPC condition, X2(1)=4.14, p=.042, but not in the IFG and Sham conditions, p's>.65. Conclusion. Application of cathodal HD-tDCS to the bilateral SPC region modulated the RNP. No such effects were found for the IFG or Sham conditions. These results show, for the first time, that SPC plays a causal role in processing reference form during reference tracking in discourse. As such, these results support previous theories that were so far only supported by imaging results which do not necessarily implicate causality (Boiteau et al., 2017; Conder et al., 2017). Models of language comprehension that address discourse should include the parietal region as central to reference processing. Example stimuli: Ed moved into an apartment with Brooke. He brought most of the furniture. Ed / Brooke / He / She liked having a roommate to help out.

Topic Areas: Meaning: Discourse and Pragmatics, Reading

## Studying the association between co-speech gestures, mutual understanding and inter-brain synchrony in face-to-face conversations

***Poster C13*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Successful communication rests on achieving mutual understanding and resolving troubles in understanding between interlocutors. Co-speech gestures represent a flexible and adaptable resource to meet different communicative demands; they have been shown to contribute significant amounts of semantic information and to facilitate mutual understanding in interaction. Recently, inter-brain synchrony has been proposed as an important aspect of social interaction and is often deemed to reflect alignment and mutual understanding. Notably, both the spatial orientation towards the interlocutor and the visibility of their bodily signals have been observed to affect inter-brain synchrony, providing further evidence for the importance of visual communicative signals in dyadic interactions. Nonetheless, it has not yet been investigated if the presence of visual communicative signals such as co-speech gestures, which are known to facilitate mutual understanding, actually affect the strength of inter-brain synchrony. In the present study, we used dual-EEG and audio-visual recordings to study if inter-brain synchrony is modulated by the presence of co-speech gestures. We do so in both clear and noisy communication settings to focus on periods of trouble in understanding, which can be elicited by both problems in general understanding as well as problems due to external conditions. Dyads performed a tangram-based referential communication task with and without background noise, while both their EEG and audiovisual behavior was recorded. Representational gestures and semantically meaningless movements are being annotated in the audiovisual data. We compare inter-brain synchrony in moments where representational gestures are used versus meaningless movements in the clear and in the noise condition. Additionally, other-initiated repairs (e.g. clarification requests) are annotated in order to explore whether co-speech gestures modulate inter-brain synchrony during episodes of miscommunication (repair initiations) and episodes of mutual understanding (repair solutions). Overall, we expect higher inter-brain synchrony in repair solutions compared to repair initiations, but we expect the presence of representational gestures to increase inter-brain synchrony within repair conditions. Additionally, we expect that this pattern will be even stronger in the noise condition, due to the auditorily challenging communication setting. Preliminary results will be presented and discussed in light of previous findings on inter-brain dynamics during face-to-face communication.

Topic Areas: Meaning: Discourse and Pragmatics, Signed Language and Gesture

## Understanding the Influence of Surprisal in Joke Comprehension through N400, P600, and Late Frontal Positivity

***Poster C14*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To understand a joke, comprehenders need to incorporate unexpected information into their discourse models. For example, in the joke “My doctor has never violated his oath: the oath he took years ago to become a millionaire,” the word ‘millionaire’ is unexpected. However, it also prompts us to activate different aspects of background knowledge regarding doctors. Here we use regression models to examine whether single trial EEG amplitude associated with language ERP components, namely N400, P600, and late frontal positivity (LFP), are sensitive to the predictability of sentence-final words in jokes and in non-funny controls, utilizing a predictability measure derived from the large language model GPT3. EEG was recorded from the scalp as healthy adults read 80 Jokes, 80 Straights, viz., non-funny controls in which the critical word in the joke was replaced by a word with a similar cloze probability, and 80 Expecteds, filler sentences with predictable sentence final words. After preprocessing, single trial EEG amplitude was measured by averaging across relevant time windows (N400: 300 - 500ms, LFP and P600: 700 - 900ms) at six electrodes for each component based on the ERP language literature. The surprisal of each critical word was computed by taking the negative log of word probability provided by GPT3. A series of mixed effect models were constructed to predict the amplitude of single trial N400, P600, and LFP. All models included random intercept terms for each critical word, subject, and channel; fixed effects included experimental condition (i.e. joke, straight, and expected), and surprisal. Akaike information criterion (AIC) was used for statistical model comparisons. Single factor regressions revealed N400 amplitude was significantly predicted by surprisal ($p < 0.001$) and experimental condition (condition[Joke] $p < 0.001$; condition [Straight] $p < 0.001$). In the additive model including surprisal and experimental conditions, surprisal remained significant ($p = 0.02$), as did the condition effect for jokes ($p = 0.004$); the condition effect for straights was no longer significant ($p = 0.09$). These analyses suggest that while N400 elicited by unexpected straights was captured by predictability estimates from the language model, N400 elicited by jokes was not. In addition, single factor regressions also indicated that P600 amplitude was significantly predicted by experimental condition in jokes (condition[Joke]: $p = 0.012$) but not straights (condition[Straight]: $p = 0.17$); surprisal was not a significant predictor ($p = 0.16$). These analyses suggest the enhanced P600 elicited by jokes indexes processing demands not directly related to the predictability of the word in context. Because the LFP is typically elicited only in high constraint contexts, joke/straight sentences were divided into high and low constraint items and modeled separately. For high constraint materials, LFP amplitude was significantly predicted by surprisal ($p < 0.001$), and by experimental condition for jokes (condition[Joke]: $p <0.001$) and but not straights (condition[Straight]: $p = 0.355$). In models of low constraint materials, none of the predictors were significant. This analysis suggests that in high constraint sentences, jokes elicited enhanced LFP that may reflect the detection of situation-model level violations.

Topic Areas: Meaning: Discourse and Pragmatics, Syntax and Combinatorial Semantics

## To predict or not to predict: The role of context alternatives and truth for the processing of negation

***Poster C15*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Studies on negation processing often report a Polarity-by-Truth interaction: False affirmative sentences show longer response times and larger N400 ERPs relative to true affirmative sentences, whereas the effect is reversed for negative sentences. Furthermore, context has been shown to facilitate negation processing. The Polarity-by-Truth interaction has been linked to variations in lexical associations, predictability, or the need of constructing two subsequent mental representations during the comprehension of negative sentences. To disentangle the context-independent effect of negation as a syntactic operator from the context-dependent effect of predictability we ran five ERP-experiments employing a picture-sentence-verification paradigm. Predictability was manipulated by varying the number of alternative sentence continuations provided by the context and making it equivalent for both sentence polarities. The scenarios depicted three different objects, one or two of which were then selected (framed green) or rejected (framed red) by a virtual player. After the objects were marked, an affirmative or negative sentence (in German) was presented phrase-by-phrase, e.g., “Julia has/has not chosen the plum”. In experiments 1A/B, all stimuli sentences provided a true description of the scenario (false fillers were added). In the strongly constraining context, there was only one object that could complete a true sentence, i.e., one selected object in the affirmative condition or one rejected in the negative condition. In the weakly constraining context, there were two alternative objects that could complete a true sentence. The ERPs were measured on the sentence critical nouns referring to one of the objects. In experiments 2A/B, we tested affirmative and negative false descriptions in the two contexts (true filler sentences were added). In Experiment 3, all conditions were combined to test the Polarity-by-Truth-by-Context interactions. We show that the number of contextually available alternatives modulated the online processing of affirmative and negative sentences similarly. Relative to the weakly constraining context, in the strongly constraining context, where the processor could form a unique prediction for a true sentence continuation, we observed a smaller N400 response when the prediction was confirmed, and a larger N400 when the prediction was violated, for both sentence polarities. Over all experiments, the main effect of negation was observed as a long-lasting positivity occurring around 300 ms post-onset and extending towards the end of the 1000 ms epoch. The effect of Truth was directly dependent on the context rather than polarity: In the strongly constraining context, false sentence continuations elicited larger N400s than the true ones, for both sentence polarities, whereas the effect of Truth was reversed in the weakly constraining context for both negative and affirmative sentences. Additionally, we observed interactions between Truth, Polarity and Context. Our experiments show that after dissociating the cost of predictability, negative sentences still show a processing cost that is not reducible to the cost of an additional word in a sentence. This cost occurs both in the form of an interaction between negation and prediction mechanisms (as shown by negation and context-by-truth interactions in the N400 time-window) as well as in the form of effortful meaning integration mechanisms in negative sentences (positivity).

Topic Areas: Meaning: Discourse and Pragmatics, Syntax and Combinatorial Semantics

## Intracranial EEG recordings of inter-individual communication

***Poster C16*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Interpersonal communication allows exchange of knowledge and creation of new concepts, by forming predictions about the intentions of others. Studying the neural basis of human interpersonal interaction is challenging. Here, we introduce a novel experimental approach based on dual intracranial EEG (iEEG) with excellent spatiotemporal resolution. We developed a novel task assessing how categorical representations are refined by interacting with one another. We hypothesized that cognitive alignment will result in interbrain correlations, in a hierarchy of brain regions involved in decision-making and social interaction. We further hypothesized that successful and unsuccessful communications will modulate interbrain synchrony in distinct brain networks. We simultaneously recorded iEEG data from pairs of patients (PoP) undergoing presurgical evaluation for medication refractory epilepsy at the same hospital when their iEEG exploration were overlapping. We created a communication task where both patients assumed the roles of sender/receiver in alternating order. The sender's goal is to communicate features about an item (animal or object) by adjusting two axes (about size, texture, environment, or noisiness). The receiver tries to guess which of the two combined items (an animal and an object) the sender is describing. Feedback at the end of each trial is provided. We recorded 569 electrodes across four PoP (from 47 to 141 per patient) for a total of 317 trials across all PoP. To study synchrony, we extracted local field potentials (LFP; 1-20Hz), evaluated responsive electrodes, and tested the correlation between pairs of electrodes across PoP. We compared correct versus incorrect trials at the trial onset, i.e., when communication is initiated, and at feedback presentation, i.e., after communication has ended. Our results show that all PoP performed the task successfully (~81% of correct trials). We found that the number of electrodes with a strong inter-patient synchrony decreases in all four PoP between the onset of the communication ($x = .075$) and its end ($x = .055$) ($p < 0.05$). At the trial onset, the pairs of electrodes neurally coupled across the patient pairs were different for trials that were later correct, or incorrect. At the feedback period, we found pairs of electrodes with strong neural correlations in response to correct but not incorrect feedback. These results show that during communication; 1) brain synchrony manifests across multiple brain regions, 2) fades out as communication ends, 3) neural alignment differs between successful vs. unsuccessful communication. Thanks to these encouraging results, a wireless version of this experiment is currently being developed in order to record PoP across sites.

Topic Areas: Meaning: Lexical Semantics, Methods

## The neural basis of visual and language tendencies in modes of thinking

***Poster C17*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Huichao Yang[1], Xiaoying Wang[1], Tao Wei[1], Jiahui Lu[1], Yanchao Bi[1,2]; [1]Beijing Normal University, [2]Chinese Institute for Brain Research

Human brain possesses rich internal representations of the world, supporting various types of cognitive processes. Recent studies have revealed intriguing individual variations in terms of the experiential modes of

such internal processes, with people reporting to have different degrees of inclinations to experience internal visual or language (verbal and orthographic) modes (e.g., Internal Representation Questionnaire, IRQ, Roebuck and Lupyan, 2020). We tested whether such subjective differences reflect neural trait differences by examining the relationship between IRQ scores and the intrinsic and task-based brain activity patterns. The relationship between internal mode inclinations and resting-state functional connectivity (rsFC) patterns were examined using rsfMRI and IRQ data ($N = 45$). Leave-one-subject-out support vector regression (SVR) was performed to test if one's rsFC pattern could predict her visual or language scores on the IRQ. The whole-brain rsFC pattern (180 cerebral brain partitions, Craddock et al., 2012) significantly predicted IRQ visual score ($r (44) = 0.362$, permutation (5000) $p = 0.006$; mean absolute error (MAE) = 0.428, permutation (5000) $p = 0.010$) and IRQ verbal score ($r (44) = 0.367$, permutation (5000) $p = 0.017$). At the region of interest level, the rsFC patterns of visual ROIs (the early visual cortex and lateral occipital cortex) predicted IRQ visual score ($rs > 0.416$, MAEs < 0.423, both FDR-corrected $ps < 0.01$), and of the language network ROIs predicted IRQ verbal score ($rs > 0.366$, MAEs < 0.514, both FDR-corrected $ps < 0.01$). Whether internal mode inclinations affect how the brain responds to external stimuli was examined with a word reading fMRI task ($N = 45$) and a picture naming fMRI task ($N = 25$). In the word reading task, the whole brain activity pattern predicted IRQ orthographic score ($r (44) = 0.327$, permutation (5000) $p = 0.001$; MAE = 0.596, permutation (5000) $p = 0.013$), with significant correlations observed in the right visual word form area (VWFA; $r (44) = 0.416$, $p = 0.004$) and the language network ($r (44) = 0.323$, $p = 0.031$). In the picture naming experiment, the activation strength of the early visual cortex significantly correlated with IRQ visual score ($r (24) = -0.452$, $p = 0.023$). Taken together, individual variations in terms of subjective internal process mode differences are indeed systematically associate with brain differences: individuals with higher internal visual tendencies associate with early visual cortices' specific functional connectivity pattern at rest and weaker responses to picture stimuli; those with stronger language tendencies associate with language network's specific functional connectivity patterns at rest and stronger right VWFA activation to visual word stimuli. Such individual neural variations underlying the internal representation modes invite further considerations for knowledge representation mechanisms and for interpreting brain data more broadly.

Topic Areas: Meaning: Lexical Semantics, Multisensory or Sensorimotor Integration

## Investigating the association of new verbal labels with novel actions, a behavioral study.

***Poster C18*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Although for many years language has been considered amodal and separated from other cognitive functions, neuroscientific and neuropsychological studies established evidence of an anatomical and functional link between language and action. Moreover, it seems that actions can also be modulated, among other aspects, by the semantics of language. Indeed, in many studies, an effect of nouns, adverbs, and verbs on reach to grasp movements has emerged. However, this role of language on actions has mostly been studied with existing words, leaving a gap on the role of new labels on the sensorimotor experience. For this reason, our idea is to investigate the role of new labels on actions. In particular, we hypothesize that associating new labels with novel actions can facilitate categorization and motor chunking processes on the action sequence, so that labeled actions are represented in a superordinate chunk and therefore recalled and performed faster. In order to test this hypothesis, we conducted a pilot study in which 10 healthy right-handed and Italian mother-tongue participants were recruited and divided into two groups. Both groups were asked to perform a motor task consisting of alternatively executing two novel actions acquired in the practice phase through some videos. Crucially, during the practice phase, in the experimental group (label group), actions were also associated with new labels, while actions were left unnamed for the control group (no-label group). We measured the amount of time needed in order to start the action and we run a qualitative analysis of the pilot results. On average, participants belonging to the label group start the action before when the action is associated with a new label compared to the no-label group. However, the distribution of the answers shows a peak of faster reaction times in the no label group, even if for fewer participants compared to the label group peak. Finally, results distribution shows that, in some trials, participants belonging to the no-label group started the action even after two seconds, while the same doesn't happen for the label group, in which actions started in all trials by two seconds. More data, however, will be collected and analyzed before the conference. In addition to the present work, we will also investigate the role of inner speech in learning new actions. Specifically, we want to add a third group in order to explore whether an articulatory suppression task during the presentation of the action videos interferes with the acquisition of the new actions and, consequently, decreases the speed of their execution.

Topic Areas: Meaning: Lexical Semantics, Multisensory or Sensorimotor Integration

## Semantic and phonological networks in older adults: A systematic scoping review

***Poster C19*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The neural correlates of semantics and phonology have been studied extensively. However, reviews have largely focused on neurologically healthy young adults, emphasizing semantic or phonological networks, without consideration for their overlap. This scoping review specifically explores the interplay between the semantic and phonological neural networks in older adults to better understand the extent to which they may be distinct or overlapping. Following the PRISMA extension guidelines for scoping reviews, we carried out a systematic search strategy to identify relevant primary research journal articles. Thirty-eight studies were included in the scoping review, representing a range of populations (i.e., neurologically intact older adults, post-stroke aphasia, primary progressive aphasia, dementia, mild cognitive impairment, and Parkinson's disease) and methodologies (e.g., task-based functional magnetic-resonance imaging, lesion-symptom-mapping), with sample sizes ranging from 11 to 1,231 participants. Based on the number of studies identifying relationships with a given region, we report gray matter regions and white matter association tracts that demonstrate potential for semantic or phonological specialization in older adults, as well as those that appear to play a prominent role in both networks. The regions identified are largely consistent with regions implicated in the semantic and phonological networks of younger adults, but we highlight potential differences. The results of this scoping review provide insight into the degree of separation between semantic and phonological networks in older adults, which may impact recovery for older adults with acquired communication impairments. A meta-analysis addressing this topic is a potentially valuable future direction and we make recommendations for such an analysis.

Topic Areas: Meaning: Lexical Semantics, Phonology

## A longitudinal study of neural correlates of semantic processing in young Chinese-English bilingual children

***Poster C20*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Young bilingual children can use their languages differentially and appropriately in different language contexts, and their bilingual experiences may influence children's neural circuitry for learning to read. Previous research has demonstrated that second language (L2) experiences lead to functional and structural neural adaptations (Abutalebi et al., 2011; Abutalebi and Green, 2016; Pliatsikas et al., 2017). Little is known about the developmental changes in cross-language transfer regarding brain activation in young Chinese-English bilingual children. The aim of the present study was to examine the impact of early bilingual exposure on young Chinese-English bilinguals during semantic processing. We conducted a longitudinal functional Near Infrared Spectroscopy (fNIRS) study in 30 Chinese-English bilingual children to examine their brain activity in the semantic judgment task. All bilinguals had learned English before the age of 5, with a minimum of 1 year of English exposure before the first fNIRS scan. Participants were received the first fNIRS scan in their 1st-grade (mean age, 6.6 ± 0.3 years, age range 6.2–7.2) and a follow-up scan with an interval of 2 years (mean age, 8.6 ± 0.3 years, age range 8.1–9.1). They completed an auditory semantic judgement task in both Chinese and English. During the fNIRS imaging task, children heard two words and were asked to indicate if word pairs were related in meaning. The semantic judgment task included two levels of semantic difficulty requiring either high-association (easy) or low-association (difficult). The contrast of the low- versus high-association was defined to reveal the hemodynamic activity in semantic processing. Behavioral results showed that bilingual children were more accurate in both low- and high-association conditions for the 2nd than the 1st wave during the Chinese semantic task, and the same improvement was found during the English task. Compared to the 1st wave, bilinguals showed the developmental increase in the left posterior middle temporal gyrus (pMTG) during the Chinese semantic task in the 2nd wave, suggesting that they might have more elaborated semantic representations of Chinese over time. In addition, bilinguals showed the developmental increase in the right parietal regions during the English semantic task, suggesting that they might have increased engagement in the semantic network over time. Overall, our findings suggested that bilingual children show a relatively rapid development of semantic representations in the left pMTG for L1. Also, they used a compensatory mechanism in the right IPL, potentially to help their semantic processing for L2. These findings suggest bilingual children might develop different patterns of neural activity for semantic processing.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

## An ERP Study of Chinese-English Bilingual Sub-Lexical Processing

***Poster C21** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous studies have shown that bilinguals activate both of their languages in a non-selective manner. This co-activation is involuntary, which means that they cannot effectively inhibit one language while processing words in the other language (Thierry & Wu, 2007). However, whether this co-activation can extend to the sub-lexical level is still a subject of debate (Chen & Perfetti, 2021). In this study, we used both behavioral and event-related brain potentials (ERPs) to test sub-lexical processing in Chinese-English bilinguals. Thirty-three bilingual participants completed an EEG-based semantic relatedness task during which they were asked to judge whether pairs of English words were related in meaning or not. A 2x2 design was used. In one of the manipulated factors, half of the word pairs were related in meaning (e.g., +S: dog-cat), and half of the items were unrelated (e.g., -S: dog-roof). In the other manipulated factor, the Chinese translations of half of the pairs shared a sub-lexical (semantic) radical in form(+F) (e.g., 氵 is a semantic radical in Chinese which means 'water'), and half of the pairs did not share a sub-lexical radical(-F). Altogether, there were four conditions: +S+F river '河', +S-F rain '雨', -S+F law '法', and -S-F hand '手'. The behavioral results showed that participants had a shorter reaction time with semantic related word pairs. Accuracy, on the other hand, suggested an impact of hidden Chinese radicals: pairs with unrelated radicals in Chinese resulted in significantly higher accuracy than pairs with related radicals. The ERPs results revealed a main effect of semanticity, with a larger N400 found in semantic unrelated word pairs. Critically, independently of semanticity, there was an effect of the hidden radical manipulation: words that shared related radicals in Chinese elicited a reduced P200 compared with words that did not share. These findings demonstrate that native-language activation is automatic for bilinguals even when the L1 is not explicitly activated by the paradigm. Critically, this activation extends to the sub-lexical level. Testing of a matched group of monolingual English speakers is underway and so far, 12 participants have been collected. Their preliminary ERP results showed a main effect at the N400 time window but no effect at the P200 time window. This corresponds to our prediction that monolingual English speakers will only show sensitivity to semanticity, but not to the hidden Chinese radical manipulation.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

## Abstract Concepts are Weakly Embodied in the Second Language of Chinese-English Bilinguals

***Poster C22** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Embodied cognition posits that processing concepts requires sensorimotor activation. Previous research has shown that the perception of perceived power is spatially embodied along the vertical axis. However, it is unclear whether such mapping applies equally in the two languages of bilinguals. In the current study, we

employed event-related potentials (ERPs) to compare the neural correlates of spatial embodiment in Chinese-English bilinguals and in native English speakers as they process the abstract concept of perceived power. We recruited 25 bilingual participants and 25 English native speakers as a control group. Our stimuli consisted of 120 Chinese words and 120 translation equivalents in English. The stimuli were further divided into 60 high/low perceived power human words (metaphorical relation-to-space, e.g., king/servant), high/low spatial references (direct relation-to-space, e.g., sun/ground, 30 words) and animal names (fillers, e.g., tiger/rabbit, 30 words). Participants were instructed to report the source of auditory words as being presented from either above or below their sitting position. Behaviourally, we failed to find an expected main effect of congruency between sound origin and metaphorical relation-to-space of perceived power, and we only found a main effect of language on RTs for words with a direct or metaphorical relation to space. Bilingual participants tested in Chinese registered more correct responses to congruent than incongruent items, whereas no such difference was found in English. ERP results based on our pre-registered analyses also failed to modulate P3 or N400 amplitude or interact with language. However, exploratory analyses on high-power human words showed a congruency effect on RTs for high-power words only. Furthermore, participants made fewer errors for congruent than incongruent stimuli when responding to high- as compared to low-power words and when they were tested in Chinese relative to English. Critically, analyses focusing on high-power words showed that bilinguals elicited ¬more positive P3 amplitudes in the congruent than incongruent condition, and more negative N400 amplitudes in the reverse comparison. This, however, applied when they were tested in Chinese, not in English. Finally, we found no such effect in English controls. Our findings suggest that spatial embodiment of perceived power may differ across languages in bilinguals, namely weaker embodiment effect in bilinguals' second language (English) compared to their first language (Chinese). This discrepancy may be due to cultural factors, such as differences in the emphasis placed on power-related concepts in Chinese and Western cultures, or language proficiency, as participants had different levels of expertise in their two languages.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

## P300 on Steroids: Evaluating the Suitability of Fast Periodic Visual Stimulation for Implicit Emotional Word Processing in Bilinguals

***Poster C23*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Bilinguals are thought to experience attenuated emotional responses when communicating in their second language (L2). Although behavioural and electrophysiological studies have shown differential emotional modulation in L1 and L2, we need an approach statistically robust at the individual level that will allow researchers to study correlations with other factors such as proficiency and exposure. Here, we attempted to test the suitability of a Frequency Tagging (FT) paradigm to observe L2 emotional detachment in Polish-English bilinguals. In FT, stimuli in different conditions are presented at specific frequencies to which EEG is expected to entrain selectively. Computing frequency power and signal-to-noise ratio then enables the comparison of entrainment in the different conditions. To do this, we showed participants neutral and negative words presented at a fast pace in both languages. Participants (n=30) were asked to press a button upon detecting a word pertaining to a category specified at the beginning of each block (clothing item or colour name). Due to insufficient precision of the stimulus delivery system, negative and neutral word presentation was diluted across four frequencies rather than the two planned, reducing entrainment and interfering with frequency-based analysis. We thus decided to explore the potential fast pace of periodic visual presentation with event-related potentials in each condition between 150–250 ms ("fast" P300 window). Indeed, given that for every ten words, three were negative and seven were neutral, we could expect that negative words would act as deviants. In line with predictions form L2 emotional detachment theory, we found that the response to negative words in English elicited reduced fast P3 amplitudes as compared to Polish equivalents, whereas no significant difference was found between languages for neutral words. We conclude that fast-paced stimulus presentation is compatible with ERP quantification of higher-level word processing, which offers at least three advantages: 1) increased power, 2) reduced experiment duration, and 3) enhanced participant engagement. A temporally accurate version of this study is now underway to evaluate the full potential of FT for the study for written word processing in general, and the L2 emotional detachment in bilinguals, in particular.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

## Keep Calm and Create On: Time-Frequency Exploration of Creative Ideation in the Native and Second Language

***Poster C24*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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We need more creativity. Creativity gives hope, it solves problems, it finds ways out of crises, it progresses civilisation. Interest in the neuroscience of creativity has recently surged, with EEG studies showing increased alpha frequency power when people generate original as compared to unoriginal ideas. Also, creative individuals tend to display greater alpha power than less creative individuals. To our knowledge, no study to date has attempted to compare creative ideation across languages in bilinguals. Here, we used time-frequency analysis to explore brain oscillations patterns associated with ideation (divergent thinking) and idea selection (convergent thinking) in bilingual participants engaged in an adaptation of the Alternative Uses Task, which requires participants to provide novel, unusual, and plausible uses for everyday objects. Participants were tested in the native (L1 Polish) and the second (L2 English) language to investigate potential differences between languages in terms of creative output and underlying brain activity. Polish-English bilinguals (N=30) with high proficiency in English (C1-C2) engaged in three successive 30-second cycles of idea generation for a total of 20 items (ten per language), whilst EEG was recorded using a 64-channel BioSemi ActiveTwo system. Each trial started with the presentation of a prime object featuring an image and superimposed word (e.g., a hat). After typing in the object's common use, a first ideation cycle started, at the end of which participants reported the most original / unusual use they had imagined for that object within that cycle. Preliminary analyses of 15 datasets revealed distinctive alpha and beta power modulations, both within and across cycles, but critically also between languages. As expected, alpha (8-12 Hz) power was particularly sustained throughout all ideation cycles in all participants, especially over right posterior electrodes, with a slight tendency to decrease over time within cycle and from one cycle to the next. There was no difference between languages in alpha power over time or across cycles. Strikingly, we found significant differences between languages in both the lower (18-20 Hz) and upper (26-30 Hz) beta ranges: Whereas beta power surged at the beginning of each cycle and sometimes reoccurred within a cycle in L1, the opposite trend applied in L2, where we observed wide-scale desynchronisation relative to baseline. Critically, this pattern applied not only to group-averaged results but also each of the participants considered individually. We interpret this result as showing that ideation in L1 requires monitoring of spreading of activation in a multidimensional semantic-associative space, whereas such process is likely scaled down in L2, and possibly less prone to spurious interference from irrelevant or competing mental representations. These results suggest that bilinguals engaging in creative ideation may experience less “cognitive stress” from the challenge set by the task in their second language.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

## The impact of L2 and bilingual experience on predictive processing in EEG

***Poster C25*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Bilingualism has become increasingly common throughout the world. However, its effects on cognition and language processing are still not well understood, compared to monolinguals. Additionally, those areas that have been well studied in bilinguals often show mixed results. One such area is language prediction. It is well established that monolinguals will predict upcoming words in highly constraining contexts, thereby facilitating language processing. Effects of facilitation due to prediction can be found on the N400 (Brothers et al., 2019; Kutas & Hillyard, 1980). Additionally, individual differences in the slope of aperiodic EEG oscillations in a broad band of frequencies have also been correlated with prediction during language processing (Dave et al., 2018; Bornkessel-Scheslewsky et al., 2022). Typically, the EEG of neurotypical individuals has more power for slower oscillations (e.g., delta) relative to fast oscillations (e.g., gamma), and this proportion can be estimated from the 1/frequency (1/f) slope of the power spectrum. Individuals who have a steeper 1/f slope also show greater N400 effects of prediction during language processing (Dave at al., 2018). In contrast, studies investigating predictive processing in bilingual L2 have shown mixed N400 results (Martin et al., 2013; Kaan et al., 2016), and aperiodic activity has not been examined in these studies. It currently is unknown if these mixed N400 findings in studies of predictive processing in bilinguals are due to differences in L2 or the participants’ status as bilinguals, as the majority of the studies have only compared monolinguals to bilinguals in their L2. The present study aims to investigate this question. To do so, we will test English monolinguals, Chinese-English bilinguals (English L2), and English-Chinese (English L1) bilinguals using sentences in English. Stimuli will consist of 40 sentences each in high and low cloze conditions (adapted from Brother et al., 2019). The same target words will be used in both conditions, but the context sentences will be different. During reading, EEG will be recorded. Analysis will include multiple regression to predict the size of the N400 effect and aperiodic slope across conditions and across groups. If differences in the N400 effect are significantly different for the English L2 group as compared to the others, then the results will be interpreted to reflect a specific difference in predictive processing in L2. In contrast, if the monolinguals show significant differences in prediction

outcomes as compared to both bilingual groups, this will be interpreted as a general difference in predictive processing in bilinguals. Any differences in aperiodic slope would be novel and may indicate differences in reliance on top-down processing or model updating (Bornkessel-Scheslewsky et al., 2022).

Topic Areas: Multilingualism, Methods

## Mediation Effects of Bilingual Language Variability on RS EEG Oscillations: A Large-Scale Investigation

***Poster C26*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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An increasing number of studies show that bilingualism reshapes the brain and under certain conditions can modulate its ability to process information (see reviews in Green & Abutalebi, 2013; Pliatsikas et al., 2019). While much previous work has focused on the effects of bilingual experience on executive function using a combination of behavioral and electrophysiological methodology, recent literature has shown that “task-free” electrophysiological techniques (e.g., resting state EEG) are also excellent methods to test the extent to which bilingual experiences might result in neural adaptations (Bice et al., 2020; Pereira Soares et al., 2020). Resting state EEG (rs-EEG) measures intrinsic neural activity and temporal dynamics of functioning brain networks at rest (Buzsáki, 2006). Distinct EEG oscillations have been linked to differential mechanisms that sustain relevant cognitive systems, such as working memory (Miller, et al., 2018), inhibition/cognitive control (Klimesch et al., 2007) and language processing (Bornkessel et al., 2004; Giraud & Poeppel, 2012). Within the neurocognition of bilingualism field, previous literature has shown that bilinguals have greater frequency power and coherence (i.e., functional connectivity) between scalp regions than monolinguals (Bice et al., 2020), and that individual variables of the dual language experience (e.g., age of acquisition (AoA), language use at home and societal contexts, and proficiency) modulate neural correlates of the same two measures (Pereira Soares et al., 2020). In the present study, we combined 5-minute eyes closed rs-EEG data collected by several labs spread across the globe (central Europe, Scandinavia, and the USA) leading to a final sample of 400+ bilinguals with various degrees of bilingual engagement patterns and experiences. Among other factors, participants varied with regards to their language background, geographical location, and bilingualism type (comprised of a mixture of both early and late bilinguals with different degrees of language attainment). Measures of power (within all frequency bands) and coherence are computed for the brain data, whereas bilingual variables such as AoA of the L2/2L1, Duration of Bilingualism, and language Entropy are extracted from the relevant background questionnaires (LSBQ, Anderson et al., 2018; LHQ, Li et al., 2019). Mediation analyses are underway to understand the modulatory role of bilingual language experiences on rs-EEG power and coherence in this large heterogeneous sample, but crucially to understand the (possible) mediative role that context of acquisition and bilingual type/attainment might have within this dataset. This paper, a first of its kind in terms of (brain) sample size and diversity of bilingual types/contexts, has the potential to break new grounds when it comes to understanding if modulatory and mediatory effects are linked to the (social) context in which bilingual languages develop and how bilingualism as a dynamic experience may be a source of outcomes at a

neural level.

Topic Areas: Multilingualism, Methods

## Neural substrates of morphological processing in Chinese-English bilingual children

***Poster C27*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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This study aims to investigate the influence of bilingualism on children's neural architecture of reading development. We explore this inquiry by focusing on bilingual children's morphological awareness. Due to the structural differences in morphology between Chinese and English, the neural substrates of morphological processing could reflect the cross-linguistic transfer effects on children's literacy development. To examine the influence of cross-linguistic differences on bilingual development, we recruited 29 Chinese monolingual and 33 Chinese-English bilingual first graders to complete an auditory morphological judgment task during fNIRS (functional Near Infracted Spectroscopy) neuroimaging. During the imaging task, participants heard three spoken words in a sequential order and were instructed to choose the word that shared a morphemic root or derivational affix with the first word, as compared to the phonologically similar distractor. In the Chinese task, all stimuli involved two characters, one of which had the same sound across the target, answer, and distractor words. On the other hand, all the stimuli were single English words in the English task. Monolingual participants completed the task in Chinese and bilingual participants completed the task in both Chinese and English. fNIRS results revealed the language-specific effect, with bilingual children eliciting stronger activation over the right hemisphere in the English relative to Chinese task. This finding suggests that bilingual children require additional cognitive resources to process English morphology, the second language. Additionally, the results demonstrated the cross-language transfer effect. Compared to monolinguals, bilingual children showed stronger activation over the left posterior superior/middle temporal gyrus in the Chinese task, suggesting a larger reliance on sound-and-meaning integration during morphological processing. Overall, the findings suggest that bilingual children employ different neural circuities for processing each language, and that exposure to the language with different structure influences the processing strategies for the literacy development.

Topic Areas: Multilingualism, Morphology

## Syntactic Processing of Word Category Information in Spanish-English Bilinguals

***Poster C28*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Existing research in bilingual language processing often focuses on language prediction at the semantic level.

However, not enough is known about the nature of syntactic prediction in bilingual language comprehension. During reading, parafoveal word previews can provide native English speakers with crucial information about the syntactic structure of a word, even at the earliest stages of processing. A target word that is preceded by a preview with congruent word category information facilitates reading times, independent from semantic constraints, suggesting that readers can form rapid syntactic predictions about upcoming words (Brothers and Traxler, 2016). In this ongoing project, we used a gaze-contingent boundary technique to investigate whether bilinguals can similarly use word category constraints to form syntactic predictions in a second language as native speakers. Two groups were tested in this eye-tracking study: participants with English as a native language and proficient Spanish-English bilinguals with Spanish as a native language. Both groups read a series of English sentences in which the parafoveal preview showed either a noun or verb that is congruent or incongruent with the word category of the target word. Filler sentences appeared in 50% of the trials. Short comprehension questions occurred following 25% of the sentences. Linear mixed effect models were conducted to examine the probability of skipping the target word as a function of the word category congruency of the preview. Initial results in the bilingual group show an interaction in skip rate, an early measure of reading, between word category (nouns vs. verbs) and preview validity (valid vs. invalid) and no significant effect of preview validity in Spanish-English bilinguals. Further analysis revealed a significant effect of preview validity on first fixation durations, suggesting that although bilinguals are not making predictions of word category information in the earliest reading measure, there may be a delayed effect in subsequent reading times. This study will illuminate the nature of syntactic word category prediction in bilingual language processing.

Topic Areas: Multilingualism, Reading

## Brain activation for language and its relationship to cognitive and linguistic measures: a multimodal exploration

***Poster C29*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language learning and use both require a complex set of skills spanning from auditory perception to higher-order syntactic planning. Abilities related to memory, pattern recognition, and motor control all participate in language functions. Brain correlates for language abilities (Golestani, 2012; A. G. Hervais-Adelman et al., 2011; Kepinska et al., 2017; Reiterer, 2018; Turker et al., 2017), language experience (A. Hervais-Adelman et al., 2018; Jouravlev et al., 2021; Malik-Moraleda et al., 2022), as well as other language-relevant cognitive skills (Brissenden & Somers, 2019; Earle et al., 2020; Imaging et al., 2000; Ullman, 2004; Zhang et al., 2017) have been established by a wealth of previous publications. However, a multimodal and multivariate investigation linking cognitive, motor, other domain-specific skills with language abilities and brain activation for language is still lacking. The objective of the present work is to carry out a data-driven investigation of the key dimensions that underlie language learning, their subcomponents and their relationship with language-related brain activation. This work analyses of a subset of the data collected for the Aptitude WP (https://evolvinglanguage.ch/research/#biological). We obtained behavioural and brain data from 150 participants with a wide multilingual background (with self-reported knowledge of 1 to 50 languages). A subsample (N=29) had previously been diagnosed with dyslexia. We included general cognition measures such as fluid intelligence, attention, pattern recognition, and memory (verbal, procedural, visuospatial, declarative) as well as measures of arithmetic, musicality, and fine motor skills. Additionally, all the participants were assessed on language-specific tests, spanning from traditional language aptitude measures (phoneme perception and production, rote learning, grammar analytic ability) to tests used for diagnosing dyslexia (phonological awareness, auditory working memory, rapid naming, spelling and decoding). The participants also completed questionnaires regarding motivation for language learning, reading history, language experience, and musical training. For each participant, fMRI data were collected using a 3-Tesla Siemens Prisma scanner. Functional activation maps for language were obtained using an adapted version of the AliceLoc localizer from (Malik-Moraleda et al., 2022). In the localizer, participants listened to 24 passages (18 s each) from the book 'Alice in Wonderland', read by a female native speaker of their first language (L1). There was also a baseline condition, comprising 24 degraded versions of the passages, following the procedure from (Malik-Moraleda et al., 2022). The above work has resulted in two datasets: a behavioural dataset, comprising around 50 variables derived from the most relevant scores on the tasks and questionnaires, and a brain dataset comprising voxel-wise brain activation for the L1. These multimodal data will be analysed using partial least square correlations (PLS) which allows for the identification of the main dimensions explaining variation within each dataset, and in a second step, to uncover multivariate patterns underlying common features between the two. This exploratory work is expected to uncover the main relationships between cognition and language, and their links to language-relevant brain activity.

Topic Areas: Multilingualism, Speech Perception

## The Influence of Native Language on Motion Event Encoding: An ERP Study

***Poster C30*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Linguistic relativity is the idea that native language influences cognition and perception (Sapir, 1941; Whorf, 1956). According to linguistic relativity, speakers of manner-on-verb languages (e.g., English) and path-on-verb languages (e.g., Spanish) differentially attend to motion events based on their manner and path, respectively. However, little research has addressed how linguistic differences related to path and manner influence perception (Flecken et al., 2015). The current study investigates the extent to which English native language influences visual attention to, and implicit processing of, motion events manipulating path and manner. Thirty adult Native English speakers (Mage = 19.07, SDage = 2.84) and eighteen adult Spanish-English bilinguals (Mage = 20.22, SDage = 1.48) viewed motion events followed by sentences describing the preceding video presented one word at a time, while their EEG was measured with a 64 electrode Brainvision cap. Trials were either congruent (manner and path of video matched sentence), manner incongruent (manner of video did not match manner of sentence), path incongruent (path of video did not match path of sentence), or completely incongruent (neither manner nor path of the video matched sentence). Participants' task was to press a button indicating whether or not each sentence was congruent to the preceding video. Using a 4 x 2 mix-design ANOVA on behavior we found a main effect of group that was driven by better overall performance in accurately categorizing motion events for monolinguals ($M = 96.89\%$) than bilinguals ($M = 93.23\%$; $t(109.12) = -3.51$, $p = 0.0006$). There was also a main effect of condition driven by all participants being significantly less accurate when identifying path ($M = 92.19\%$) and manner ($M = 94.68\%$) incongruencies than congruent events ($F(3,188) = 6.95$, $p = 0.0002$). Using a cluster-corrected permutation analysis, we identified significant clusters of activation at an alpha of 0.05 across groups during processing of path and manner independently. A 2 x 2 mix-design ANOVA comparing manner congruency (manner incongruent v manner congruent) across groups (monolingual v bilingual) in the N400 time window (350-550 msec) revealed a significant interaction over left-central electrodes ($p < 0.05$). This interaction was driven by a larger N400 effect between congruent and incongruent trials for bilingual compared to monolingual adults. These findings suggest bilinguals demonstrated greater surprisal on trials involving manner incongruencies compared to monolinguals. A 2 x 2 mixed-design ANOVA comparing path congruency (path incongruent v path congruent) across groups (monolingual v bilingual) in the N400 time window (350-550 msec) revealed a significant main effect of group at widespread left-central electrodes ($p < 0.05$). This main effect was driven by a larger N400 effect between congruent and incongruent trials for monolingual compared to bilingual adults, suggesting path incongruencies were more semantically taxing for monolinguals than bilinguals. Taken together, our findings indicate native language influences both explicit and implicit perception of motion events.

Topic Areas: Multilingualism, Speech Perception

## 'Beyond the literal meaning'. Processing implied emotion in second language sentence processing.

***Poster C31*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Models of sentence comprehension in a first language (L1) propose that semantic and pragmatic information, including emotions, are processed simultaneously and incrementally through unification operations. Recent event-related brain potential (ERP) studies in second language (L2) comprehension have explored pragmatic processing. These studies indicate that information common to both L1 and L2, such as world knowledge and speaker identity, is processed similarly to L1. This is reflected by an increased N400 component when the information is incongruent. However, when it comes to emotion-related information, which is typically acquired through experience in L1 but challenging to grasp in an L2 classroom setting, pragmatic processing requires additional cognitive effort. This is evident through a sustained positivity observed in the ERP data. Given the importance of interpreting pragmatic information during communicative interactions, our study aims to investigate whether L2 users, like L1 users, incrementally infer implied emotions during sentence comprehension. To achieve this, we conducted an ERP study in which we presented advanced English users who were native Spanish speakers with sentences in both their L1 and L2. In the same sentence context, we manipulated emotionally neutral words to create three conditions: a) negative-semantically congruent, b) emotionally neutral-semantically congruent, and c) emotionally neutral-semantically incongruent. a- A bee flies towards Joe's ear and then doesn't move. b- A bee flies towards Joe's yard and then doesn't move. c- A bee flies towards Joe's tennis and then doesn't move. The ERPs were time-locked to the onset of the critical word (underlined in the examples). Analyses of semantic congruency revealed a larger N400 amplitude for neutral incongruent contexts compared to neutral and negative congruent contexts in both language conditions, suggesting increased difficulty in semantic integration. Regarding implicit emotion processing, we observed a reduced N100 amplitude only in L1 for the negative condition compared with the neutral conditions, indicating early processing of implied emotion. In contrast, in L2, a sustained positivity was observed, larger in the negative than in the neutral conditions, suggesting additional cognitive load when processing emotional sentences. Our findings indicate that implied emotion is incrementally integrated during L2 comprehension, but its processing differs between L1 and L2, aligning with previous observations that emotion-related pragmatic information requires additional processing in L2 sentence comprehension. These findings contribute to our understanding of L2 language comprehension models.

Topic Areas: Multilingualism, Speech Perception

## Comparing neural measures of prediction between native and second language listeners in continuous speech

***Poster C32*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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When listening to speech, speakers continuously anticipate upcoming phonemes, words and concepts in their native language using prior context (Ferreira and Chantavarin, 2018), integrating information at the sublexical, lexical and sentence level. However, second language learners have been shown to rely less on syntactic information and previous input to predict upcoming material, including not using grammatical gender to restrict prediction of an upcoming noun (Lew-Williams & Fernald, 2010), waiting longer to predict in filler-gap contexts (Omaki & Schulz, 2011) and not exhibiting the same evoked responses as native speakers (Hahne & Friederici, 2001). These differences are generally taken as evidence that listeners do not actively predict upcoming material in a second language. However, more recently it has been suggested that task-related effects which alter online processing, as well as differences in the distributional information that listeners have of their second language could give rise to results which might falsely indicate that these listeners do not form predictions (Kaan, 2014). In order to investigate these mechanisms during online processing in a second language, we analyze continuous naturalistic data where native Sinhala and Mandarin speakers listen to an English audiobook while magnetoencephalography (MEG) responses are recorded. Using multivariate Temporal Response Function (mTRF) analysis (Ding and Simon, 2012) on the continuous speech and neural responses, and comparing to a corpus of native English speakers listening to the same audiobook (Brodbeck et al. 2022), we demonstrate that second language listeners exhibit very similar responses to native speakers and do predict upcoming input integrating phoneme, lexical and sublexical level contextual information. Responses in Sinhala and Mandarin speakers are similar to each other and those of native English listeners. We see few differences in how the neural responses can be accounted for by prediction features and the time

lag of the mTRF response. Small differences in lateralization can be seen with second language learners showing an increased bias towards prediction-modulated speech responses in the left hemisphere over native speakers. These results provide evidence that second language listeners may indeed leverage prediction in similar ways as native listeners during online continuous listening tasks. We posit that these results differ from previous results for two reasons. First, task effects might play a role in previous results and second language listeners may show more markers of prediction during a continuous listening paradigm than constrained experimental contexts. Secondly, knowledge of statistical information of a language — ie. phoneme and lexical transition probabilities — likely plays an important role in whether prediction is observed in second language learners. The participants in this experiment were advanced learners of English who currently study at an English-speaking university, meaning they likely have a robust representation of the distributional information of English, resulting in similar neural responses to native speakers. We conclude that naturalistic listening studies are particularly useful in investigating mechanisms in second language listeners and that this work should go hand-in-hand with controlled experiments in order to uncover how these processes differ between language backgrounds.

Topic Areas: Multilingualism, Speech Perception

## English proficiency modulates the agreement attraction effects on N400 and P600 in processing the subject-verb number agreement

***Poster C33*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Subject-verb number agreement has posed a persistent difficulty for Chinese learners of English, even for advanced learners. Agreement attraction occurs when reading comprehension is interfered with by a local noun embedded in a prepositional phrase (e.g., *The key to the cabinets are rusty.) while determining the subject noun. This interference leads to more errors and longer reaction times. The representation account suggests that the effect results from a false semantic representation of subject noun phrases. However, the cue-based memory retrieval account indicates that the reanalysis of a proper subject noun from candidates stored in memory is triggered upon encountering the verb. Event-related potentials (ERPs) have been used to capture dynamic stages of online reading comprehension. The N400 functions as a marker for the processing of semantic or morphosyntactic information, whereas the P600 serves as a measure for detecting syntactic anomalies or reflecting difficulties in syntactic integration. Tanner, Nicol, and Brehm (2014) investigated agreement attraction in native English speakers using ERP. Grammaticality and attraction were manipulated. Grammaticality refers to the agreement in number between subjects and verbs. Attraction refers to the number agreement between attractors and verbs. They reported the agreement attraction on P600 in reading ungrammatical sentences, which supports the cue-based memory retrieval account. Mandarin Chinese lacks number agreement at the morphosyntactic level. Chen and his colleagues (2007) used the same procedure to examine the agreement attraction in Chinese learners of English. They found the agreement attraction effects on both N400 and P600 in grammatical sentences. However, it is unknown if this effect is exhibited in ungrammatical sentences. This ERP study aims to investigate how proficiency affects agreement attraction in Chinese learners of English using the same experimental design of Chen et al. (2007). Fifty-nine Chinese learners of English aged 20-35 were recruited and divided into three groups based on their performance on English vocabulary and grammar assessments. Sentences were displayed with a 1-3 word phrase structure. Cluster-based permutation was conducted to evaluate the temporal and topographic distribution. Low-proficient English learners showed the grammaticality effect on prolonged N400. It suggests that low-proficient learners tend to process the grammaticality at the semantic level. Medium-level learners showed an interaction between grammaticality and attraction on N400 and the main effect of attraction on P600. These suggest that medium-level learners process the local dependency at the syntactic level and the agreement attraction at the semantic level. Interestingly, high-level learners exhibited the interaction between grammaticality and attraction on P600, suggesting that agreement attraction was managed at the syntactic level. To summarize, English proficiency modulated agreement attraction on N400 and P600, indicating that L2 learners with varying proficiency levels use distinct mechanisms for agreement computation. Lower-proficient learners rely on semantic features to continuously evaluate complex noun representations, which supports the representation account. In contrast, high-level learners with well-developed syntactic metalinguistic knowledge tend to process the agreement attraction at the syntactic level, which supports the cue-based memory retrieval account.

Topic Areas: Multilingualism, Syntax and Combinatorial Semantics

## Suprasegmental cues modulate lexical access: ERPs from North Germanic varieties

***Poster C34*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Most models of spoken word recognition assume that lexical access is an interplay between forward and backward-looking processes. Listeners probabilistically activate a cohort of possible lexical candidates which is incrementally reorganised as the signal unfolds. Neurophysiological correlates of both types of processes have been identified within 500 ms after the onset of the relevant phonemes (for a review, see Gwilliams & Davis, 2022). Suprasegmental cues such as tone and voice quality can provide lexical and morphological information in an additional dimension on top of unfolding segments. We reanalysed ERPs from three North Germanic language varieties to investigate the influence of suprasegmental cues on spoken word recognition, Central Swedish, South Swedish and Danish. All three language varieties have a two-way word accent distinction. The accents have a similar distribution but are realised differently across varieties. For instance, accent 1 is realised as a low tone on the stressed syllable in Central Swedish, a pitch fall in South Swedish and as a type of creaky voice in Standard Copenhagen Danish. We used combined pronunciation lexica and frequency lists to calculate estimates of lexical uncertainty and information gain at suprasegmental cue onset. Participants listened to target words incorporated into low-constraining carrier sentences. Using single-trial

mixed-effects regression models run every 4 ms, we investigated temporally fine-grained event-related potential effects of lexical uncertainty and information gain associated with suprasegments. Only forward-looking processes showed solid results: Lexical uncertainty, operationalized as cohort entropy, correlated positively with ERPs at frontal sites within 200 ms after suprasegmental cue onset and negatively at posterior sites after 200 ms. The findings are in line with a previously reported frontal pre-activation negativity (PrAN) for more constraining phonological cues (Roll et al., 2015). Backward-looking information gain associated with the onset of suprasegmental cues resulted in effects with similar polarities and latencies, but these did not survive correction for multiple comparisons. The findings indicate that the PrAN effect is driven by forward-looking processes – perhaps due to task demands. The weaker effect of information gain could also be due to task demands or because measuring points were late in words. While a model including only segmental information mostly performed better, it was outperformed by the suprasegmental model from 200-330 ms at frontal sites. This indicates that in this time window, suprasegmental cues contribute to lexical access over and beyond segments in the North Germanic varieties investigated. This points to a spoken word recognition system making use of any available information, including prosodic, to access relevant lexical candidates (Marslen-Wilson, 1987). In addition to being lexically distinctive, North Germanic word accents are associated with morphological structure and specific word endings (Rischel, 1963). Swedish listeners can use the accents to activate suffixes even when stems do not carry lexical meaning (Söderström et al., 2017). Therefore, it is possible that the word accent effect reflects not only expectations about the lexical identity of unfolding words but also about their morphological structure.

Topic Areas: Prosody, Speech Perception

## Speech prosody serves temporal prediction of language in the frontal cortex via neural entrainment in the auditory cortex

***Poster C35*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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INTRODUCTION: Temporal prediction assists language comprehension. In a series of recent behavioral studies, we recently showed that listeners employ rhythmic prosodic modulations to predict the duration of upcoming sentences, speeding up comprehension. At last year's SNL conference, we presented preliminary MEG evidence that this effect is driven by neural oscillations at delta-band frequency (i.e., < 4 Hz). Delta-band oscillations had been previously known to synchronize with speech prosody. Our preliminary analyses showed that oscillations do not only synchronize with prosody during stimulation, but carry prosodic rhythms into the future to serve downstream temporal prediction. In the current submission, we provide the final sensor space MEG analyses of this effect. More importantly, we also present new source-level MEG analyses to address the underlying functional neuroanatomy. Prior work has shown that synchronization to prosody relies on right auditory regions, whereas prediction in general is mostly associated with left frontal areas. The current results demonstrate that the shift from synchronization to prediction indeed associates with a shift from auditory to frontal areas. METHODS: Our study combined an initial repetitive prosodic rhythm (entrainment phase) with a subsequent visual sentence presentation (target phase). We used two prosodic contours (slow and fast), the duration of which either matched or mismatched the duration of an upcoming visual sentence. In the entrainment part of each experimental trial, a contour was repeated 3 times to induce rhythmic entrainment. In the target part, the target sentence was presented word by word; presentation was duration-matched to the rate of the previous prosodic stimulus. We first hypothesized that delta-band oscillations would entrain to the rate of the prosodic contours in the right hemisphere. Second, we expected that brain activity at the frequency of the preceding contour would still be detectable in the MEG signal recorded during the visual target sentence, predominantly in the left hemisphere. Third, we expected an error response when the duration of the target sentence mismatched the duration of the entraining contours. RESULTS: During the entrainment phase, we observed sensor-space MEG coherence with the contours at the stimulation rate ($p < 0.001$, corrected), which was source-localized to right-hemispheric auditory areas. During the target phase, activity at the frequency of the preceding contour was still detectable in the MEG ($p < 0.001$, corrected); strikingly, sources shifted to the left frontal cortex. Critically, when the target sentence was shorter than expected from the preceding contour, an M300 ERF was observed at the offset of the short sentence—likely indicating an omission response under the expectation of a long sentence. CONCLUSION: We conclude that prosodic entrainment is a functional mechanism of temporal prediction in language comprehension. The entrained oscillations appear to shift from right bottom-up (= auditory) regions in the entrainment phase to left top-down (= predictive) regions in the target phase. The conserved prosodic frequency determines the temporal prediction of the duration of upcoming stimuli. The mechanism of prosodic entrainment could potentially be used as a facilitatory means in dialogue, enhancing mutual comprehension.

Topic Areas: Prosody, Speech Perception

## The representational dynamics of speech prosody: An MEG study

***Poster C36*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speech prosody plays a critical role in communication, particularly in conveying the speaker's intention through intonation. Previous fMRI research in our lab demonstrated a network predominantly in the right hemisphere for processing speech prosody. This network consisted of an auditory ventral pathway connecting the posterior (pSTS) and anterior superior temporal sulcus (aSTS), and auditory-motor dorsal pathways connecting pSTS and the inferior frontal gyrus (IFG) and premotor cortex (PMC). Existing models suggest that prosody is acoustically analyzed in the bilateral posterior temporal regions and is abstracted and evaluated in the right anterior temporal and frontal regions. However, it remains to be shown how these areas represent prosodic information over time. To this end, we collected magnetoencephalography data from 34 native German listeners while they listened to single words ("Bar" [bar], "Paar" [pair]; on average, 480ms) that gradually varied in prosody (statement – question) and word-initial phoneme (/b/ – /p/) along orthogonal continua generated by audio morphing. Participants categorized these words in terms of either prosody or phoneme in alternating blocks. We analyzed the data in two major steps in source space (eLORETA). Firstly, we conducted a whole-brain searchlight multivariate pattern analysis (MVPA) using a linear classifier to identify the brain regions differentially involved in the phoneme and prosody tasks and their temporal dynamics.

Secondly, a representational similarity analysis (RSA) was carried out in these areas to determine whether and when the multivariate differences between the tasks represent the acoustics of the prosodic contours or the abstract categories of statement and question. Specifically, the neural activity patterns across stimuli were compared with modeled patterns based on either the acoustic or categorical (behavioural) dissimilarity of the stimuli. The RSA was repeated with a whole-brain searchlight approach to confirm these results and screen for potential contributions of further brain regions. The MVPA revealed a distributed set of bilateral frontotemporal areas, replicating and extending our previous fMRI findings. Notably, the right PMC and pSTS were involved earlier (around 400 ms after word onset) than the right insula/IFG (around 550 ms), suggesting different processing stages of speech prosody. The region-based RSA showed that bilateral temporal (around 400ms) and right frontal regions (around 550ms) represented the prosody acoustics, while only the right pSTS (around 450 ms) showed categorical representations of question/statement. Similar representational dynamics of prosodic information were found in the searchlight RSA, but within broader frontotemporal regions, with a right-hemispheric predominance. These preliminary findings indicate that both acoustics and abstract categories of speech prosody are primarily represented in temporal areas. While the acoustics are represented bilaterally, the categorical representations of speech prosody are lateralized to the right hemisphere. The additional acoustic representations that emerged later in the right frontal regions could reflect the evaluative process to sharpen the categorical representations for final decision-making. The representational transfer between the involved regions will be further investigated with a directed information transfer analysis. Overall, our multivariate approach draws a comprehensive spatiotemporal picture of the cascade of perceptual and evaluative processes in the brain which underlie the comprehension of prosody.

Topic Areas: Prosody, Speech Perception

## Neural mechanisms of attitudinal prosody perception in a second language: an fMRI study

***Poster C37*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Attitudinal prosody is important in social communication as it conveys the speaker’s attitude or intention. It contrasts with linguistic prosody, which adds mainly syntactic or semantic information to the utterance. Previous first language (L1) brain research has shown that social cognition areas, such as the medial prefrontal cortex (mPFC) and anterior middle temporal gyrus (aMTG), are essential for the understanding of speaker intention from prosody (Hellbernd & Sammler, 2018). However, perceiving attitudinal prosody in the second language (L2) has been challenging for L2 learners, probably due to limited L2 exposure and proficiency (Shochi et al., 2016). Furthermore, processing sentence-level prosody requires the integration of semantic and syntactic information during sentence comprehension. Consequently, L2 learners may experience increased cognitive load in sentence processing involving the left inferior frontal gyrus (IFG), which may extend to L2 attitudinal prosody processing. In this study, we employed fMRI to examine the brain networks involved in the processing of prosodic attitudes in L2 by comparing linguistic and attitudinal prosodic sentences in L2 and L1. Moreover, we investigated whether the level of individual L2 exposure affects this mechanism and, if so, how. The participants were 32 healthy, right-handed Japanese native speakers (11 females, mean age 20.4) who had acquired an intermediate level in English as L2. Each participant's level of L2 exposure was assessed through a questionnaire measuring their daily English listening and use. We prepared stimuli of sentences with two types of prosody (Attitudinal-A vs. Linguistic-L) and in two languages (L1-J vs. L2-E), forming four conditions (AE, LE, AJ, and LJ) presented in a block paradigm. Inside the fMRI scanner, the participants performed a two-alternative forced judgment task where they were required to distinguish either the attitudinal prosody or linguistic prosody of each sentence. For the linguistic condition, they had to either identify the focus location or the sentence type (statement or question), and for the attitudinal condition to categorize either the friendliness or the confidence of the utterance. Statistical analyses were performed with SPM12, using a random effects model (voxel-level FWE-corrected $p < 0.05$) Three major findings emerge. First, consistent with previous studies, the L2 and L1 attitudinal prosody conditions [AE+AJ] enhanced significantly greater activation in the mPFC and aMTG than the linguistics prosody conditions [LE+LJ]. Second, as an interaction effect tested by the contrast ([AE>LE]>[AJ>LJ]), the L2 attitudinal prosody condition produced greater activation in the opercular part of the left IFG and premotor area (Small Volume Correction, FWE-corrected $p < 0.05$). This finding suggests that L2 learners are linguistically loaded while processing attitudinal prosody. Third, when the effect of the amount of L2 exposure was tested with the [AE>LE] contrast, we found a significant correlation in the thalamus during L2 attitudinal prosody processing, supported by the accuracy rate of AE data, which presents a substantial positive correlation with the amount of L2 exposure. Our findings suggest that language exposure may be important in acquiring L2 attitudinal prosody and provide insights into the brain networks associated with attitudinal prosody processing.

Topic Areas: Prosody, Speech Perception

## Intonation Units in spontaneous speech evoke a neural response beyond speech acoustics

***Poster C38*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Spontaneous speech is produced in chunks called Intonation Units (IUs; Chafe 1994). IUs are defined by a set of auditory cues, including changes in syllable delivery rate, resets in pitch level, resets in volume and pauses. IUs are presumably universal in human language, and we recently found that they have a consistent temporal structure across six languages with different grammatical and socio-cultural profiles (Inbar, Grossman and Landau, 2020). Linguistic theory suggests that IUs pace new material relative to the discourse, and as such serve as a window onto the dynamic focus of attention in speech processing. In this study, we identify a neural response unique to the boundary defined by the IU. We characterize the distinct contributions to this response of acoustic variation, on the one hand, and linguistic structuring, on the other. We measured the EEG of participants (N=50) who listened to different speakers recounting an emotional life event in Hebrew. We analyzed the stimuli prosodically into IUs, and categorized each word as either ending an IU or not. Additionally, we quantified an acoustically-based measure of prosodic boundary strength at each word. We modelled the neural response at each EEG channel and time point relative to word offset using a hierarchical GLM approach. We find that the EEG response to IU-final words differs from the response to IU-nonfinal words over and above the expected response for a given acoustic boundary strength. The EEG response at IU closure includes a negative deflection at right-anterior electrodes, starting as soon as the last word in the IU ends and lasting circa 200 ms. IU closure is further characterized by a centroparietal positive deflection between 150-500 ms after the last word in the IU. In addition, we find that stronger acoustic boundaries elicit a larger anterior negativity between 100-400 ms. This pattern of results resembles a known ERP component, the Closure Positive Shift (CPS; Steinhauer, Alter and Friederici, 1999). The CPS was found at prosodic phrase boundaries in several other languages using isolated, constructed sentences. To the best of our knowledge, this is the first study to characterize a CPS-like response to spontaneous speech during naturalistic listening conditions. Moreover, we accomplish this within the framework of functional linguistics, in which there is an established connection between the prosodic chunking of speech and the flow of information during communication. In addition, we address a debate in the CPS literature considering the extent to which the CPS reflects a linguistic structuring of the input beyond the bottom-up response to acoustic boundary cues. By explicitly modelling both contributions to the CPS, acoustic and linguistic, we find what appear to be two different components within the classical CPS. Finally, we discuss our findings in light of the body of research on rhythmic brain mechanisms in speech processing, and delineate the ways in which IU-related neural activity contributes to the previously characterized delta-band neural speech tracking.

Topic Areas: Prosody, Speech Perception

## Prosodic cue weighting by French-English bilinguals when assigning lexical stress in English: Preliminary ERP and behavioural results

***Poster C39*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Learning to adapt one’s prosodic processing to a second or non-dominant language can be difficult because learners need to assign new meaning to acoustic cues already used in their native language (L1). This process is even more difficult if the second language (L2) uses different prosodic constructs than the L1. For instance, while fundamental frequency (F0) rises are associated with lexical stress in English, they are associated with phrase boundaries in French. Lexical stress and phrase boundaries both provide important information about how to segment the speech stream; thus, the misinterpretation of an F0 cue in an L2 (e.g., as indicative of a phrase boundary instead of lexical stress) could lead to segmentation errors, hindering speech processing. In the present study, we paired a behavioral and an event-related potential (ERP) task to examine how French-English bilinguals with varied language experience assign weight to F0 and syllabic duration cues when locating English lexical stress. The stimuli consisted of bisyllabic homonyms with different stress patterns (trochaic nouns, iambic verbs). The homonyms were recorded as both nouns and verbs by a native speaker of English and edited to create stimuli with conflicting lexical stress cues. For instance, syllabic duration could suggest a trochaic pattern while the F0 suggested an iambic pattern. In the behavioural task, participants were presented with original and manipulated versions of the homonyms and were asked to report which syllable

was accented. In the ERP task, participants listened to original and manipulated recordings of one homonym in an oddball paradigm blocked by word category (e.g., standard = original noun, deviants = F0 edited noun, duration edited noun, and original verb, and vice versa; Näätänen, et al., 2004) while watching a silent movie. The recorded ERPs were pre-processed according to field standards (Luck, 2005), and difference waves between deviant and standard conditions were computed across language groups (English-L1 and French-L1). To date, twenty English-French bilinguals have participated in both tasks (10 English-L1, 10 French-L1). Interestingly, preliminary analyses of the behavioural and ERP results suggest different patterns of effects, with the behavioural task showing that prosodic modulations (F0 or syllabic duration) affected stress assignment in both homonym categories (noun or verb) in a similar manner across listeners, irrespective of their L1. In contrast, visual inspection of topographic representations of the ERP difference waves suggests that French-L1 listeners reacted differently from English-L1 listeners when hearing stimuli with conflicting prosodic cues, particularly during the verb block. Specifically, English-L1 listeners showed MMN-like negativities to two types of deviant stimuli (original noun and F0 edited verb) while the same deviants elicited positivities in the traditional P300 time-window in French-L1 listeners. Taken together, these preliminary results suggest that although listeners' preattentive processing of prosodic cues might be conditioned by the cues' weight in the L1, it does not prevent L2 listeners from adapting their interpretation of the perceived acoustic cues to the specifics of their L2.

Topic Areas: Prosody, Speech Perception

## Neural bases of the facial imitation of auditory smiles in EEG and SEEG

***Poster C40*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Spoken interaction is based on verbal and non verbal information. Prosody plays an important role during communication by providing information on the other person's intention that can be explicitly or implicitly processed. For instance it has been shown that listeners mimic smiles perceived in the speakers' voice, even when they don't see their face, and even when they don't consciously recognize the voice as smiling (Arias et al., Current Biology 2018). This behavior suggests a complex form of cognitive processing involving the phonological recognition of the spectral signature of smiled speech, the activation of sensorimotor networks linking this signature with oro-facial motor activity and, potentially the involvement of social-cognitive and emotional circuits linked to social communication. However, the exact neural bases of unconscious facial imitation of smiled speech remain largely unknown. In this planned study, we will collect behavioral data, facial EMG activity (zygomatic and corrugator muscles) and EEG activity recorded from electrodes placed on healthy controls' scalp (EEG, N = 20) or directly implanted in drug-resistant epileptic patients's brain (SEEG, N = 20) while they listen and rate smiling speech. Forty sentences recorded by 4 speakers (2M/2F) with a smiling or non-smiling tone will be used. The EEG study will consist of the passive listening of 3 blocks of 80 sentences (40 smile and 40 non-smile) each, followed by an active listening task where participants judge whether the sentences are smiling or not by pressing a button 2 seconds after the outset of the sentences. Only the active listening task will be used in SEEG. From previous literature, we expect to find more mimicry in active than passive tasks. In passive tasks, we expect to find 10-15% false-alarm (non-smiling stimuli wrongly detected as smiling) and miss trials (when smile is not detected). Zygomatic EMG is expected to be activated during hits & misses, but not false alarms and correct rejections; conversely, corrugator EMG should be deactivated during hits & false alarms, but not misses and correct rejections. In the EEG data, we will focus first on the comparison of the passive versus active task, then on the comparison of miss versus hit trials within the active task. We will mostly use time-frequency analyzes during the sentences and ERPs locked to the decision. The SEEG paradigm will help us define the brain regions involved in the implicit detection of smile with a focus on temporal lobes for the auditory processes, motor and premotor areas for the preparatory response (mimicry), and frontal lobes for the overt decision. The EEG collection will take place during Summer 2023, the first SEEG acquisition early Summer, with a rhythm of once a month, and the first data analysis are planned to be available in the Fall.

Topic Areas: Prosody, Speech Perception

## Relevance of prosodic information for spoken communication at the lexical and discourse levels: Evidence from psychometric and electrophysiological data

***Poster C41*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Prosody underpins various linguistic domains ranging from semantics to discourse. Pitch accent, one of the most notable features of prosodic phenomena, not only distinguishes lexical meaning as in the Swedish words anden (with Accent 1) ‘the duck’ and anden (with Accent 2) ‘the spirit’, but also sets focus for the most critical constituent of the discourse. The present study concerns with the relevance of lexical and focal functions of pitch accent for a coherent interpretation of linguistic message in Swedish. Using psychometric and electroencephalographic (EEG) measures, we investigated how listeners judge pitch accent violations in isolation and combined. Experimental stimuli consisted of one hundred sets of short dialogues, each having three sentences: an informative background sentence (e.g., It is a water bird with broad bill), a wh-question inquiring a specific information (e.g., What did Sven see?) and a target sentence with critical information (e.g., Sven saw the duck). The pitch accent on the critical information was either congruent or incongruent in relation to its lexical (indicated by accent numbers) and focal (indicated by square brackets) functions, creating four experimental conditions: i) correct discourse (e.g., Sven saw [the duck1]), ii) lexical accent violation (e.g., Sven saw [the duck2]), iii) focal accent violation (e.g., [Sven] saw the duck1), and iv) combined violation (e.g., [Sven] saw the duck2). The dialogues were presented auditorily, and the native Swedish speakers were asked to judge the correctness of the target sentences, actively in the psychometric paradigm and passively in the EEG paradigm. Psychometric data from forty participants (21 male, 19 female; age range 22–38 years) indicated that all violations (ii-iv) interfered with the coherent interpretation of message, and were judged as incorrect by the listeners. However, there was also a statistically significant difference in perceived correctness of pitch accent violations depending on the level they were occurring on. Focal accent violations led to a lower correctness score compared to lexical accent violations, and the effect of combined violation was additive. Put differently, the listeners were more sensitive to focal accent violations than lexical accent violations. Interim results from an ongoing EEG data collection (13 native speakers; 4 male, 9 female; age range 20–35 years) are in accordance with the psychometric data, and indicated the largest N400 response to the combined violation, followed by the focal accent violation and the lexical accent violation. These findings show that an accent mispronunciation impairs understanding of the semantic content and discourse relevance of critical information, and that the language comprehension system reveals different sensitivities to lexical accent and focal accent anomalies. Accent mispronunciations at the discourse level result in higher costs for spoken communication than accent mispronunciations at the lexical level. This pattern of results provides evidence that the brain does not only extract the lexical and focal aspects indicated by pitch accent but also gives different weights of relevance to them for a functioning spoken communication.

Topic Areas: Prosody, Speech Perception

## Language and tool use both need putamen: A VLSM study

***Poster C42*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Tool use and language are two major hallmark behaviors of human evolution. These two behaviors have been hypothesized to share a common cognitive origin – hierarchical processes. Supporting evidence included correlations in behavioral tasks, transfers in learning, and overlapping neural activity in basal ganglia. Here we test this hypothesis using a causal brain modal – patients with brain damage – and examine the relational pattern in which brain lesion leads to deficits in language and tool processing. Ninety-three patients with brain injury and 43 healthy controls were recruited. They completed a wide range of behavioral tasks related to language and tool processing and underwent structural MRI scans with lesions manually traced for each patient. First, Voxel-based lesion-symptom mapping (VLSM) was employed to detect voxels important for sentence comprehension and for tool use, with word-picture verification as control task for sentence comprehension and action imitation for tool use to exclude impairment due to individual word comprehension and peripheral motor processes. Regions whose lesion lead to deficits in both sentence comprehension and tool use were identified based on two analyses: Regions with significant voxels for both analyses; Regions whose VLSM t-scores for the two tasks were significantly correlated across voxels. Both analyses converge on left putamen. To more directly examine whether the common effect between sentence comprehension and tool use was indeed related to hierarchical processing, we performed an error analysis on language production– the “cookie theft” description task. The proportions of well-formed sentences and embedded clauses being generated were taken as a measure of syntactical hierarchical ability for each patient. VLSM analysis using this measure also converged on left putamen. These above results were robust across a series of validation analyses using different statistical measures (Bayes z-scores compared to the healthy control group) or different brain parcellation template (the Human Brainnetome Atlas). These results provide further supports for the role of basal ganglia (putamen in particular) in supporting joint processes of tools and languages, showing that the integrity of this subcortical structure is necessary in normal (hierarchical) language and tool processing. An account naturally accommodate these findings are tool use and language both entail the ability to integrate lower-order elements into higher-order units, which is supported by putamen.

Topic Areas: Syntax and Combinatorial Semantics, Disorders: Acquired

## Grey and white matter substrates of syntactic comprehension: lesion-symptom mapping and indirect structural disconnection mapping on 130 left-hemisphere stroke survivors

***Poster C43*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The neural underpinnings of syntactic processing during sentence comprehension are far from being identified by current neurocognitive models of language comprehension. Traditionally, frontal regions (e.g., left posterior inferior frontal gyrus, IFG) were considered critical (Friederici, 2011; Hagoort, 2013). More recently, temporal regions (left posterior middle temporal gyrus, MTG), are regarded as more indispensable to syntactic comprehension (Matchin & Hickock, 2020). The processing of syntactically complex sentences is also dependent on dorsal tracts (Friederici, 2011; Hagoort, 2013; Bornkessel-Schlesewsky & Schlesewsky, 2013), while the involvement of ventral tracts (typically associated with semantic processing) is yet to be determined. Finally, syntactic processing has been investigated by using different types of non-canonical sentences interchangeably. However, sentences may be syntactically complex for different linguistic reasons. In this study, we investigated the grey and white matter substrates of syntactic comprehension in a large cohort (N = 130) of left-hemisphere stroke survivors. We analyzed the comprehension of different types of sentences (simple declaratives and non-canonical subject-extracted, object-extracted, and passive sentences) by selecting specific subtests of the CYCLE-R test (Curtiss & Yamada, 1988). Neural correlates of performance were assessed using both univariate and multivariate (Ivanova et al., 2021) lesion-symptom mapping (LSM) with lesion size, age, education, and time post-stroke as covariates. White matter disconnection severities were calculated via Indirect Structural Disconnection Mapping (Lesion Quantification Toolkit, Griffis et al., 2021). The impact of tract-level disconnection severities on the comprehension of the different sentence types was assessed through correlation analyses (Bonferroni-corrected alpha = 0.0056). Results of the LSM analyses identified the left mid to posterior MTG, and the posterior superior temporal gyrus (STG) as crucial for processing all sentence types. Non-canonical sentences also involved the left anterior MTG and STG, planum temporale and polare, and Heschl’s gyrus. Correlation analyses showed that the comprehension of all sentence types is affected by the disconnection of ventral tracts (inferior fronto-occipital fasciculus, uncinate fasciculus, inferior longitudinal fasciculus) in the left hemisphere and corpus callosum (posterior division). The processing of all non-canonical sentences was also affected by the disconnection of the middle longitudinal fasciculus. The disconnection of the dorsal tracts (arcuate fasciculus, superior longitudinal fasciculus) affected only the comprehension of subject and object-extracted sentences (not passives or declaratives). Our results show that syntactic comprehension relies on left temporal regions (Dronkers et al., 2004; Matchin et al., 2022) and underlying white matter pathways. Left frontal regions were not found to be critical, but the disconnection of fiber tracts connected to frontal areas did significantly impact syntactic comprehension, especially for non-canonical sentences (Ivanova et al., 2021; Wilson et al., 2011). The comprehension of different types of non-canonical sentences was affected by damage to slightly different regions and fiber tracts. Therefore, syntactic complexity should be better stratified in future research.

Topic Areas: Syntax and Combinatorial Semantics, Disorders: Acquired

## Neural Encoding of Syntactic Structures during Natural Speech Planning and Production

***Poster C44** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Spoken language is a highly efficient and structured means of conveying information, enabling humans to transform thoughts rapidly and accurately into meaningful messages. Central to this expressive capacity is our ability to manipulate complex syntactic configurations, transforming conceptual meaning into hierarchically organized sequences of words. However, the precise mechanisms by which the brain constructs such syntactic structures during speech planning and production remain largely unsettled. Existing studies on sentence planning and production have primarily used techniques with limited temporal resolutions or employed artificial tasks, leaving a significant gap in our understanding of the neural dynamics supporting the generation of syntactic structures during natural speech. To address this gap, we analyzed intracranial brain recordings obtained from French-speaking patients with intractable epilepsy while they engaged in spontaneous speech production, such as talking about past events or narrating a story. After transcribing and aligning the speech material, we leveraged state-of-the-art natural language processing (NLP) models to extract linguistic features that define the syntactic structure of the patients' produced sentences. These features were based on constituency (e.g., syntactic classes; the number of opening and closing syntactic nodes, or "top-down" and "bottom-up" chunking schemes) and dependency tree structures (e.g., thematic labels, dependency distances, number of left- and right-hand side dependencies), as well as probabilistic measures such as syntactic conditional probabilities (e.g., syntactic surprisal). To characterize how constituency tree structures are encoded in the neural signal during spontaneous speech planning and production, we first quantified the number of syntactic nodes at each word following both a top-down and bottom-up parsing strategy. We then fit multivariate temporal response function (TRF) models to predict brain responses based on the two parsing schemes. Preliminary findings indicate that decreases in broadband high-frequency activity in the left middle temporal gyrus and middle frontal cortices are predictive of the number of opening syntactic nodes at each word, in line with a top-down chunking scheme. This analysis will be extended to other syntactic dimensions such as syntactic class, dependency structure, and syntactic conditional probabilities, to examine how these features are encoded in cortical and subcortical brain regions during spontaneous speech planning and production.

Topic Areas: Syntax and Combinatorial Semantics, Language Production

# Endogenous Cortical Rhythms of Hierarchical Structure Building in Language Production

***Poster C45*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous research has demonstrated the neural oscillations' ability to track quasi-rhythmic patterns (syllables, words, and phrases) during speech comprehension (Ding et al., 2016; Kaufeld, 2020; Meyer, 2018). Since syntactic phrases are not directly encoded in speech signals, it was proposed that an internally generated rhythm might feed the acoustic speech entrainment with syntactic knowledge. Yet the correspondence between this rhythm and prosodic boundaries (physically marked in speech), has been questioned (Glushko et al., 2022). Moreover, previous studies focused on linear word groups without embedding, raising concerns about capturing nested syntactic structures with a single oscillatory band (Kazanina & Tavano, 2023). Our study aims to test these ideas in language production, where hierarchical structure building may be imposed on the production output in a top-down manner, given the absence of speech features for entrainment. We recorded participants' EEG responses while they typed sentences of different embedding depths, following specific picture configurations on a computer monitor. Typing was chosen over speaking to avoid potential entrainment confounds to self-monitoring during speaking, while still requiring typical production stages prior to motor execution (Rumelhart & Norman, 1982). We contrasted between Dutch subordinate (e.g., Dutch equivalent of [[the woman] [yells [that [[the man] cries]]]]) and coordinate (e.g., [[[the woman] yells] [and [[the man] cries]]]) clauses. Although they share a similar linear order of input, subordinates involve additional syntactic depth of embedding (indicated by bracketing). We hypothesized that producing subordinates results in increased neural entrainment at the rate of phrase-structure building compared to coordinates. Participants were instructed to start typing immediately after picture presentation to minimize variability in planning time prior to typing onset. Keystrokes were time-logged for synchronization with EEG recordings. Data from 18 participants have been collected. Typed strings were annotated in two ways. Firstly, each keystroke opening a phrasal bracket was coded as 1, while the rest as 0 (bracket presence), reflecting linear concatenating. Secondly, each keystroke was coded based on the number of phrases it opened (bracket count), reflecting hierarchical embedding. Two phrase rates were obtained by dividing annotation values by the duration of each trial, and ± 1 standard deviation of each mean rate was taken to form the phrase bands. After preprocessing and artifact removal/attenuation, the EEG signal was band-pass filtered separately through each band, and then Hilbert-transformed to extract instantaneous phase and power. We computed Gaussian Copula Mutual Information (MI) (Ince, et al., 2017) between the resultant time series and the annotated time series, separately for each electrode, participant, and condition to quantify the degree of phrase rate tracking. Our hypothesis predicted higher MI values for subordinates at the phase rate reflecting embedding (bracket count) if the brain employs rhythmic patterns to encode nested relationships during structure building in language production. Conversely, if structure building relies solely on linear concatenation of phrases, we expected higher MI values for coordinates at the phrase rate of bracket presence. Significance of MI values will be determined with cluster-based permutation tests (Marisand & Oostenveld, 2007). Preliminary analysis has confirmed such trend in our data.

Topic Areas: Syntax and Combinatorial Semantics, Language Production

## How delaying the target verb resolves the N400 semantic illusion

***Poster C46*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Kate Stone[1], Milena Rabovsky[1]; [1]University of Potsdam

Unexpected words within a context elicit large N400 brain potentials. However, sometimes N400s at unexpected words are small when stereotypical agent and patient roles are reversed, such as at 'arrested' in 'the cop that the thief arrested' ("N400 semantic illusion"). The illusion can be resolved if the presentation of 'arrested' is delayed temporally or with neutral information ('that evening') [1,2], but this delay effect was only recently observed. We tested a novel manipulation of the delay's content to probe whether an existing account of the illusion could accommodate the delay effect: In the Sentence Gestalt (SG) model, the illusion results from uncertainty between event knowledge and syntactic cues like word order [3]. Semantic association is the stronger cue and 'arrested' is perceived as plausible. Delaying the verb may resolve the illusion by allowing syntactic cues more time to constrain interpretation. If so, this would predict that a delay containing semantically associated information may instead sustain the illusion. We tested these predictions by manipulating the semantic association of the delay. In contrast, other accounts of the initial illusion would predict that the delay effect should not replicate at all [4:6]. Methods. Materials: German sentence pairs such as "Everyone in the train saw which.ACC/NOM fare evader the.NOM/ACC ticket inspector caught"; case marking on the determiners was swapped to reverse the stereotypical agent and patient. The verb was either not delayed, delayed with neutral words ("further up": syntactically consistent, no semantic association), or delayed with semantically informative words ("without a ticket": consistent + semantic association). Participants: 74 native German speakers. Analysis: Bayesian linear mixed effects model of mean amplitude from 300-500 ms after target verb onset (caught) across centro-posterior electrodes. Predictors: role order (canonical/reversed) × delay (none/neutral/informative). Predictions: An interaction of role order and delay: N400 should be larger for reversed sentences after the neutral but not the informative delay where stronger semantic association should sustain the illusion. Results. Despite a main effect of role order, estimates were not consistent with an interaction of role order and delay at the group level. However, individual estimates were surprisingly uniform: In the neutral delay condition, every reader demonstrated a small N400 increase for reversed sentences relative to the no delay condition. In the informative delay condition, most (but not all) readers showed an N400 decrease in reversed sentences relative to the neutral delay condition. Conclusions. The small but consistent effect of the neutral but not the informative delay across readers supports the SG model's account that the N400 semantic illusion results from initial semantic-based interpretation that can be constrained by syntax over time [3]. Competition from additional semantic cues appears to outweigh the benefit provided by additional syntactic constraint. The small interaction effect size informs future experiments as large samples are needed to provide evidence for interactions [7]. References. [1] Chow et al. (2018) [2] Momma et al. (2015) [3] Rabovsky et al (2018) [4] Bornkessel-Schlesewsky & Schlesewsky (2013) [5]

Brouwer et al. (2017) [6] Kuperberg et al. (2007) [7] Gelman et al. (2020)

Topic Areas: Syntax and Combinatorial Semantics, Meaning: Lexical Semantics

## Neural Correlates of Syntactic Unification in Minimal Phrases: Evidence from an EEG Study in Audio and Visual Modalities.

***Poster C47*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Tanzida Zaman[1], M. Blake Rafferty[2], Ashley W. Harkrider[1], Devin M. Casenhiser[1]; [1]University of Tennessee Health Science Center, [2]New Mexico State University

An electroencephalography (EEG) study by Rafferty et al. (2023) found that participants demonstrated significantly greater neural synchrony when they read pseudoword noun phrases (the moop) compared to when reading the same words in reversed order. Other research, however, found that participants who listened to pseudoword sentences showed comparatively little neural synchrony (Kaufeld et al. 2020, Coopmans et al. 2022). These divergent findings may be due to differences in reading versus listening. To test this possibility, we both replicated Rafferty et al to confirm neural synchrony for pseudowords during reading and tested whether neural synchrony is also elicited when the stimuli are presented auditorily. Finally, we investigated the comparative amount of neural synchrony when stimuli are presented with identical or varying inter-word intervals. Methods: Forty participants (experiment 1+2) listened to and read stimuli from two conditions: unifiable and non-unifiable. Unifiable stimuli consisted of an English determiner followed by a pseudoword (the moop). In non-unifiable stimuli the words were reversed so that they did not form a complete phrase. Differences in neural synchrony were measured using Inter-trial phase coherence (ITPC) at the phrase rate (.5 Hz) and the word rate (1 Hz). We hypothesized that regardless of stimulus modality, participants would demonstrate greater ITPC for unifiable stimuli at the phrase rate, while they would show no differences at the word rate. In a second experiment we manipulated the duration of auditorily presented stimuli to create two conditions: isochronous (word duration and inter-word intervals were held constant), and anisochronous (word durations were allowed to vary naturally). We hypothesized that the isochronous condition would exhibit greater differences in neural synchrony when comparing unifiable and non-unifiable conditions. Results: For visual stimuli, 17/20 participants elicit greater ITPC for unifiable words than the non-unifiable words. Participants also demonstrated significantly greater ITPC at the phrase rate ($p = 0.003$) for unifiable words. No significant difference was observed at the word-rate ($p = 0.764$). For auditory stimuli, 13/20 participants elicited greater ITPC in the unifiable condition. Somewhat unexpectedly the unifiable word pairs elicited only marginally higher ITPC when compared to non-unifiable words ($p = 0.064$). Again, no differences were observed at the word rate ($p = 0.840$). In Experiment 2, 19/20 participants who heard stimuli presented isochronously demonstrated greater ITPC for unifiable words, and significantly greater ITPC for unifiable words was found for the phrase-band ($p= 0.001$) but not for the word band ($p = 0.075$). When the stimuli were presented anisochronously, 15/20 participants elicited greater ITPC in the unifiable condition, and there was marginally greater ITPC for unifiable phrases in the phrase-band ($p= 0.059$). No differences were observed in the word band ($p = 0.143$). Conclusion: Results confirm previous evidence that neural oscillations can synchronize with linguistic structures. Further, since neural synchrony is elicited even when stimuli lack content words, the results suggest that syntactic patterns need not project from lexical items, as

has been previously suggested. Finally, the results from experiment two underscore the extent to which neural synchrony depends on the temporal predictability of stimuli.

Topic Areas: Syntax and Combinatorial Semantics, Methods

## Simple and complex tool use improve language syntax comprehension

***Poster C48** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Do language and motor skills share cognitive processes? It has recently been suggested that a form of hierarchical nesting processing may operate in both skills: motor syntax in manual actions and language syntax in sentence comprehension. Language syntax characterizes the rules governing sentence structures. A sentence is a linear sequence of elements (words) which are dependent one to the other in several levels of nesting. Syntax thus makes it possible to form more or less complex and recursive language structures to generate an infinite diversity of linguistic expressions from a finite number of elements. Goal-directed actions have more recently been described in comparable terms: in an action such as serving coffee, or a simpler action such as moving an object, each element of the operative chain is carried out in a sequential order that similarly includes dependencies between elements and hierarchical nesting. In a previous work relying on the principles of learning transfer, we showed that adult participants trained to enter pegs on a board using a tool significantly improved their performance in a subsequent language syntax comprehension task. In contrast, the control group trained in the same task with the bare hand showed no improvement in the language task. We concluded that using a tool significantly increased the motor syntactic complexity of the operative chain, which resulted in a transfer of syntactic learning from action to language. Here we aimed to investigate further the transfer of syntactic learning by manipulating the hierarchical complexity of action and the presence/absence of a tool. As in the previous study, adult participants performed a language syntax comprehension task, before and after a motor training session. Two groups (n=20 each) were trained with blocks of embedded motor structures (each trial requiring one to three movements), the first group using their hand alone (CH: complex hand), the second group using a tool (CT). Two other groups (n=20 each) were trained with blocks of simple non-embedded actions (only one peg movement), either with their hand (SH: simple hand) or a tool (ST). Our results show that following tool-use training participants improved their overall performance in the language syntax comprehension task, no matter the complexity of the action trained. In addition, we observed (1) a better comprehension of complex syntactic constructions in the CT group; (2) a positive correlation between motor and language performance in the CT group, suggesting that language syntax abilities can predict motor proficiency for complex tool use. Importantly, we did not observe an effect for SH nor CH groups, meaning that motor embedding complexity alone is not sufficient to produce learning transfer. To conclude, our results are in line with the idea that motor skills and language share common domain-general syntactic processes. Also, the learning transfer due to tool use can benefit from the addition of embedded actions.

Topic Areas: Syntax and Combinatorial Semantics, Multisensory or Sensorimotor Integration

# Initial motor skills determine the benefits of tool-use learning over syntax in language

***Poster C49*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Claudio Brozzoli[1,2], Mallory Augier[2], Roussey Juliette[3], Roy Alice C[1,4], Boulenger Véronique[1,4]; [1]These authors contributed equally, [2]Equipe IMPACT CRNL - INSERM U1028 - Université Claude Bernard Lyon 1, [3]Université Aix-Marseille, [4]DDL - CNRS U5596 - Université Lumière Lyon 2

Empirical findings during the last decades revealed that language leverages the sensorimotor circuits handling perception and action to process phonemes and semantics. Yet, evidence was scant for an embodied syntax. Recently, we revealed that planning to use a mechanical tool and understanding sentences with a complex syntax (i.e., object-relatives) activate the same brain structures within the Basal Ganglia (BG) and prompt similar patterns of neural activations.1 If tool use and syntax rely on common neural resources, could one benefit from training the other? In line with this prediction, we unveiled cross-domain learning transfer: using a tool improves syntactic comprehension of complex structures in language. Individuals are however not equally dexterous in using a tool and the initial motor skills might determine the learning curve during motor training. The differences in tool-use dexterity might be crucial for the occurrence of syntax learning transfer between tool use and language. According to the exploration-exploitation model of motor learning, different processes during motor learning differently recruit the BG.2 This can affect the occurrence of benefits from tool use to language. Indeed, the initial exploration phase (linear progress) is associated with activity in the anterior caudate, one of the regions shared by tool use and syntactic processes. Once the motor skill is acquired (in the proximity of the plateau of an asymptotic trend), the activation elicited by motor practice shifts to the posterior caudate, a cluster not shared between the two functions.3 Such neuro-functional dynamics of brain activations accompanying motor learning predicts that less dexterous participants with the tool, who might spend more time in the exploration phase during training (with a linear rather than asymptotic trend of learning), ultimately might also gain more benefits for language. We tested (1) whether the individual initial tool-use dexterity impacts motor learning; (2) whether different profiles of motor learning in using the tool (linear vs. asymptotic) determine different benefits for syntactic processes in language. We first assessed tool dexterity in 40 healthy adults with the Purdue pegboard test. We then evaluated syntactic comprehension in the same participants, before and after tool-use training. Our results show that the majority of participants with a lower score at the initial motor assessment with the tool, displayed a linear rather than asymptotic progression during tool-use training. The frequency of participants displaying linear and asymptotic learning curves was instead similar in the group with higher scores in the initial motor assessment. Crucially, a significantly larger improvement in syntax was found in the group of less dexterous participants with the tool (mostly linear learners) compared to the more dexterous ones (equally distributed in linear and asymptotic learners). In conclusion, our findings support the idea of syntax as a domain general function for action and language and point to the need of adapting the tool complexity to individual abilities to better recruit common resources with language. Thibault et al. Science, 2021 Graybiel Curr Opin Neurobiol, 2005 Choi et al. PNAS, 2020

Topic Areas: Syntax and Combinatorial Semantics, Multisensory or Sensorimotor Integration

## When the N100 reflects the top-down prediction of verbal inflection during pronoun processing

***Poster C50*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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It is well known that N100 component is related to both auditory and perceptual processing (Schwartze et al., 2013; Thornton et al., 2007) and the top-down and attentional processing (Schwartze et al., 2013; Thornton et al., 2007, Getz & Toscano, 2019). Yet, to date, it is still debatable if top-down prediction related to pronoun-verb relationships influence the elicitation of N100 component during pronoun processing. Moreover, grammatical features are not the sole representation that are accessed during subject-verb processing (Molinaro et al., 2011) as previous studies have shown that language statistical properties are involved in language processing (Seidenberg & MacDonald, 1999) and subject-verb agreement is processed by sequence detectors linking the representations of morphemes that are likely to occur in succession (Pulvermüller, 2003). Hence, there are two aims in this present study. First, to investigate whether top-down prediction depending on the strength of co-occurrence frequency between French pronouns and their verbal inflections influenced the N100 component during pronoun processing. Second, to investigate if there is automaticity in top-down prediction related to pronoun-verb relationships as previous study showed that subject-verb agreement is automatically processed (Gunter & Friederici, 1999). To achieve the first aim we compared the N100 amplitude elicited by the processing of highly predictable pronouns of verbal inflections (i.e., 'nous' – we and 'vous' – you plural) to that by the processing of lowly predictable pronouns of verbal inflections (i.e., 'je' – I and 'tu' – you singular). Pronouns were auditorily presented as primes in a grammatical priming paradigm. To investigate the automaticity, we conducted two EEG experiments. In the first experiment, participants had to perform a lexical decision task on the auditory targets following the presentation of primes (n=23), while in the second experiment, they had to perform a noun categorization task on the targets (n=20). As expected, we observed a larger N100 after the processing of highly predictable pronouns of verbal inflections in comparison with that of lowly predictable pronouns of verbal inflections in both experiments ($p<.001$). This effect was not affected by the task ($p>.2$). This suggests that the N100 reflects the top-down prediction of verbal inflection during pronoun processing and that this prediction, which was driven by the strength of co-occurrence frequency between pronouns and verbal inflections, occurs automatically. The current findings support the predictive coding framework (Friston, & Kiebel, 2009) claiming that the brain continuously infers the probabilities of sensory input from higher-level representations in order to predict the upcoming input.

Topic Areas: Syntax and Combinatorial Semantics, Phonology

## Neural resources underlying prosody-syntax interactions

***Poster C51*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Recent research aims to understand how the brain encodes various levels of linguistic information using naturalistic speech stimuli, allowing more generalizable neuroscientific exploration of brain function (Broderick, 2018; Huth, 2016; Pallier, 2010; Brennan, 2012; Rutten, 2018; Santoro, 2017). Few studies have focused on the spatial distribution or temporal dynamics underlying the interaction between the processing of different levels of language, for example in the processing of higher-level syntactic operations versus that of lower-level features like speech prosody. Linguistic prosody has been shown to play a role in guiding the interpretation and prediction of syntactic structure (Bennett & Elfner, 2019), and it is therefore timely to investigate how the neural processing of these two features interact to influence the predictability and reliability of speech processing. In a recent study, we examined the neural processing of syntax in the temporal domain using MEG data (Degano, 2023). We found that prosodic cues enhance the neural processing of syntax, revealing an intricate interaction between acoustic features and more abstract linguistic information, and their pivotal role in facilitating effective human communication. Given the intrinsic limitation of MEG data in localising relevant brain networks, we are currently extending these questions to an openly available fMRI dataset. Further, we're interested in seeing the extent to which our findings generalise across languages differing in terms of their typological distance. The current project aims to shed light on the neural localization underlying the prosodic boosting of syntax For this, we are analysing an open source fMRI dataset comprising a total of 112 native speakers of one of three languages: English, Chinese and French speakers (Li, 2022). Each language group listened to excerpts of the audiobook "The little prince" in their respective languages: English (49 participants), Mandarin (35 participants), and French (28 participants). We will first extract prosodic and syntactic information from the language-specific speech stimuli themselves, in the different languages, to a) replicate the previously observed English-language syntax-prosody interaction, b) test for the presence of such a relationship also in French and in Mandarin. Prosodic features will include intonational and rhythmic information obtained through spectral analysis of the speech signal (Suni, 2017), while syntactic features will make use of statistical and linguistic modelling to capture the syntactic information within the stimuli in each language . We will also make use of typological databases (e.g. https://wals.info/) to identify the best local and also more distant syntactic features of interest. We will then analyse the fMRI data using encoding models (Naselaris, 2011) to investigate the brain network that encodes the prosody-syntax interaction, in the fMRI data obtained in the different languages. This dataset offers the unique opportunity to examine the question of the prosody-syntax interaction across three languages that differ in terms of their typological features both at the prosodic and syntactic levels, with English and French being more similar to one another than Mandarin(Dryer, 2013), shedding light on the brain handles these linguistic features in diverse language contexts.

Topic Areas: Syntax and Combinatorial Semantics, Prosody

## EEG Hyper-Connectivity and high-gamma Differentiate PPA from Normal Aging

***Poster C52*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Primary progressive aphasia (PPA) is a rare neurodegenerative syndrome characterized by progressive deterioration of language abilities. Diagnosis is assisted with medical imaging methods such as MRI or PET and lexical and/or language metrics. Significant effort has been made by many authors to automate the process of differentiating between healthy and PPA patients[1]. Low density EEG is of significant interest given its low cost and complexity, especially where equipment and specialized clinicians are scarce. However, very limited research is available regarding the use of EEG in PPA diagnosis. It is not clear which metrics characterize PPA and therefore differentiate PPA from normal aging. Here we will address this question using feature extraction in machine learning algorithms. We used resting state eyes-closed 8-channel (F7,F8,T7,T8,CP3,CP4,P5,P6) EEG recordings from 8 healthy elderly participants and 14 from PPA patients (9 lvPPA, 5 nfvPPA). The data was re-referenced using the common average re-referencing method, preprocessed to remove noise and the removal of (non-)linear trends, and consequently segmented into 8.192 second epochs. This resulted in a dataset with 361 healthy epochs and 294 PPA epochs. Functional connectivity was calculated using the Relative Wavelet Entropy (RWE) method, which is a method of constructing a synchronization matrix whose values represent the degree to which the energy distribution among the EEG rhythms (δ, θ, α, β and γ) are similar for each electrode pair. The relative energy ratios for each rhythm were also calculated for the whole EEG and for each electrode separately. Both the functional connectivity metrics and rhythm energy ratios were statistically analyzed using the Spearman rank correlation coefficient (ρ) to determine which features were statistically significant for distinguishing between the healthy control and patient groups. Functional hyper-connectivity in PPA compared to controls significantly differentiated the two groups in the following pairs: CP3-F7 ($\rho=0.6195, p=1.0970e-07$), CP3-T7 ($\rho=-0.2375$, $p=7.4850e-10$), F7-T7 ($\rho=0.7083, p=7.3104e-10$), F7-P5 ($\rho=0.5951, p=5.3899e-06$) and T7-P5 ($\rho=0.1322$, $p=6.9477e-04$). The EEG rhythm ratios that were statistically significant ($p<0.001$) were both slow rhythms as expected for a neurodegenerative disorder, such as the δ (whole EEG,F7,F8,T7,T8,CP3,P6), θ(T8,CP4,P5), α(F7,F8,P5,P6), and β(whole EEG, F7,T7,P5), as well as fast ones γ(F7, T7, T8, CP3, CP4, P5 and P6). The present study shows that EEG-based functional connectivity can reliably differentiate PPA from healthy controls and that EEG metrics can be used as a biomarker for PPA when other mediums are not available. Furthermore, we show for the first time, that PPA can be distinguished from healthy controls both in slow, as expected in neurodegeneration, but also in fast rhythms. EEG with its high temporal resolution offers further insight into the PPA syndrome. [1] Wilson, Stephen M., et al. "Connected speech production in three variants of primary progressive aphasia." Brain 133.7 (2010): 2069-2088.

Topic Areas: Disorders: Acquired, Computational Approaches

## Effects of social engagement and individual motivation on aphasia outcomes

*__Poster C53__ in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Individuals with post-stroke aphasia often cite social interaction with their families and communities, and individual motivation to improve their speech and language, as important factors in their recovery process [1–2]. However, these constructs are difficult to measure, and it remains unclear whether they contribute to aphasia recovery above and beyond the key predictors of lesion location and extent [3]. In this study, we investigated whether social engagement and/or individual motivation are predictive of aphasia outcomes. The present analysis is based on 93 individuals who presented with acute aphasia after dominant hemisphere stroke (age 61.6±13.7, range 23–90; 52/41 male/female) and for whom language evaluations (Quick Aphasia Battery [QAB] [4]) and interviews probing social and motivational factors were acquired between 3 months to 1 year post-stroke. Acute QAB overall scores were 4.6±3.1 and final scores were 7.8±2.1 on a 10-point scale. To measure social engagement and motivation, speech-language pathologists carried out a thorough interview with each patient, along with their caregiver where appropriate. We used a standardized bank of questions (e.g., Who do you spend time talking to? What kinds of things do you do to stay busy each week? Do you belong to any groups? etc.). Then, we rated social engagement and motivation, each on a 5-point scale (none, minimal, fair, good, excellent). These ratings were included as predictors in a linear model of aphasia outcome (QAB overall score). Other predictors included time post onset, age, sex, handedness, education, stroke type, damage to frontal, fronto-parietal, and temporal ROIs, and total lesion volume. The model explained 74.4% of the variance in aphasia outcome, with lesion factors accounting for much of the variance, as described previously [3]. We found that social engagement had a highly significant effect on aphasia outcome (β=0.73±0.20 QAB points per social scale point, 95% CI=[0.34, 1.12], t=3.71, p=.0004), with a medium effect size (f2=0.181, Δr2=4.6%). Social engagement also had a significant effect in an ancillary analysis of change in QAB overall score from the acute to the final observation (p=.0020). In contrast, individual motivation did not have an effect on aphasia outcome (β=–0.14±0.13, CI=[–0.39, 0.12], t=–1.07, p=.29). Our findings provide strong support for the importance of social engagement after stroke, suggesting that an enriched social environment with frequent opportunities to communicate with multiple consistent communication partners facilitates recovery from aphasia. This implies that support for social reintegration should be prioritized in the clinical management of individuals with aphasia. Future work will focus on psychometric validation of our rating approach, detailed temporal analyses of the bidirectional relationships between aphasia and social engagement, and investigation of other environmental and individual factors that may influence aphasia outcomes. [1] Le Dorze et al. Aphasiology 2014;28:421-439. [2] Woodman et al. Disabil Rehabil 2014;36:2031-43. [3] Wilson et al. Brain 2023;146:1021-39. [4] Wilson et al. PLoS One 2018;13:e0192773.

Topic Areas: Disorders: Acquired,

## Using FLAIR MRI to Account for Hypoperfusion in Examinations of Brain-Behavior Relationships in Acute Stroke

*__Poster C54__ in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Investigations of neuroanatomical structures associated with behavior are often conducted during chronic stages of stroke recovery. However, findings in this population may be influenced by functional reorganization and thus not reflect typical neurological function/organization. Ideally, investigations would be completed during the acute phase of recovery, before reorganization has occurred. Investigations in acute ischemic stroke present some unique challenges, though, such as needing to account for dysfunction associated with hypoperfusion in addition to the lesion. Currently, magnetic resonance perfusion weighted imaging (PWI) or CT perfusion are the gold standard for identifying hypoperfusion, but are not always available or may be contraindicated for some participants. Recently, Reyes and colleagues (2022) proposed an alternative method for quantifying hypoperfusion using hyperintense vessels—which reflect reduced blood flow—on fluid-attenuated inversion recovery (FLAIR) MRI (viz. the NIH-FHV score). This study examined the relationship between the locations of hypoperfusion on FLAIR compared to perfusion-weighted imaging (PWI; Bunker & Hillis, 2023). FLAIR and PWI scans for 101 individuals (48 female; median[range] age = 73[58-83]) with hyperacute ischemic stroke (i.e., prior to tissue-type plasminogen activator [tPA]) were scored for presence/absence of FLAIR hyperintense vessels (FHVs, the markers used to determine the NIH-FHV score) and hypoperfusion on PWI (time-to-peak >4sec) in six vascular regions: the anterior and posterior cerebral artery territories (ACA, PCA), and four sub-regions of the middle cerebral artery (MCA) territory including frontal, temporal, parietal, and insular. We examined associations between presence/absence of hypoperfusion on FLAIR/PWI using Pearson's chi-square and Cramér's V. There were significant associations ($p$'s $\leq .001$ after correction) in the location of hypoperfusion/hyperintense vessels in all vascular areas except for the ACA territory, presumably due to low power (only n=3 with FHVs and n=5 with PWI deficits in this region). Cramér's V indicated that the associations were "strong" (ACA) and "very strong" (all other regions). Results replicate prior work establishing an association between the location of FHVs and perfusion deficits on PWI (Bunker et al., 2022). Likewise, these results validate prior investigations showing associations between various neurological and behavioral measures (e.g., NIHSS, naming, picture description, and neglect) and NIH-FHV scores in specific vascular regions independent of lesion volume (Bunker et al., 2022, Stein et al., 2022). Together, the current/previous studies provide validity that regions of hypoperfusion identified using the NIH-FHV score do indeed correspond with the location of perfusion deficits on PWI as well as various outcome measures. Since PWI may not always be collected with an MRI stroke protocol, whereas FLAIR is nearly always collected, the NIH-FHV score is an attractive alternative for quantifying the amount/location of hypoperfusion when PWI is not available. The NIH-FHV score has clinical utility in acute stroke care but also could be a useful tool for investigating brain-behavior relationships in acute stroke populations to account for dysfunction associated with hypoperfusion. We intend to present this work in conjunction with a tutorial of the background and methods of the NIH-FHV score (to support implementation), as well as our collective evidence supporting its application in clinical and research settings.

Topic Areas: Disorders: Acquired, Methods

## Mapping the vascular territories in left hemisphere stroke

***Poster C55*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Lesion-symptom mapping (LSM) has been a cornerstone of cognitive neuroscience since the 19th century, where Broca's and Wernicke's aphasia were first described. Classical neurology studies were limited in their ability to map precisely, in contrast MRI allows us to map with millimetre specificity. One major caveat that is rarely addressed relates to the fact that brain damage after stroke is not random but constrained by neurovasculature. It is known that LSM can be prone to mis-localisation (e.g., Mah et al., 2014), where the error is skewed towards the areas most likely to be damage (for middle cerebral artery (MCA) stroke, that is commonly the medial insula and subcortical regions). The problem is not alleviated with novel multivariate mapping methods (Sperber et al., 2019). This suggests an alternative approach is needed, however, before one can develop such an approach we need to be able to map the vascular territories. In a proof of concept study, we showed a coherent statistical structure in the lesion profiles of left hemisphere stroke aphasic patients (Zhao, Halai, et al., 2020). Importantly, the underlying structure mapped onto post mortem angiography studies of the MCA. The sample was, however, relatively small and we were unable to measure reliability. In this study, we used 526 left hemisphere stroke patients from the PLORAS database and applied hierarchical clustering analysis to the lesions. We chose this method because the neurovascular system is known to follow a hierarchical framework across three major arteries (anterior [ACA], MCA, posterior [PCA]). We first used minimum description length to determine the number of likely clusters (iterated 100 times across sub-samples). We estimated 28 clusters, which were then extracted as 3-D volumes. From a macro scale, we identified four large clusters ordered in the proximity from anterior to posterior: ACA, superior MCA, inferior MCA and PCA. This fits with known anatomy and expected nature of lesions in a typical stroke population. We used the areas described in the post mortem studies as validation to link to the regions identified in the current study – there was an extraordinarily high degree of conformity. We repeated the analysis for reliability (split-half), where we applied the same clustering algorithm to two random sub-samples. We matched clusters based on spatial overlap using DICE. In order to determine stability, we iterated this 1000 times with a random split-half each time. The average DICE for all clusters was 0.5 (SD=0.15; range=0.21-0.77). All but four clusters had DICE values above 0.4. DICE was correlated with the frequency of lesion to a cluster (r=0.69), suggesting that less stable clusters might be driven by fewer data points. We also found that the distance between clusters across split halves was stable and correlated (r=0.7), which means the overall shape and structure remained stable. We demonstrated the reliability and stability of a neurovascular atlas. This raises important questions for LSM in our field: e.g., 1) can we use knowledge of the statistical structure in correcting mis-localisation in LSM?; and 2) are these clusters our 'effective' resolution?

Topic Areas: Disorders: Acquired, Methods

## Online Eye-Tracking for Clinical Research: A Validation Study with Aphasia Patients

***Poster C56*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background: Eye-tracking presents a useful tool to investigate the neural bases of human language processing in healthy and impaired populations. However, results from clinical eye-tracking studies involving small sample sizes bear weak generalizability. Instead, a reliable online paradigm widens the accessibility of clinical research. Slim and Hartsuiker (2022) and Wisiecka et al. (2022) revealed promising results to shift eye-tracking measures online through webcam technology in healthy adults, despite recording delays of up to 300ms online. However, these studies did not compare web-based vs. in-lab eye-tracking within participants. Additionally, no study has yet established the feasibility of using web-based eyetracking to investigate language comprehension processes in adults with aphasia. Using a within-subject design, we investigate (1) whether results from online eye-tracking are comparable in spatio-temporal accuracy for a sentence-picture matching task in persons with aphasia (PWA) and controls; and (2) what methodological issues arise from online eye-tracking with PWA. Data collection is ongoing. Online and in-person auditory picture-matching tasks are presented to PWA and age-matched controls in a counterbalanced order. Auditory questions are presented while two pictures (a target and foil) are shown on-screen. For the in-person task, an EyeLink 1000 Plus tracker is used. For online eyetracking, the WebGazer.js algorithm running in Gorilla.sc is used to track the eyes through participants' webcams. Participants are hypothesized to look more at the target picture after the auditory prompt disambiguates the choice between the two pictures. However, PWA may show slower, less pronounced looks to the target, and given previous results (Slim & Hartsuiker, 2022) disambiguation effects may be delayed in web compared to lab data by as much as 300ms. Preliminary data from a double case study including one PWA and one control suggest comparable results between modalities. Both lab and web eye-tracking are sensitive to uncovering differences between healthy and impaired participants. Temporal accuracy in the lab is greater than on the web (500Hz vs 60Hz). Nevertheless, both modalities show participants looking more at the target picture as sentence comprehension unfolds, suggesting effects of sentence disambiguation are evident from both systems. The included control showed faster and stronger disambiguation effects, with looks to the Target averaging >80% around 5 seconds post-trial onset in both the lab and web experiments. The included PWA reached >60% looks to the target picture around 8 seconds post-onset in both modalities. Preliminary results suggest that both eye-tracking modalities are comparably sensitive to between-participant differences, despite the greater temporal and spatial resolution of lab-based compared to online eye-tracking. If the pooled results do not reveal a cross-modal temporal delay, virtual eye-tracking may expand the breadth of research seeking to shift to online measures and may therefore lead to far greater reliability and generalizability of studies involving PWA. Both modalities continuing to yield comparable results would suggest that virtual eye-tracking holds promise for incorporating larger sample sizes and encompassing a further reach for aphasia research, which would have highly important implications for the field at large.

Topic Areas: Disorders: Acquired, Methods

## Distinct brain morphometry patterns revealed by deep learning improve prediction of aphasia severity

***Poster C57*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Mounting evidence suggests that post-stroke aphasia severity depends on the integrity of the brain beyond the stroke lesion. Neuroimaging models combining lesion anatomy with global and regional brain integrity can better explain aphasic symptoms, yet some of the interindividual variability remains unaccounted for. A source of variability that is overlooked by uni- and multivariate models is the spatial interdependence between brain regions or the lesion. Here, we tested whether deep learning with Convolutional Neural Networks (CNN) on whole brain morphometry (i.e., tissue volumes segmented by FSL's FAST) and lesion anatomy can better predict which individuals with chronic stroke (N=231) have severe aphasia, and whether encoding spatial dependencies in the data might be capable of improving predictions by identifying unique individualized spatial patterns. Over repeats of a nested cross-validation scheme, we show that a tuned CNN achieves significantly higher accuracy and F1 scores than a tuned Support Vector Machine (SVM) that discounts spatial dependencies, even when the SVM is nonlinear or trained on lower-dimensional data by integrating widely used linear or nonlinear dimensionality reduction techniques. Ensemble averaging and stacking model predictions did not improve performance, implying that more conventional machine learning did not provide complementary predictive information to the CNN. Performance parity was only achieved when the SVM was directly trained on the latent features learned by the CNN. The SVM performed nearly as well when trained on higher dimensional feature saliency maps returned by the CNN, but only when saliency was more likely to reflect the unique spatial patterns that could be captured by a CNN. Saliency maps demonstrated that the CNN learned more widely distributed patterns of brain atrophy predictive of aphasia severity, whereas the SVM focused on the area around the lesion. Ensemble clustering of CNN saliency maps revealed roughly a dozen distinct morphometry patterns that were unrelated to lesion size, highly consistent across individuals, and implicated unique brain networks. Although these patterns demonstrated a tendency for patients with severe aphasia to be predicted on the basis of contralateral brain features to the stroke, individualized predictions of severity depended on both ipsilateral and contralateral features outside of the lesion. Our findings illustrate the degree of heterogeneity in the spatial distribution of atrophy in individuals with aphasia, show that these patterns are predictive of severity, and underscore the potential for deep learning to improve prognostication of behavioral outcomes from neuroimaging data, emphasizing the potential benefit of exploiting spatial dependence at different scales in multivariate feature space.

Topic Areas: Disorders: Acquired, Methods

## fNIRS Functional Connectivity in Chronic Post-Stroke Aphasia: A Pilot Study

***Poster C58*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Functional near-infrared spectroscopy (fNIRS) provides an opportunity to investigate neural activation in more naturalistic settings, as participants wear a portable cap while engaging in real-world tasks (e.g., speaking, conversation, movie watching). fNIRS additionally provides an opportunity to investigate neural activation in clinical disorders such as aphasia, as it can be used with individuals who are either ineligible for fMRI or unable to tolerate fMRI examination due to reduced health status. fNIRS functional connectivity (FC) analyses have also recently gained popularity as a measure of neural network dynamics both at rest and during tasks. Therefore, the aim of this study is to investigate fNIRS FC during movie watching in people with aphasia (PWA) and two groups of neurotypical adults (HC). To date only two studies have investigated fNIRS FC in post-stroke aphasia, making this a relatively novel contribution to the field. Methods: 14 neurotypical young adults (YHC), 15 neurotypical older adults (OHC), and 17 PWA, completed a movie watching task in which they were first instructed to watch 68-second silent narrative videos, and then provide 15-second verbal summaries. Offline behavioral measures were administered to ascertain aphasia severity for PWA (WAB-R, BNT, and CLQT). fNIRS data were collected via a NIRx NIRSport2 continuous-wave NIRS device. The fNIRS montage consisted of 16 sources and 15 detectors forming 37 long-separation channels covering bilateral frontal, temporal and parietal regions. An ROI-based fNIRS FC analysis will be conducted to investigate intra- and inter-hemispheric connectivity in oxygenated- (HbO) and deoxygenated- (HbR) hemoglobin between regions of interest (ROIs) in the perisylvian language areas and contralateral homologues. The 68-second movie watching segments will be extracted and pre-processed via transformation of raw data to optical density, motion artifact correction, band-pass filtering, and conversion of optical density to hemoglobin concentration units via the Modified Beer-Lambert Law. For PWA, channels within lesioned areas will be manually excluded. Following pre-processing, 15 seconds will be removed from the beginning and end of each epoch to reduce potential effects of unstable signals. fNIRS signals will be averaged across channels to form broad ROIs (e.g., bilateral inferior frontal gyri (IFG), middle frontal gyri (MFG), precentral gyri, and temporal and parietal regions). FC maps will be obtained for each participant by computing the Pearson correlation coefficient r across each ROI on the time series data. Group FC maps will be computed by averaging individual FC maps. Linear mixed effects models will be conducted to compare FC values between groups across ROIs. For PWA, FC values will be correlated with assessment scores to investigate the relationship between fNIRS FC and aphasia severity. Anticipated Results: We anticipate PWA will show reduced intra-hemispheric and inter-hemispheric FC compared to HC due to damage within perisylvian language areas and neural network disruptions post-stroke. Additionally, we hypothesize that greater intra-hemispheric and inter-hemispheric connectivity will be associated with milder aphasia. Summary: These results will provide preliminary evidence on the use of fNIRS FC analyses to measure cortical network dynamics during naturalistic tasks in healthy and clinical populations.

Topic Areas: Disorders: Acquired, Methods

## Lesion-symptom mapping of pre-surgical language deficits in patients with left-hemisphere primary brain tumours

***Poster C60*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Patients with primary left hemisphere brain tumours have been reported to present with or without language impairments prior to treatment. However, the majority of studies to date have involved brief tests of verbal fluency and confrontation naming, with relatively few administering a comprehensive language assessment. In the present study, we investigated the incidence of pre-operative language impairments in a sample of patients with primary left-hemisphere brain tumours with the Comprehensive Aphasia Test (CAT) and employed lesion-symptom mapping to identify associated tumour sites. Thirty-four patients participated in the present study. Approximately 71% of the sample were classified as aphasic based on their performance on at least one CAT language subtest, with 44% impaired on at least two, and 29% impaired on at least three. Most showed deficits on verb naming, picture description, and word reading and comprehension subtests. After controlling for age, sex, education, tumour grade, and lesion volume, verb naming and comprehension of written word subtests were significantly associated with lesions to the anterior and medial temporal lobe (parahippocampal and fusiform gyri), respectively. Voxel-wise disconnection analyses revealed verb naming deficits were significantly associated with disconnection of the arcuate fasciculus terminations in the middle and superior temporal gyrii, while reading comprehension deficits were associated with disconnection of inferior, middle and superior cerebellar peduncle pathways. These results indicate pre-operative language impairments are common, occurring in the majority of tumour patients in the present cohort. In addition, the prominent language impairments reflect tumour encroachment on language-related temporal lobe regions and connected white matter pathways. This information may prove useful for predicting language outcomes and planning appropriate language therapies following surgery.

Topic Areas: Disorders: Acquired,

## Functional localization of the language and the multiple demand network in individuals with chronic post-stroke aphasia

***Poster C61*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction Aphasia is an acquired language disorder impairing communication ability and is principally caused by a stroke in the language-dominant left hemisphere. Neuronal changes occur in individuals with aphasia (IWA) as they try to restore their language abilities. However, there is ongoing debate about the role of the domain-general multiple demand (MD) network in supporting language recovery. One possible reason for the contradictory findings is the use of group-based region of interest (ROI) analyses that do not account for individual variability in functional networks (Fedorenko et al., 2010). In contrast to previous studies, we aim to determine the language and MD network in a subject-specific manner using functional localization. Additionally, we compare two receptive language localizer tasks, namely a visual (reading) and auditory (spoken language) task, which are believed to represent the same language network in healthy young participants but has not yet been investigated in elderly or IWA. Methods We conducted functional MRI (fMRI)

tests on 15 IWA (mean age=64 +- 14 years) in the chronic stage of stroke recovery (>1 year) and 12 healthy controls (HC, mean age=67 +- 9 years). IWA had suffered a stroke in the left hemisphere or bilaterally. Participants performed a spatial working memory task, which included a hard and an easy condition. To suit our target population (i.e., older and stroke population), this task was simplified from Fedorenko et al. (2010), who showed that in young adults the hard>easy contrast robustly activated the MD network. Participants also performed two existing language localizers: a visual reading (sentences>nonwords) and an auditory spoken language (intact>degraded, speech-shaped noise) task, which aim to functionally localize the language network. The method used for network identification followed the approach described by Fedorenko et al. (2010). To investigate the involvement of the MD network during language comprehension, we conducted t-tests (FDR-corrected) to test for activation of single-subject-defined MD regions during the language localizer tasks. Finally, we assessed the spatial overlap between the three functional networks (MD network and language networks defined by visual and auditory localizers) using Dice similarity coefficients. Results During the language reading task, neither group showed significant activation within the single-subject-defined MD network. For the listening task, significant activation was observed in the right (t=5.43, p=0.004) and left insula (t=4.06, p=0.01) of the HC group, but not in IWA The Dice score for the overlap between the MD network and the language networks defined by visual and auditory localizers was 0 for both groups. The mean Dice scores for the two language localizers were 0.27 (SD=0.12) for IWA and 0.23 (SD=0.09) for HC across brain regions. Discussion The MD network does not support language functioning in chronic stroke patients with aphasia or in healthy elderly individuals. The role of the MD network in acute or subacute stroke patients must be explored in the future. While there was some overlap between the language network defined by the auditory and visual localizers, these localizers exhibited differences in activation patterns across language-related brain regions, which will be discussed and further investigated.

Topic Areas: Disorders: Acquired,

## Memory Performance in Alzheimer’s Disease and Primary Progressive Aphasia

***Poster C62** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction : The ability to learn and remember new information naturally diminishes in cognitively normal adults across the life span (Cabeza, 2002) but is especially reduced in individuals with Alzheimer’s disease (AD) (Moradi et al., 2017). Recent accounts have also documented verbal episodic memory deficits in primary progressive aphasia (PPA) a neurodegenerative disorder primarily characterized by impaired language performance. This was particularly true for the logopenic variant (lvPPA) (Eikelboom et al., 2018) that has mostly AD pathology. A key process needed to form memories relies on distinguishing similar representations and transforming them into non-overlapping events through pattern separation (McClelland et al., 1995). Prior research has shown that pattern separation abilities are indicative of memory decline both in healthy older individuals as well as in individuals with AD (Stark et al., 2013). However, no prior research has investigated pattern separation abilities in PPA and its variants. The goal of the present study was to investigate the pattern separation abilities in two variants of PPA (lvPPA and non-fluent, nfvPPA) and compare lvPPA to AD, since they share the same pathology. Methods: Pattern separation abilities were evaluated in patients with lvPPA (n=22), nfvPPA (n=10), AD (n=8), and healthy controls (n=7). We used the Mnemonic Similarity Task (MST ) that consisted of (a) an encoding phase of photographs of everyday objects where participants classify objects as “indoor” or “outdoor”, and (b) a surprise recognition phase during which participants are asked to identify the objects presented as “old” (repeated items), “similar” (lure items), or “new” (foil items). As pattern separation index, we measured the Lure Discrimination Index (LDI), i.e., the rate of responding “similar” to a similar lure item minus the rate of responding “similar” to novel objects (foils) (Stark et al., 2013). Analyses included a set of pairwise t-tests investigating LDI differences between: the three patient groups with HC, lvPPA with nfvPPA since they are variants of the same disorder, and lvPPA with AD since they have the same pathology. Results: Group comparisons showed statistically significant differences between HC and AD ($p=0.009$), as well as between HC and lvPPA ($p<0.001$), with higher scores for HC. No significant difference was found between HC and nfvPPA. Comparisons of lvPPA with the other two patient groups showed a significantly lower score compared to nfvPPA ($p = 0.004$), but no significant difference compared to AD. Discussion: Results demonstrated a strong relationship between pattern separation abilities and diagnosis of AD and lvPPA. Importantly, nfvPPA showed a pattern separation profile more similar to HC compared to lvPPA. These results show a strong association between AD and lvPPA, which presumably relates to the shared underlying pathology of these two groups. At the same time, the dissociation between nvPPA and lvPPA may reflect the distinct pattern of atrophies these variants present, with the predominant posterior temporoparietal atrophy observed in lvPPA, a region that is spared in nfvPPA (Eikelboom et al., 2018; Gorno-Tempini et al., 2008).

Topic Areas: Disorders: Acquired,

## Exploring Structural Impoverishment in LSD Model of Psychosis

***Poster C63*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language abnormalities are considered biomarkers of schizophrenia and other psychotic disorders, which share similar perceptual and cognitive alterations with psychedelic experiences. It has been shown that, similar to schizophrenia, low to moderate doses of psychedelics enhance semantic association, while other evidence point towards changes in different components of language production over the time course of the acute and sub-acute LSD effects. Notwithstanding these similarities, few studies explored the language profile of neurotypicals under psychedelics. To be considered: syntax hasn’t been examined in speakers under psychedelic experience. Literature on language and schizophrenia are filled with studies characterizing anomalies at all levels of language. Recently, however, there has been strong evidence of syntactic deficits, supporting the hypothesis of language-specific deficits in schizophrenia. Accordingly, it has been argued that the inability of patients with schizophrenia to build complex propositions and coherent semantic relations between them might reflex impoverishment of grammatical knowledge. In other words, schizophrenia leads to grammatical deficits at the competence level, resulting faulty linguistic performances. It is, thus, not only important to investigate the role of language-specific deficits in schizophrenia and other psychotic disorders, but also to distinguish anomalies of the linguistic system from deficits of other cognitive resources, such as memory and attention, allowing us to tease apart impairments related to linguistic competence from those concerning linguistic performance. Our study examines linguistic variables indicative of structural deficiency (i.e., indicative of semantic, syntactic and morphological anomalies) in narratives of neurotypical individuals, native speakers of Brazilian Portuguese, under low to moderate LSD dose. The narratives under examination were previously collected by Wiessner and colleagues for the purpose of exploratory studies on the acute and subacute effect of LSD on different aspects of cognition, which adopted a randomized, double-blind, placebo-controlled, crossover design, in which 24 healthy participants, randomly assigned to treatment order, received 50µg of LSD or inactive placebo, in two treatment sessions and a washout period of 14 days between the sessions. The methodology adopted by us to analyze narratives available in Wiessner and colleagues' corpus consists of semantic and structural analyses based on a syntactic manual annotation system, with analyses of structural complexity and semantic coherence within sentences and nominal expressions. Special attention has been given to overuse of matrix clauses and null pronouns, as markers of simpler and deficient structures, and on the anomalous use of referential pronouns, as markers of problems of linguistic reference, which have been found to be indicative of grammatical deficits in schizophrenia, and associated with the chronicity of the disorder. As we argue, the LSD model of psychosis might provide us with productive empirical grounds to distinguish impairments of linguistic competence from those of performance in psychosis.

Topic Areas: Disorders: Developmental, Language Production

## No evidence of altered resting-state brain functional connectivity between adults who stutter and adults who do not stutter

***Poster C67*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Stuttering is a neurodevelopmental disorder characterised by difficulty in producing fluent speech. Brain imaging studies in people who stutter during both perceptibly fluent and dysfluent speech production have revealed abnormal activity in brain areas involved in speech motor control and sensory feedback, including the inferior frontal gyrus bilaterally, basal ganglia nuclei, supplementary motor cortex, the cerebellum, and auditory cortex. Diffusion-weighted imaging studies have consistently revealed disruptions to the white matter connections between these areas. In contrast, functional connectivity studies in people who stutter have produced rather inconsistent findings. These studies explore functional connectivity at rest removing the potential effects of task demands and performance on measures of brain activity, which may be particularly important in studies of people who stutter. We obtained resting-state functional MRI data sets at both high temporal and spatial resolution in 49 adults who stutter (AWS, 39 men and 10 women; age range 19-45 years) and 38 adults who do not stutter (AWNS, 27 men and 11 women; age range 19-44 years). 1125 echo-planar

volumes with an in-plane resolution of 2 x 2 mm and 72 slices 2-mm thick were collected using a short TR (0.8 s). Participants were instructed to keep their eyes open and fixate a cross on a black screen. Individual resting-state datasets were first analysed by subject-level independent component analysis (ICA) using FSL MELODIC and cleaned using FIX to remove noise components. Group ICA was performed to extract 50 independent components (ICs, 13 signal, 37 noise). Dual regression analyses were carried out to extract subject-specific spatial maps of these components. Spatial maps were compared between the groups of AWS and AWNS using t-tests and nonparametric permutation tests, which included gender, age, and handedness as covariates. The decision criteria were set as $p < 0.05$ with threshold-free cluster enhancement (TFCE). A small cluster in the right lateral middle occipital cortex (cluster size = 2, minimum $p = 0.0176$) from the group comparison of the default mode network showed higher functional connectivity in AWS than AWNS. However, it did not survive after Bonferroni correction of multiple comparisons for the number of components analysed. Furthermore, because of the imbalanced gender ratio in this study, we performed a follow-up analysis on only male participants (39 men who stutter, 27 men who do not stutter). As for the main analysis, a small cluster in the right lateral middle occipital cortex (cluster size = 7, minimum $p = 0.0084$) from the group comparison of a default mode network IC showed higher connectivity in AWS compared with AWNS. This finding also does not survive after correction for multiple comparisons. In summary, with this large sample and high temporal resolution resting-state fMRI data, we found no evidence of altered resting-state brain connectivity between adults who stutter and adults who do not stutter. More targeted, hypothesis-driven analyses may be necessary to reveal abnormal resting-state connectivity in people who stutter. Alternatively, functional differences may only emerge during engagement in task in this population.

Topic Areas: Disorders: Developmental, Methods

## Real-time magnetic resonance imaging reveals hyper-and hypokinetic articulators in stuttering

***Poster C68** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Real-time magnetic resonance imaging (rtMRI) improves the visualization of movement patterns of inner articulators. Here we sought to reveal atypical invisible articulatory movements of inner articulators in persistent developmental stuttering during fluent and dysfluent non-word production.Sixteen fluent speakers (FS) and 18 adults who stutter (AWS) read the non-words [gakʃaitidɔyk] and [natʃaitidɔyt] while supine in a 3T rtMRI. We recorded a midsagittal cross-sectional plane covering mouth, mandibular nasal cavities, pharynx, and larynx at 55 frames per second. For each non-word, we qualitatively characterized the movements of articulators in FS in meticulous detail. We then analyzed events unequivocally stuttered. We observed dysfluent productions of [gakʃaitidɔyk] and [natʃaitidɔyt] in 15 of 18 AWS. After careful exclusion of other dysfluencies, 54 stuttering events from 9 AWS and 45 stuttering events from 6 AWS remained for the qualitative analysis of [gakʃaitidɔyk] and [natʃaitidɔyt], respectively. We assessed five articulatory components, i.e., lips, velum, tongue tip, tongue body, and tongue radix. Having described an abnormal movement pattern, each rater (L.U. and M.H.) went back to video clips of four randomly selected FS. We checked again whether any trace of the movement abnormality seen in AWS could be detected in FS. We calculated odds ratios for each abnormal movement pattern to occur at a stuttering symptom compared to another stuttering symptom using a mixed-model binary logistic regression. During stuttered events in AWS, we observed sustained contractions of the tongue tip, resembling dystonia; tremor of the tongue body with an average frequency of 6 Hz; and spurious, mostly isometric contractions of the tongue or velum. These movements were unevenly distributed and partially matched the stuttering symptom: Tremor was mainly observed during repetitions. The odds to observe a tremor was 109 times higher when the stuttering symptom was a repetition compared to when it was a silent block. Sustained contractions and spurious movements were observed with repetitions, prolongations, and silent blocks. An odds ratio analysis linked the extra movements to silent blocks rather than repetitions. None of the deviant movement patterns was observed in four randomly selected FS. rtMRI enables unprecedented insights into the morphology of stuttering, which comprises all three typical categories of movement disorders (hyperkinetic, dystonic, and hypokinetic). Dystonia-like sustained movements and tremor point to an involvement of the basal ganglia. This methodological breakthrough emphasizes the neurogenic component of stuttering and gives rise to classifying developmental stuttering as a movement disorder.

Topic Areas: Speech Motor Control,

## Bridging verbal coordination and neural dynamics

***Poster C69*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Our use of language, which is profoundly social in nature, essentially takes place in interaction contexts and is therefore based on coordination rules that each interlocutor must respect. It is then necessary to adapt our actions in real time, particularly our verbal productions. Here, we recorded the intracranial brain activity of 16 patients with drug-resistant epilepsy while they performed a verbal coordination task with a virtual partner (VP). More precisely, patients had to repeat short sentences synchronously with the VP. Based on a model which describes the synchronisation behaviour of coupled oscillators, the VP can track the instantaneous phase of the patient's speech signal and predict it so that it can adjust in real time with the patient. Moreover, by changing the coupling strength parameters, we could modulate patients capacity to synchronise speech with the VP. This coordination task allows us to monitor the coupling between the patient and the VP in a continuous manner. From speech signals, verbal coordination was estimated by computing the variability of the phase lag (PLV) between the verbal productions of patients and VP. For each patient, a large variability of this coordination index was found across trials, indicating more or less successful coordinative behaviour. We focused on high frequency activity power (HFa, 70-125Hz) of the neural activity and showed, compared to a baseline, an increase in temporal (STG BA22) and frontal (IFG BA44) regions. While these regions showed a similar increase of HFa, looking at the relation between neural (HFa) and behavioural (PLV) data points to a differential role of the two regions. More precisely, power increases in STG BA22 was associated with positive correlations, while power increases in IFG BA44 was associated with negative ones. In other words, a poor coordinative verbal behaviour implies a greater involvement of frontal regions and a reduced involvement of auditory regions. Our results highlight different activity dynamics depending on the ability to adjust our verbal productions, and show that combining dynamically resolved behavior and neural data is a powerful avenue to better understand natural speech processing.

Topic Areas: Speech Perception, Language Production

## A Language-Specific Left-Lateralized Network for Auditory Naming

***Poster C70*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Naming is a fundamental cognitive function and is an integral part of language assessment in clinical settings. Recent clinical stimulation mapping and neuroimaging evidence indicate that auditory naming, within the context of everyday linguistic discourse, recruits distinct prefrontal cortex regions compared to picture naming. However, the underlying neural dynamics of these processes remain poorly understood. In this study, we aimed to investigate whether and how auditory naming engages language-specific prefrontal regions to process increasing semantic load. We conducted a battery of language production tasks on 50 neurosurgical patients undergoing Electrocorticographic (ECoG) monitoring. The tasks included picture naming and auditory naming (“what a king wears on his head”), with visual word reading and auditory word repetition serving as control tasks. All tasks utilized the same set of 50 words, but with different retrieval routes (randomly interspersed within the block). Region of interest analysis of high gamma broadband activity (70-150 Hz) revealed sustained enhancement in left inferior frontal gyrus (IFG) and left middle frontal gyrus (MFG) specifically during auditory naming, preceding production. We confirmed the effect with multifactor linear regression model, which showed significant interaction effects of electrodes in the aforementioned regions for auditory and semantic features from -1000 ms ~ 250 ms locked to production, $p<0.01$. We then employed an unsupervised clustering approach which was data-driven and not constrained to specific anatomical regions. We identified a novel network in the frontal cortex, centered on the border of IFG and MFG, exhibiting robust task-selectivity for auditory naming before articulation, with significantly greater activity across all electrodes and time. Clustering analysis further showed that this network was distinct from another cluster exhibiting pre-articulatory responses irrespective of task within IFG and portions of precentral gyrus. The two networks also exhibit different temporal profiles of activation: the naming network peaks around 450 ms prior to production, and the pre-articulatory network peaks around 250 ms prior to production. To investigate the nature of semantic load in the naming network, we applied three encoding models (acoustic, semantic integration, and task-based attention) across all active electrodes (cross-validated prediction models of high gamma electrode activity). The results provided evidence that the naming network primarily encodes increasing semantic load, rather than acoustic or task-based attention. (r^2 = 0.006 for the semantic integration model after variance partitioning, which was significantly above permutation baseline, p<0.01). Lastly, we investigated the laterality of this network across both hemispheres to assess language-specificity. Our findings demonstrated strong left lateralization within the naming network, while networks associated with sensory perception and motor execution exhibited little significant differences in laterality (95% confidence interval of the activation laterality index for each cluster, varied from -1 to 1 where 1 represents left laterality: motor: [0.0641 0.0665]; auditory: [0.1383 0.1408]; visual: [-0.0016 0.0017]; pre-articulatory: [0.5132 0.5157]; naming: [ 0.6319 0.6339]). In conclusion, our study uncovers a novel left-lateralized naming network centered around the border of IFG and MFG, specifically involved in processing increased semantic load.

Topic Areas: Speech Perception, Language Production

## Speech processing beyond linguistic contents: a model-guided MEG study

***Poster C72** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The use of language, both reception and production, generally goes beyond linguistic forms and engages internal representations of the world that are shared across cognitive domains to guide behavior. To better understand the interplay between language and internal world representations, it is important to study neural processing of language that involves the extraction of information beyond its linguistic content. However, investigations on the neural substrates of human language largely focus on identifying neurophysiological landmarks of specific linguistic processes, such as semantics and syntax, and ignore its behavioral relevance. Recent neurophysiological studies that tap beyond linguistic aspects of language comprehension are mostly based on functional magnetic resonance imaging (fMRI) during reading comprehension. Notably, a line of research from Fedorenko and colleagues shows that, on the one hand, language-specific processing is carried out in a neuronal network that is dissociable from networks that are involved in domain-general behavioral tasks. On the other hand, these networks, especially the language and the default-mode networks, are co-activated during language comprehension tasks that require the inference of non-linguistic information. However, due to the temporal limitation of fMRI, it is impossible to interpret from such co-activation the real-time interactions among the involved brain areas, which are particularly crucial in understanding the processing of highly dynamic and ambiguous speech signals. To fill this gap, we devised a magnetoencephalography (MEG) study guided by a computational model of hierarchical information passing, aiming to explore the neural-computational mechanisms that subserve the dynamic extraction of non-linguistic information from natural speech signals. During the MEG experiment, subjects perform several speech comprehension tasks that engage different internal information-passing models that focus on extracting different aspects of non-linguistic information. By contrasting neural responses across task conditions, our primary goal is to identify spatial, temporal and spectral characteristics of neural information passing between linguistic and non-linguistic processing. We show our pilot results and discuss plans for further analysis.

Topic Areas: Speech Perception, Meaning: Discourse and Pragmatics

## Context-Contingent Connectivity Patterns of Taboo Words

***Poster C73*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Taboo words (i.e., “expletives,” “curse words,” “obscenities,” “swear words,” “profanity,” etc.) are an evocative subset of the lexicon that are highly context-contingent. They are often, though not always, used at the extreme ends of the valence spectrum to convey highly negative (“f*** you!”) or positive (“f*** yes!”) affect. Relatedly, they are frequently expressed during moments of high affective arousal; however, they may also be used in moments of low arousal, e.g., as fillers. Their tabooness originates from their literal meanings (reference to body parts, sexual acts, religiosity, etc.), yet their use in context is more often abstract. It has been previously shown that these factors (valence, arousal, concreteness) play a fundamental role in differentiating taboo word use from that of other words. We have found that brain activity in core affective regions associated with cognitive processing of these factors (e.g., amygdala, cingulate cortex, insula, prefrontal cortex, precuneus, cerebellum) is modulated by the perception of taboo words. It remains unknown, however, whether contextually dependent use-cases result in functional anatomical differences in taboo word processing. It could be that taboo word perception is neurobiologically consistent regardless of context, or it could instead be that taboo words perceived in different contexts are distinctly processed in the brain. We propose a middle ground, that core affective regions activated during taboo word processing will show differential connectivity with other regions depending on context. For example, we anticipate that more concrete use-cases will demonstrate functional connectivity with sensorimotor regions, while more abstract use-cases will be functionally connected with regions associated with supramodal processing, e.g., theory of mind. To address this question, we plan to use a subset of our Naturalistic Neuroimaging Database (NNDb), a publicly available functional and anatomical dataset of participants watching full length films in the magnetic resonance imaging (MRI) scanner (56 participants, 27F/29M, aged 18 – 55, watching 1 of 7 films). A group of six trained annotators rated each utterance in the films on Likert-type scales of 1 – 9 for affective arousal and valence, and labeled each curse word usage as literal, figurative, or both. We will perform dynamic generalized psychophysiological interactions (gPPI) analyses between regions that previously demonstrated parametrically modulated activation in response to taboo words’ arousal, valence, and concreteness (as described above); and the rest of the brain. We will then examine whether dynamic changes in connectivity are correlated with the contextual ratings.

Topic Areas: Speech Perception, Meaning: Discourse and Pragmatics

## Gradients of brain connectivity modulate language processing with modality-specific mechanisms.

***Poster C74*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Lidon Marin Marin[1,2], Susanne Eisenhauer[1,2], Elizabeth Jefferies[1,2]; [1]University of York, [2]York Neuroimaging

Centre

Auditory and visual language comprehension involves a series of processing steps in the brain, starting with modality-specific primary cortices, and eventually recruiting common heteromodal regions (such as the ventral anterior temporal cortex or “semantic hub”) responsible for decoding higher-level language features and integration with the evolving semantic context (1–3). Language processing at intermediate steps is also proposed to involve activation of modality-tuned brain regions, as different features of the stimuli are analysed (e.g., phonetic or orthographic characteristics) (1,2). Although previous investigations have identified the location of these mechanisms in the brain, recent studies suggest that whole-brain patterns of functional connectivity might also be crucial for language processing. The ‘principal gradient of intrinsic connectivity’ – i.e. the component of resting-state fMRI data that explains the greatest variability in whole-brain connectivity patterns – represents the gradual shift from input-driven processes to more abstract ones, since higher gradient values are located closer to heteromodal brain regions, and lower values coincide with primary sensory regions (4). Previous studies have started to explore the relationship between this gradient and heteromodal semantic cognition (5–8), while a recent study found that visual, orthographic and lexical properties of words are represented towards the sensory end of the gradient (9). Moreover, the gradient explaining the second-most variance in intrinsic connectivity, which represents the separation of visual from auditory and somatomotor regions (4), suggests that distinct dimensions of large-scale cortical organisation may capture the similarities versus the differences in language processing depending on modality. However, this hypothesis is largely unexplored. The main objective of our study is to investigate how these two gradients of human brain connectivity can capture the organisation of language processing in different modalities. To do so, we will use a publicly available fMRI dataset of 102 participants scanned during sentence listening (10) and will replicate the methodology of a previous study using the same dataset with visual stimuli (9). First, we will explore whether the principal gradient is related to the brain’s response to the psycholinguistic characteristics of auditory stimuli (GLM). These characteristics will include word-level (auditory duration, phonological distance and word frequency) and contextual measures (semantic similarity and word position in the sentence). We will also compare our results to our paper of reference (9), in order to explore modality differences. We expect to find word-level auditory characteristics to be mainly represented at the sensory end of the gradient, and contextual characteristics at the heteromodal end (significant correlation of brain’s effect of characteristics and gradient). We also expect word-level relationships to be localised in modality-tuned regions that are distinct from primary systems, and recruited in a dissociable fashion for spoken and written inputs (9). We will also explore whether the second gradient underlies the brain’s response to different modalities at different levels of the language processing hierarchy. Taken together, these findings will establish whether two gradients capturing the large-scale organisation of connectivity underlie similarities and differences in language processing across modalities. This will provide a framework for understanding language activation in diverse task contexts.

Topic Areas: Speech Perception, Meaning: Lexical Semantics

## Examining semantic processing in the face of a spectrally degraded speech signal

***Poster C75*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Christina Blomquist[1], Rochelle Newman[1], Jan Edwards[1], Ellen Lau[1]; [1]University of Maryland

Cochlear implants (CIs) have transformed the lives of deaf listeners. While these devices enable individuals to hear via electrical stimulation of the auditory nerve, the signal is spectrally degraded, making speech perception and language comprehension more difficult. Specifically, phonemic contrasts relying on perception of spectral acoustic features are less reliably discriminated by listeners with CIs. Here we describe an in-progress ERP study of spectrally degraded speech processing in healthy adults, designed to test the hypothesis that increased phonemic ambiguity in turn drives expanded semantic competition during comprehension. Both adults and children with CIs demonstrate decreased efficiency and accuracy in understanding spoken language. Eye-tracking studies have revealed that listeners with CIs are slower to access the meaning of spoken words, and less efficient at using this information to facilitate processing of upcoming words. The few studies using ERPs to investigate speech recognition by listeners with CIs have also demonstrated delayed semantic processing (e.g., increased N400 latencies). The current study investigates a potential mechanism underlying these delays: expanded cohort competition. Increased ambiguity of the initial phoneme of a word (e.g., shave-save sound more similar when speech is spectrally degraded) may lead to a larger cohort of words competing during word recognition, and cascading activation could lead to semantic associates of these competitors being considered as well. Expanded competition at the phonological and semantic level could explain delays in both single-word processing and higher-level semantic integration. We measure the N400 elicited in a spoken word-picture mismatch task in which the words have initial phonemes that are harder-to-perceive in a spectrally degraded signal (i.e., /t/ vs. /k/ and /s/ vs. /ʃ/). Participants are listeners with typical hearing (TH) perceiving speech that is degraded in a similar manner to the cochlear implant signal, compared to a control group listening to clear speech. ERPs will be recorded while participants perceive pictures (e.g., beard) preceded by spoken primes that either fully match the target (Match prime; beard), are semantically related to the target (Semantic prime; shave), or rhyme with the semantically-related word (Phonosemantic prime; save). In addition, two types of phonemic contrasts will be used to distinguish the semantic and phonosemantic prime: contrasts that are more ambiguous when perceived via a CI (place; shave vs. save) and those that are easily perceived (multiple cues; shave vs. grave). Data collection is ongoing. In preliminary analyses from 26 participants we computed average FZ voltage across the critical time window: 250 to 550 ms after picture onset. Difference measures for the Match (beard), Semantic (shave), and Phonosemantic (save) effects were computed by comparing each condition to the easy-to-perceive phonosemantic (grave) prime. Initial results show that compared to the control group, which demonstrates match, semantic, and phonosemantic effects, the degraded speech group shows a smaller match effect and an absent semantic and phonosemantic effect. If these results hold, they may suggest that delays in lexical processing aren't driven by expanded cohort competition, but rather perhaps due to slower activation of the perceived word that may actually limit semantic access and competition.

Topic Areas: Speech Perception, Meaning: Lexical Semantics

## Integrating Face and Acoustic Cues During Native- and Nonnative-accented Speech Processing: The Role of Face Cue Predictability

*Poster C76* in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port

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Individuals in our diverse linguistic landscape may speak native-accented speech in one context and nonnative-accented speech in a different discourse context for the same language (e.g., heritage speakers in the United States may use native-accented English with friends from school but may use nonnative-accented English with family members). The present study consists of a series of ERP experiments that manipulate the face cue predictability regarding the upcoming speech accent. Specifically, listeners will be introduced to speakers that either have a predictable accent (produce only one accent) or an unpredictable accent (can produce two accents). Our research questions include: 1) Do listeners use face cues to predict the accent of the upcoming speech and how do they integrate face cues and speech accent during online native-accented and nonnative-accented speech processing? 2) How does the predictability of face cues regarding the upcoming speech accent affect the neural correlates of native-accented and nonnative-accented speech processing, at the 2a) word level and 2b) sentence level? Monolingual American English listeners will first be familiarized with each speakers' accent(s) (only American-accented English, only Chinese-accented English, or both Chinese-accented and American-accented English) via introduction videos. Then, participants will complete either a go/no-go lexical decision task (Exp. 1B) or a sentence processing task (Exp. 2B) while EEG is recorded. A face cue (photo of the speaker) will be concurrently presented as the audio is played. Crucially, there will be a time delay between the onset of the face cue and the onset of the speech signal. In both experiments, following C. Martin et al. (2016), we will analyze the mean amplitude activity during this pre-speech period to examine face cue predictability effects. In Exp. 1B, the go/no-go lexical decision task will involve single word/nonword audio stimuli, and listeners will be asked to press a button when they hear an animal word. Following C. Martin et al. (2016), ERP analyses will be conducted at the N1 time window and the N400 time window to examine lexicality effects. In Exp. 2B, the sentence processing task will involve well-formed sentences and sentences with semantic anomalies or pronoun mismatches. Following Grey et al. (2020), ERPs will be analyzed at the critical semantic or pronoun items manipulated in the sentence, in the N400 time window and the P600 time window, respectively. For both experiments, following the cue integration model (A. Martin, 2016), we predict that ERP effects will be modulated by the face cue predictability (top-down information) and the accent of the speech (bottom-up information). Two additional experiments will first be conducted to examine the neurocognitive mechanisms related to the processing of spoken words (Exp. 1A) and sentences (Exp. 2A) with the same EEG tasks as Experiments 1B (go/no-go lexical decision task) and 2B (sentence processing task), respectively, but without a face cue, as a speech-only control group.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Title: Does rhythmic movement improve neural tracking of linguistic features, thereby facilitating speech perception?

*Poster C77* in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port

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Listening to speech activates cortical regions of the sensorimotor system, but their functional role in speech processing is strongly debated. The temporal attending theory proposed that the motor system is involved in predictive timing, aligning fluctuations of attention to rhythmic cues in the auditory stream. Behaviorally, it has been shown that temporal processing of an auditory stream is improved when participants produce overt rhythmic movements compared to when they are staying still. In this work, we wondered if the motor system is implicated in processing linguistic rhythms during speech perception, such as the phrasal, syllabic or lexical rates. Our objective is to investigate whether activating the motor cortex through rhythmic movements can enhance the tracking of some linguistic timescales and facilitate speech comprehension in challenging listening conditions. In a first experiment, participants performed a behavioral task consisting of understanding sentences embedded in noise. Each sentence was preceded by a priming phase in which participants rhythmically tapped with their index finger. Tapping at a tempo of 1, 2, and 4 Hz was tested, and the results revealed that tapping at 2 Hz before hearing a sentence significantly improved its comprehension. This finding suggests that spontaneous rhythmic movements (which naturally occur at 2 Hz) enhance the tracking of the lexical rhythm (2 Hz), potentially facilitating lexical segmentation. To investigate this hypothesis, we replicated this study on 10 participants using EEG recordings, focusing solely on 2 Hz tapping. We aim to explore how motor priming affects the subsequent neural encoding of different speech features. Our hypothesis posits that the lexical rate (2 Hz) should be better neurally encoded, indicating that the motor system contributes to the processing of this linguistic rhythm. Moreover, we will also investigate whether this contribution extends to some other linguistic timescales. Overall, this work shows that the use of an overt motor strategy can facilitate speech perception in challenging listening conditions, and proposes that motor areas contribute to the processing of the temporal dynamics of speech.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Specificity of Motor Contributions to Statistical Language Learning

***Poster C78*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Statistical learning is critical for detecting and extracting patterned information from continuous sensory signals, including speech. Coupling of frontal motor regions to speech sound sequences plays an important role in auditory statistical language learning (Assaneo et al., 2019). It remains however an open question how specific these motor contributions are. In the present study, we aimed to characterize the specificity of motor contributions to auditory statistical learning. In Experiment 1, we tested specificity of motor processes contributing to learning statistical regularities in speech sound sequences. Participants performed either linguistic (i.e., whispering syllables) or non-linguistic (i.e., clapping hands) motor tasks during exposure to structured speech sequences. In Experiment 2, we focused on auditory specificity and tested whether a linguistic motor task (i.e., whispering) equally affects learning statistical regularities in speech and tone

sequences. Finally, in Experiment 3, we examined whether statistical learning performance in tasks with different auditory stimulus types (i.e., speech sounds versus tones) is correlated. In all experiments, statistical learning performance was tested via a forced-choice recognition task. Whispering, but not clapping, impaired learning of statistical regularities in speech sequences in Experiment 1, but whispering had no effect on learning statistical regularities in non-speech sequences in Experiment 2. Moreover, no correlation was found in Experiment 3. Overall, our findings show that auditory statistical language learning is supported by domain-specific auditory-motor processes. These results support the idea that learning statistical regularities in speech versus non-speech relies on distinct mechanisms, and that the speech motor system contributes to auditory statistical learning in a highly specific manner.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Cortical representations for native and non-native phoneme perception

***Poster C79** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Converging evidence shows that speech perception induces activations of sensorimotor brain areas that are normally involved in speech production (Skipper et al., 2017; Franken et al., 2022, for reviews). This sensorimotor activity is particularly evident in noisy conditions and is somatotopically organized depending on the place of articulation of phonemes: listening to bilabial and dental consonants activates the motor representations of the lips and the tongue, respectively (Pulvermüller et al., 2006). Motor involvement in non-native phoneme perception has also been reported (Wilson & Iacoboni, 2006). Several studies however failed to replicate the somatotopic mapping of motor cortex in (native) speech perception (Arsenault & Buchsbaum, 2016), or showed premotor recruitment only when the degraded speech sounds became identifiable (Du et al. 2014; Osnes et al, 2011). The necessity and the role of the motor activation in processing non-/native and/or degraded/intact speech sounds therefore remain unclear. The current study aims to unravel how sensorimotor regions are activated as a function of the phonological distance between native and foreign phonemes under degraded or optimal perceptual conditions. We hypothesize that the activity in sensorimotor regions varies depending on the phonological proximity between non-native sounds with respect to the native phonological repertoire. To examine this sensorimotor organization, we run a combined behavioral and fMRI study. We recorded brain activity of twenty healthy French right-handed adults while they were listening to consonant-vowel syllables, embedding either native French consonants (/p/, /t/, /ʃ/, /ʁ/), or non-native Mandarin Chinese consonants (/pʰ/, /tʰ/, /ʂ/, /x/). While half of the syllables were masked with pink noise, the participants were required to identify the consonants as native or non-native by left hand button press. Only a single phonetic feature differentiates between consonants in three of the pairs (aspiration for /p-pʰ/ and /t-tʰ/, and tongue retroflection for /ʃ-ʂ/), whereas consonants in the fourth pair /ʁ-x/ differ on two features (voicing and place of articulation). Either intact or noisy non-native phonemes should trigger strong, though not well-circumscribed, premotor cortical activity. The phonological distance between French and Chinese consonants may however influence the activation pattern. Phonologically-close foreign phonemes (/pʰ/, /tʰ/, /ʂ/) may be

processed as degraded versions of the native consonants, thus eliciting similar activity to their noisy native counterparts (/p/, /t/, /ʃ/). On the contrary, the more distant consonant /x/ may be identified as non-native and yield the strongest premotor activity. Preliminary behavioral results show significantly lower performance to identify the Chinese fricative /ʂ/ than the French /ʃ/; no differences between other consonant pairs were found. Preliminary fMRI univariate analyses against the baseline suggest stronger activation in the left inferior frontal cortex when identifying intact French consonants, and in the bilateral superior temporal cortex and the left premotor cortex for phonemes in both languages irrespective of noise. In the supplementary motor area, the activation is stronger for intact than noisy French and for noisy than intact Chinese consonants. As next steps, multivariate and connectivity analyses will allow to assess whether premotor-temporal connectivity varies depending on the phonological distance between native and non-native phonemes.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## The role of degraded auditory input on predictive audiovisual language processing: the case of cochlear implant users

***Poster C80*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Seeing our interlocutor’s mouth helps us understand speech when the signal is suboptimal (e.g., in a noisy environment). Similar challenges are faced by deaf people with cochlear implant (CI users), whose sensory input is less detailed compared to that of normal hearing (NH) people. How does auditory and visual input integration interact with lexical predictability? Is this interaction different in CI users relative to NH people? In an exploratory electroencephalographic study, CI users and NH people were presented with audio-video recordings of an Italian speaker uttering sentences. Before the final word, an 800 ms silent gap was introduced. The predictability of the final word was determined by the preceding sentential constraint (high vs low). Additionally, mouth visibility (visible vs covered) was manipulated, but only during sentence frame presentation (i.e., during the processing of the linguistic input that allows to generate lexical predictions). In preliminary ERP analyses time-locked at gap onset on 17 CI users (age mean = 22.35, sd = 10.8; 7 males, 9 males, 1 non-binary), we found an N400 effect at centro-parietal electrodes: the low constraint condition was always more negative than the high constraint condition. However, in face of large inter-individual variability, when looking at CI users implanted early in life (age of implantation 1-3 years of age, n = 8), this effect appeared consistent only when the mouth was covered during the sentence frame, while the patterns was reversed when looking at pre-verbal deaf participants implanted later in life (age of implantation 5-43 years of age, n = 9), i.e., the effect emerges when the mouth was visible. These preliminary results suggest that not seeing the mouth of the speaker during a sentential context may differently affect lexical prediction in CI user, according to when in life they were implanted. Planned subsequent analyses include analyzing alpha-beta oscillatory activity in the silent gap prior to the presentation of the target word – arguably while predictions are being generated – and at gamma activity after target onset, to observe prediction error encoding and multisensory integration as a function of prediction. All these analyses will be carried out also for the NH control group, to further clarify what are the effects of developing a spoken language competence while having to rely on a poorer auditory input.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Neural mechanisms of sensorimotor integration in speech perception

***Poster C81*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speech perception is an active and flexible process which can be influenced by the listening context and inputs beyond audition. The sensorimotor system is crucial for controlling speech articulators during production, but may also be involved in perception of auditory speech. Engaging the articulators can influence the perception of sound, and their respective brain areas are activated in response to speech stimuli; even in the absence of production requirements. Mounting evidence endorses an active role of the sensorimotor system in guiding speech perception; however, little is known about the neurophysiological mechanisms underlying this integration. In this study, we disrupt articulatory sensorimotor feedback by applying a simple mechanical perturbation to the lip shape configuration; and assess the effective influence on both perception and neural dynamics. So far, 12 French-speaking participants classified vowels along an acoustic continuum between phonemes /u/ to /œ/ both normally (baseline), and with a small plastic tube held between the lips (liptube). We measured their ongoing brain activity from 64-channel EEG and explore the temporal, spatial, and spectral dynamics of sensorimotor integration during active speech perception. Preliminary results demonstrate variable effects on perception, with no significant differences between conditions in either the perceived boundary between phonemes, nor in the slope of psychometric curves. Nonetheless, average measures of both boundary and slope were lower in the liptube condition compared to baseline. Neural responses to vowel stimuli differed between conditions: support vector machines were able to decode condition from single trial data with up to 88% accuracy, averaged across participants. This differentiability was visible at the source level: the N100 stimulus-evoked component showed pronounced differences within the left posterior temporal lobe. Brain regions also showed differences in oscillatory activity: the beta rhythm (13 – 29 Hz), which is associated with sensorimotor processing, was most modulated throughout temporal auditory regions, and ventral sensorimotor cortices. Altogether, these findings suggest differences in speech stimulus processing and ongoing neural dynamics due to altered somatosensory feedback between conditions, which could have a downstream influence on vowel categorization. Although final results are still pending, the current findings suggest an influence of sensorimotor perturbation on the perception and associated neural processing of speech stimuli; encouraging further work into elucidating these mechanisms. Behaviourally, we observe a disruption of phonemic categories due to the articulatory perturbation. This perturbation was also reflected in neural activity, with altered brain responses to speech stimuli in regions associated with auditory speech processing. Finally ventral sensorimotor regions, which house the mouth and lip area representations, showed changes in beta-activity, which is consistent with theories of predictive motor-to-auditory signalling occurring via mu rhythm (8 – 30 Hz) dynamics. These findings highlight the importance of sensorimotor brain systems in the active perception of speech; suggesting that articulatory representations activated during listening may guide phonemic processing.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Exploring the neural basis of phonemic representations from sounds and vision.

***Poster C82*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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INTRODUCTION : Speech is a multisensory signal that we can decipher from the voice and/or the lips. If the successive computational steps necessary to transform the auditory signal into abstract language representations have been extensively explored, little is known on how the visual input of speech is processed in the brain; and how auditory and visual speech information converge onto a unified linguistic percept. In this study, we focus on the minimal abstract units of language, i.e. the phonological level. We aim to identify brain regions that are involved in auditory phonology (phonemes) and visual phonology (visemes). In particular, we aim to explore whether some brain regions represent both auditory and visual phonological representations, potentially in an abstract fashion. METHOD : We rely on functional magnetic resonance imaging (fMRI) combined with searchlight multivariate patterns analyses (MVPA) in healthy adults to characterize brain regions that represent phonological information from vision and audition. More precisely, we classify brain activity patterns evoked by a limited set of consonant-vowel syllables, composed of 3 perceptually distant consonants and 3 perceptually distant vowels, presented either auditorily (speech) or visually (lipreading). RESULTS : Preliminary analyses suggest that a network of visual, auditory, motor and frontal regions are involved in visemes recognition. Interestingly, auditorily defined phonological regions (in superior temporal gyrus - STG) seem to be involved in visual phonological representations as well. In line with previous literature, we are able to decode auditory phonemes in the classical speech perception network (auditory, motor, frontal areas). Moreover, overlap between auditory and visual decoding in mid- and posterior STG and in motor cortex indicate that these regions could be involved in the integration of auditory and visual speech phonology. We will then perform cross-modal classification between auditory and visual phonological representation in these multisensory regions to evaluate whether they implement a shared abstract representation for auditory and visual phonology. In addition, our analytical approach will be further extended using individually defined regions of interests (namely auditory phonological regions in STG, face- and word selective areas in ventral occipito-temporal cortex) from functional localizers that were acquired in all our participants.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## iEEG pattern similarity in the superior temporal cortex predicts differences across individual words in noisy audiovisual speech perception

***Poster C83*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Humans have the unique ability to decode the rapid stream of language elements that constitute speech. Although auditory noise in the environment interferes with speech perception, perceivers can partially compensate using visual information from the face of the talker. Individual words vary greatly in the visual information they contain. While previous research has shown that the superior temporal cortex is a locus for audiovisual integration and speech perception, the neural basis for perceptual differences across words remains poorly understood. Participants (N = 15) were patients with intractable epilepsy undergoing clinical monitoring in the epilepsy monitoring unit. We measured intracranial from stereotactic EEG (sEEG) electrodes in the superior temporal cortex. Words were presented in four different formats: clear auditory-only (Ac) clear audiovisual (AcV), noisy auditory-only (An), and noisy audiovisual (AnV). Noise consisted of pink noise, with an SnR of -8 dB. Each patient was presented with 110 unique words with a balanced content of different phonemes and visemes. The words were counterbalanced so that across participants, each word was presented in every format. Participants repeated back each word after presentation. The response was recorded and scored. 140 electrodes in superior temporal cortex electrodes were identified that showed a significant ($p < 0.001$ Bonferroni-corrected) response to clear auditory. We measured the percent increase in 70-150Hz broadband high frequency activity (BHA) in a window from 0 ms to 1000 ms after auditory onset, compared to a baseline window from -1000 ms to 0 ms before auditory onset. The BHA timecourse was sampled at 10 ms to produce 100 timepoints for each word/condition pair. The data from each electrode was z-normalized, and then the data across all electrodes was averaged to produce a single timecourse for each word/condition pair. Then, the timepoint-by-timepoint response to each individual word was correlated across different stimulus formats (e.g. the response to a word presented in the AnV format was correlated with the response to the same word presented in AcV format). As expected, seeing the face of the talker was beneficial (mean % correct of 31% in A-only vs. 65% in AnV). There was high variability across words in the visual benefit (mean improvement of 34% +- 29% SD). Word-level differences in audiovisual improvement were predicted by neural pattern similarity: when the response to a noisy audiovisual word was more similar to the response to the clear version of that word, perceptual intelligibility was high ($r = 0.43$, $p = 10^{-6}$). Using iEEG to measure neural activity in the superior temporal cortex, we found that the neural pattern similarity between clear vs. noisy audiovisual words reliably predicted the degree of audiovisual benefit for that word, presumably as a result of the neural integration of the viseme and phoneme content of each word. Enhancing our understanding of the neural substrates of noisy speech perception may help in the design and testing of speech perception aids and other speech-assistive technologies.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

## Establishing psychoperceptual profiles of acoustic processing: Beyond the

## gradient and categorical distinction

***Poster C84*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Research by Assaneo et al. [1-3] has identified two groups within the general population that display physiological differences in white matter structure that predict relative skill at audio-motor synchronization on a verbal entrainment task. Individuals who spontaneously synchronize their verbal output to an external rhythm possess a superior ability to correctly segment syllables in a word-learning task designed to mimic naturalistic language acquisition. These findings imply a link between auto-motor synchronization and word segmentation abilities. However, children attend to multiple cues for word segmentation [4,5]. In addition to stress timing, which corresponds to the entrainment task, prosodic features such as pitch accents and boundary tones [6,7], as well as an array of phonetic cues [8,9] interact to provide key information about where word boundaries lie. Similarly, variation in white matter structure has been proposed to explain individual differences in phonological processing [10-11] and pitch discrimination [12,13]. In this Sandbox series abstract, we investigate whether high synchronizers exhibit a parallel ability to accurately perceive other acoustic dimensions that might contribute to their ability to detect word boundaries. Importantly, we sought to better understand how distinct psychoperceptual abilities arising from physiological variation in brain structure might collectively give rise to different cognitive styles of language processing. The literature distinguishes a “gradient” cognitive style (veridical encoding of phonetic acoustic features), as opposed to a “discrete” style (encoding acoustic variation as phonemic categorical representations) [14]. More recently, this two-way distinction has been problematized by revealing partial convergence between styles: variation occurs on each scale, such that individuals may be proficient or poor at both types of encoding, or perform well in phonetic but not phonemic encoding [15]. In effort to tie together the literature on individual differences in processing mechanisms, we ask how synchronization abilities may pattern with gradient and discrete processing styles. Participants (N = 33; N = 90 anticipated) performed a series of tasks to measure (i) synchronization: participants listened to a rhythmic train of syllables and concurrently whispered the syllable ‘tah’; (ii) discrimination: a two-alternative forced choice test for pitch contours (‘rising’, ‘falling’) and vowel categories (‘same’, ‘different’); categorization: a two-alternative forced choice test for pitch contours (‘high’, ‘low’; 170-230 Hz; 10 Hz steps) and vowel categories (/ɛ/-/ɑ/; 0-400 Hz; 3 steps in F1/F2). Simultaneous EEG data was collected during passive listening of the audio stimulus files from the behavioral tests. Analysis steps include (i) group-level outcomes measures for all tests, (ii) computation of the phase-locking value for the envelopes around the stimulus syllable rates, (ii) individual-level measurement of F1/F2 values and pitch height for elicited phonetic and pitch stimuli, (iii) a mixed effects regression model comparing performance between measures; and (iv) a k-means cluster analysis of outcome scores. Preliminary findings support two bimodal distributions: (i) high and low synchronizers, and (ii) superior performance at either vowel category or pitch discrimination. However, better synchronization appears to occur when participant performance in the discrimination task is balanced across both acoustic categories. Additional analyses (elicitation data, EEG data, categorization tests) are pending.

Topic Areas: Speech Perception, Multisensory or Sensorimotor Integration

# Using frequency selectivity to examine category-informative dimension-selective attention

***Poster C85*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The ability to assign complex stimuli to behaviorally relevant categories is a hallmark of cognition. In the auditory domain, listeners must leverage experience to learn how to carve up the acoustic soundscape, both in speech perception (e.g., to differentiate among phonetic categories) and for non-speech stimuli (e.g., to differentiate the cries of predator versus prey). Theoretical accounts have posited that successful auditory categorization may rely on selective attention to diagnostic auditory dimensions (e.g., Francis & Nusbaum, 2002), with the possibility that listeners may additionally suppress non-diagnostic dimensions. The current study (target N=50) leverages fMRI to investigate whether selective attention underlies auditory categorization; specifically, we examine cortical activation when categorization depends on diagnostic information conveyed in particular frequency bands. Prior to scanning, adult listeners complete a five-day training regime in which they learn to categorize four novel nonspeech auditory categories defined in a complex multidimensional space (Obasih et al., 2023). Each stimulus consists of three consecutive high-bandpass-filtered hums (1-3 kHz) and three simultaneous low-bandpass-filtered hums (0-500 Hz), where the hums are nonspeech pitch contours derived from multi-talker productions of Mandarin words varying in lexical tone. Critically, the four stimulus categories differ in which frequency band is diagnostic of category identity; in the category-diagnostic frequency band, all three hums are drawn from a single tone category, whereas in the non-diagnostic frequency band, the three hums are drawn from different tone categories. For two categories, the high band is the category-diagnostic band, and for the other two categories, the low band is the category-diagnostic band. As such, categorization depends on recognizing category-diagnostic (but acoustically variable) hum patterns within a category-diagnostic frequency band. Here, we test the hypothesis that successful categorization requires directing attention to the category-diagnostic spectral band, while potentially attentionally suppressing the non-diagnostic band. We carry this out by comparing the amplitude of activation evoked during auditory categorization within different tonotopically mapped regions (Dick et al., 2012) as well as "attention-o-tonotopic" maps driven by explicitly cued attention to high or low spectral bands (e.g., "listen high"; Dick et al., 2017). We hypothesize that successful categorization will be linked to enhanced recruitment of cortical regions that prefer the diagnostic acoustic frequency band; here, baseline activation is indexed through a control task in which participants categorize stimuli based on stimulus amplitude. Furthermore, we hypothesize that auditory selective attention involves suppression, indexed as reduced recruitment of cortical regions that prefer the non-diagnostic frequency band (relative to activity during the control task). Preliminary results indicate that, among listeners who learn the auditory categories to criterion, there is concordance between cortical activation in the auditory categorization task, stimulus-driven tonotopic maps, and tonotopic maps driven by explicit attention. These results suggest that auditory categorization may drive selective attention to category-diagnostic dimensions, highlighting a possible mechanism through which

auditory experience may guide the formation of perceptual categories.

Topic Areas: Speech Perception,

## Exploring Neural Dynamics of Speech and Melody Processing in the Human Brain

***Poster C86*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The processing of speech and music in the human brain exhibits asymmetry, with auditory temporal modulations predominantly processed in the left hemisphere and auditory spectral modulations in the right hemisphere. However, the precise neural dynamics underlying this lateralization and the encoding of acoustic features related to speech and music processing remain largely unexplored. To investigate this, we recorded intracranial EEG data from fourteen epileptic patients with auditory region implants. Our stimulus set contained one hundred cappella songs, combining ten French sentences with ten melodies. Each song had a temporally degraded, spectrally degraded, and undegraded (original) version resulting in a comprehensive set of three hundred stimuli for analysis. To explore the connection between behavioral responses and neural activity, participants first completed a binary choice task, where they were presented with pairs of excerpts and determined if they were identical or different. Subsequently, participants underwent a passive listening phase while watching a silent documentary. By employing multivariate pattern analysis and time-frequency analysis, we trained a classifier to differentiate between sentences and melodies and examined the encoding of temporal and spectral modulations. The behavioral results demonstrated reduced sentence recognition in temporally degraded conditions and reduced melody recognition in spectrally degraded conditions. Consistent with behavioral outcomes, the decoding accuracies revealed that speech processing primarily relies on temporal modulations, whereas melody processing predominantly depends on spectral modulations. Notably, these decoding patterns were consistently observed across time and channels, suggesting the presence of a spatiotemporal code in the auditory system. Furthermore, our findings indicate that different frequency bands play a role in encoding the temporal and spectral cues involved in speech and melody processing. In future investigations, we aim to extend these findings by directly examining the functions of various oscillatory networks in speech and melody processing. Moreover, by exploring multiple dimensions (time, channels, and frequencies), we strive for a comprehensive account of how the human brain processes speech and melody.

Topic Areas: Speech Perception,

## Examining phoneme, syllable, and word level representations in continuous speech processing

***Poster C87*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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How listeners process acoustic input and access meaning from that input remains a central question in the field of speech perception. Hierarchical models of language posit that representations are tracked across different linguistic levels, with distinct processing at different timescales (i.e., linguistic units: phonemes, syllables, words, etc.; e.g., Kuperberg & Jaeger, 2016; Martin, 2016). Recent work looking at processing of continuous speech has focused on phoneme-level information processing through surprisal effects, reflecting neural sensitivity to how unlikely a given phoneme is in context (e.g., Brodbeck et al., 2022; Heilbron et al., 2022). Work from our lab, however, has shown that listeners update representations at phoneme as well as word sized timescales (Crinnion & Brodbeck, 2022). Observing distinct word and phoneme updates implies multiple linguistic levels of processing, supporting hierarchical models. Here we aim to better understand the timescales at which the brain updates representations of speech. Specifically, we ask (1) whether we find evidence for distinct phoneme, syllable, and word representations and (2) whether representations at each timescale reflect processing of broader language context, context-independent lexical properties, or both. We focus on syllables because some hierarchical models of speech emphasize syllable-level processing (e.g. Hickok & Poeppel, 2007), and there is contention around whether speech perception uses phonemes, syllables, or both as information units (e.g., Hickok, 2014; Kazanina et al., 2018). We hope to add new evidence to this debate by using an information theoretic approach to understand the timescales at which the brain updates contextual representations. In order to answer these questions, we use MEG data from Brodbeck et al. (2022) where participants listened to continuous speech (an audiobook). We used an mTRF approach to model incremental speech processing using acoustic and linguistic predictors. Of interest were entropy and surprisal predictors calculated from a lexical 5-gram model. These information theoretic predictors used phonemes, syllables, and words as units. We find evidence for distinct updates at word and phoneme timescales, even when controlling for syllable-level representations, but crucially, we do not find evidence for distinct updates at the syllable timescale. Furthermore, using a Bayes Factor analysis, we find evidence against syllable-level representations when controlling for phoneme-level processing. Additionally, as has been previously shown by Brodbeck et al., (2022) for phonemes, we find evidence that word-level updates reflect local (lexical frequency based surprisal) and global (context constrained entropy and surprisal) processing. These results suggest a partially hierarchical model in which representations are updated continuously on multiple timescales. Evidence for two distinct levels of representations potentially suggests that phoneme-level updates reflect processes of lexical access and word-level updates reflect semantic level integration. We do not, however, find that listeners track every linguistic level, as we find no evidence for updates at the syllable timescale. Using information theoretic measures and controlling for updates at multiple timescales provides a more comprehensive approach to understanding the timescales (and arguably, linguistic levels) involved in continuous speech processing.

Topic Areas: Speech Perception,

## Multiple theta-gamma interactions emerge in the auditory cortex during speech perception.

***Poster C88*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Frequency division multiplexing in the auditory cortex is observed during speech processing. High-gamma activity (~120 Hz) follows the fundamental frequency (F0) of the voice in speech while low-gamma dynamics (~40 Hz) seem more related to phonetic processing. The amplitude of both is coupled to the phase of theta oscillations (4-8 Hz), which track the speech acoustic rhythm. However, the functional role of such phase-amplitude coupling is a matter of debate. In this work, we recorded the electrophysiological activity from the auditory cortex in epileptic patients implanted with intracerebral EEG (iEEG) electrodes. The patients performed a natural speech perception task, passively listening to a 10-minutes length story. We analyzed the functional connectivity (i) between the speech envelope waveform and the cortical activity, and (ii) between different regions of the auditory cortex. Importantly, we measured the cross-frequency directionality between the amplitude of low- and high-gamma oscillations and the phase of the theta rhythm, testing different hypotheses that have been proposed for speech encoding. We show that both (low- and high-) gamma and theta oscillations in the auditory cortex are driven by the speech envelope. Interestingly, a directed functional connectivity emerges from high-gamma to theta oscillations in the brain, a feature that is not present in the speech signal. This suggests that both (theta and gamma) brain rhythms are not only tracking speech but are related to two different neuronal mechanisms that go beyond the temporal acoustic structure of the auditory input (phonemes & syllables). Overall, we present new insights in the role of auditory theta-gamma coupling in speech processing, and how the information flow between oscillations informs us about different steps of speech parsing and decoding in the brain.

Topic Areas: Speech Perception,

## Segmenting words from continuous speech in human temporal cortex

***Poster C89** in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Understanding spoken language requires extracting individual words from a continuous acoustic speech signal. Unlike written text, detecting word boundaries in spoken language is challenging because words are often not separated by silence and acoustic cues are not reliable. Thus, listeners may instead take advantage of their speech experience, segmenting words using multiple sources of learned knowledge. An outstanding question is how the brain extracts words from the speech stream; specifically it is unknown which brain areas encode word boundaries and whether those representations are independently or jointly encoded with lexical information. To address this, neural recordings with high spatial and temporal resolution are required to dissect the local cortical computations that are selective to specific acoustic, phonetic, and lexical properties. Here, we recorded high-density electrocorticography (ECoG) responses while participants passively listened to spoken narratives, and investigated the process by which the brain segments words in natural speech. We first explored whether neural populations are sensitive to word boundaries in single trials. We found neural populations throughout the lateral temporal cortex had evoked responses time-locked to word boundaries.

Specific electrodes exhibit complex, multi-phasic evoked responses, consisting of 1-3 distinct response peaks around each word boundary. We used partial correlation to show that both acoustic cues and word-level features modulated the word boundary response. Specifically, we observed a sequence of feature encoding around word boundaries: envelope cues occurred immediately after the word onset, followed by sensitivity to lexical frequency, and finally the duration of the whole word. With regard to spatial localization, acoustic-phonetic features were primarily encoded in the middle superior temporal gyrus (STG), while word-level features were encoded in the middle STG as well as the surrounding cortex in anterior and posterior STG. A widely distributed STG neural population jointly encoded multiple levels of features, and that neural population also exhibited superior word segmentation performance compared to the electrodes that exclusively encoded acoustic-phonetic or word-level features. Together, these findings suggest that the human STG is sensitive to word boundaries, with acoustic (envelope) cues and lexical features (frequency and duration) jointly contributing to the word segmentation process. The core middle STG appears to encode the acoustic-phonetic inputs, whereas lexical encoding is both in the middle STG as well as in surrounding cortical regions. These results support a new model of distributed, integrative processing in the STG during spoken word processing.

Topic Areas: Speech Perception,

## What's in a word? Raw statistical learning sequences emulate neural entrainment

***Poster C90*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Infants develop sensitivity to wordlike patterns in syllable sequences based on statistical regularities (Saffran et al., 1996). Typically, this is measured behaviorally (e.g., looking time paradigms). Recently, Choi et al. (2020; see also Batterink & Paller, 2017, 2019, 2020) reported converging EEG evidence. They presented syllables at approximately 3hz, making the word rate 1hz. Initially, subjects exhibited neural entrainment phase-locked to syllable rate (3hz, indexed by intertrial coherence or ITC). With exposure, phase-locking at word rate also emerged, potentially reflecting statistical learning, especially since word rate ITC correlates with individual behavioral learning measures. We simulated this paradigm with Simple Recurrent Networks (SRNs) trained on two regimens. The first was based on Saffran et al. (1996), with four trisyllabic pseudowords (labeled ABC, DEF, GHI, JKL). Words were randomly ordered, but words could not immediately repeat. Transitional probabilities (TPs) were 1.0 within words and 0.333 between words. The second was 6 bisyllabic pseudowords (AD, AE, BF, BG, CH, CI) based on the "box language" of French et al. (2011). All TPs were 0.5 because A-words were followed either by B or C, B-words by A or C, and C-words by A or B. We implemented SRNs with 12 input and output nodes (1 per syllable), and 12 hidden and context nodes. SRNs were trained to activate the next syllable given the current one. To simulate time series with syllable rates of 3hz (Saffran) or 2hz ('box'), we used Frank & Yang's (2018) procedure to convert hidden and output states to extended, noisy time series with 3 (or 2) syllables and 1 word per second. We calculated ITC using a conventional method for EEG. SRNs learned both regimens, and simulated human-like preferences to trisyllabic pseudowords vs. "part words" (last syllable of one word and initial one or two syllables of another). Analyses of hidden and output activations revealed human-like patterns, with high ITC at syllable rates (3hz or 2hz) early in learning, and elevated ITC at word rate (1hz) later. This seems to suggest SRNs are good candidate models for SL, since they simulate both behavioral and neural responses. However, we then estimated ITC from raw inputs. Surprisingly, ITC was elevated at both syllable and word rates. We speculate that this is due to subsets of syllables occurring at 1hz intervals (e.g., for Saffran, A, D, G, and J occur in positions 1, 4, 7, etc.; for 'box', A, B, and C occur only in odd positions). This regularity could drive word rate ITC without learning. Control analyses with syllables scrambled only showed high ITC at syllable rates. A system that developed a distinct response to each syllable could exhibit elevated ITC at word rates without learning words. However, ITC still appears to reflect learning (since ITC and behavioral measures correlated in Choi et al.). Our findings suggest that neural entrainment results must be interpreted with caution, and should be paired with converging behavioral evidence. Also, SRNs provide a promising candidate mechanism for explaining SL, though the same caveats apply.

Topic Areas: Computational Approaches, Language Development/Acquisition

## The contribution of early language experience to the cortical tracking of speech: evidence from bilingual children

***Poster C91*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The cortical tracking of speech is the temporal alignment of continuous brain activity to the information present in the speech signal. Cumulative evidence during the past decade has shown its relevance for supporting speech comprehension, as well as its atypical maturation in developmental language disorders (e.g., dyslexia). This neurocognitive mechanism is also in place and developing during infancy and childhood. However, no studies to date have addressed the question of whether accumulated language experience shapes the cortical tracking of acoustic and linguistic information from the speech signal. This was our main goal: to test whether bilingual children with considerably unbalanced experiences within each of their languages show different strategies for the cortical tracking of speech for each language respectively. We collected EEG data from 35 Basque-Spanish bilingual children (6 y.o.) with a markedly unbalanced bilingual profile (>70 % exposure to Basque, L1 hereafter; <30 % to Spanish, L2). Children listened to continuous speech in the form of two 14-minute stories (one in each language), which allowed us to assess their cortical tracking of speech at the acoustic temporal (speech envelope), lexical (lexical frequency), and semantic (sentence-level semantic distance) levels respectively. As indexes of the cortical tracking of speech, we computed speech-brain coherence and multivariate temporal response functions (mTRF). While speech-brain coherence measures the phase alignment between two signals (speech envelope and EEG activity), mTRF models the linear mapping between speech features (speech envelope, lexical frequency and semantic distance in our case) and changes in the continuous EEG signal. Through cluster-based permutation tests, we found significant speech-brain coherence in L1 and L2 within the delta frequency band (0.5 - 1.5 Hz), which aligns

with prosodic phrasing in both languages. Despite robust speech-brain coherence in both languages, there were no significant between-languages differences regardless of the markedly bigger exposure to L1 than to L2. Nonetheless, the cortical mapping (mTRF) of the speech envelope yielded a significant between-languages difference. Namely, the cortical encoding of the speech envelope in L2 was more robust than in L1. There was also a strong significant between-languages difference in the temporal response to semantic distance. In this case, children showed a more sensitive early (70-230 ms) cortical tracking of semantic information in L1 than L2. We also found that, only in L1 (Basque), the cortical tracking of speech at the envelope level predicted phonological abilities; and the cortical tracking of lexico-semantic information predicted vocabulary knowledge. Our findings initially point at a tradeoff from relying on acoustic temporal (envelope) information (L1 < L2) and on more abstract linguistic (semantic) information (L1 > L2) that is dependent on the accumulated experience within a language during the early years of life. The specific relationships between the cortical tracking of speech and different language abilities highlight the behavioral relevance of the maturation of this neurocognitive mechanism for speech comprehension. The present study can inform developmental cognitive neuroscience and neurobiology of bilingualism by bringing to context the relevance of accumulated linguistic experience for the maturation of brain processing of language during childhood.

Topic Areas: Language Development/Acquisition, Multilingualism

## Developmental trajectory of cortical tracking of native and non-native speech stimuli in monolingual and bilingual infants

***Poster C92*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Infants rely on prosodic information to differentiate the language or languages present in their environment from other unfamiliar languages and to start segmenting native speech. This study investigates cortical tracking of speech - a neural mechanism potentially underlying this early ability. Cortical tracking refers to the synchronization between neural oscillations and the temporal structure of the speech envelope. We are specifically interested in cortical tracking of low-frequency prosodic information (at the delta, <3 Hz, and the theta, 4-8 Hz, bands). These frequency bands have been related to different levels of speech processing: delta corresponds to processing of rhythm and prosody at the phrasal and word levels, while theta has been related to finer-grain linguistic analysis, involving processing of syllable-level information in speech. Hence, we predict that infants will show efficient cortical tracking of speech at the delta band in the first months of life, reflecting early sensitivity to the rhythmic and prosodic structure of native and non-native speech. On the other hand, we expect cortical tracking at the theta band to increase throughout infants' first year of life, particularly in response to native speech, as infants accumulate greater language exposure and develop the ability to encode fine-grain prosodic and phonetic detail in their native language(s). We are conducting a large-scale longitudinal study that assesses language development from 4 months to 7 years of age in 180 infants acquiring Spanish and/or Basque in a bilingual community. Here, we will report preliminary results (40 infants) for 4- and 7-month-assessments of infants' cortical tracking of speech. In this task, infants are presented with

three prerecorded stories in Spanish and Basque (both syllable-timed languages familiar to infants) and English (unfamiliar stress-timed language), while their neural activity is recorded using continuous electroencephalography (EEG). For each participant, information about the level of exposure to each language is collected using a parental questionnaire. We will calculate coherence between the neural oscillatory activity and the speech envelope. The specific frequency ranges for each band will be determined by the rates at which stressed (delta band) and unstressed syllables (theta band) occur in the stimuli from each language (Spanish, Basque, and English). At 4 months, we expect that infants will show cortical tracking of speech in response to all three languages, demonstrating language-general sensitivity to prosodic information in the speech signal. It is possible that higher coherence will be observed for the two familiar syllable-timed languages (Spanish ad Basque) than the unfamiliar stress-timed language (English) as evidence for infants' growing familiarity with the prosodic patterns of the language(s) present in their environment. At 7 months, however, we expect an increase in theta, but not delta coherence, specifically for the language that infants encounter more often in their environment (familiar dominant language), followed by the familiar but non-dominant language, and followed by the unfamiliar non-native language. This results pattern will evidence the complex relation between the effects of neural maturation and accumulating language-specific experience on infants' developing ability to encode linguistic information from the auditory speech signal.

Topic Areas: Language Development/Acquisition, Multilingualism

## Active HD-tDCS over the LIFG during L2 grammar acquisition reverses correlation between accuracy and ERP amplitude over the left frontotemporal region

***Poster C93*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Active (high-definition) transcranial direct current stimulation ((HD-)tDCS) over the left inferior frontal gyrus (LIFG) has been shown to cause an improvement in language processing during various linguistic tasks, including vocabulary acquisition, sentence comprehension, and artificial grammar acquisition. Recently, we showed that HD-tDCS over the LIFG improves L2 grammar acquisition, however, neurophysiological correlates induced by this stimulation have not yet been elucidated. In this study, 50 native Japanese speakers naïve to Spanish completed a 20-minute training of present-tense verb conjugations for the three Spanish verb types (-ar, -er, -ir). During training, half of the participants received active HD-tDCS over the LIFG (the active group), while the other half received sham stimulation in the same location (the sham group). After training, participants completed a mixed-task phase consisting of two linguistic tasks (reception, production) and two working memory tasks (word recall, animal call recall). The reception task required participants to identify whether a given verb was conjugated correctly according to the given subject pronoun. The production task required the participant to verbalize the correct conjugation when given a subject pronoun and an unconjugated verb. The two working memory tasks were used as non-linguistic control tasks. ERPs were recorded during the reception task and aligned to the critical syllable onset (i.e., the syllable of conjugation disambiguation). (Generalized) linear mixed effects ((G)LME) models were used to test the behavioral data for significant effects of stimulation. GLME models revealed that linguistic (but not non-linguistic) task accuracy was significantly improved with active stimulation, while LME models revealed no significant effects of stimulation on response time. Due to the exploratory nature of this study, to analyze ERPs, we first visually inspected whole-epoch (0¬–2000 ms) topographical maps of both groups to select regions and time-windows of interest, primarily in the difference condition (morphosyntactic violation – control). Subsequent statistical analyses revealed several significant effects of stimulation demonstrating that while the two groups had similar ERPs, the sham group exhibited overall stronger and longer-lasting potentials. Additional tests for correlations between accuracy and ERP amplitude revealed that the active group exhibited a reversal of the sham group's positive correlation between accuracy and ERP amplitude over left frontotemporal electrodes. That is, in the sham group, as accuracy improved, left frontotemporal ERPs became stronger and more positive, while in the active group, improvements in accuracy were characterized by weaker and more negative deflections. In sum, behavioral data corroborated the result from our previous study that HD-tDCS over the LIFG differentially improves L2 grammar acquisition. Meanwhile, ERP results indicated two primary effects of active stimulation: generally improved cognitive efficiency and a reversal of the correlation between accuracy and left frontotemporal ERP amplitude. Taken together, we interpret these results to indicate that HD-tDCS over the LIFG during L2 grammar acquisition caused the active group to more quickly reach a later stage of language learning (e.g., the consolidation phase), while the sham group remained at an earlier stage (e.g., shallow learning phase).

Topic Areas: Language Development/Acquisition, Multilingualism

## Are executive functions engaged in language switching? The role of language proficiency

***Poster C94*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Bilingualism research has largely presumed that bilingual speakers engage domain-general control mechanisms in language control, here called the domain-generality account. This assumption is fundamental for the claim that bilinguals might train executive functions (EFs) by means of language switching. While some studies have found that general executive control is needed for language control such as in language switching, other research has found contrasting results. This conflicting evidence suggests that EFs might be engaged to some degree in language switching, but the circumstances under which this might occur are not clearly determined. In contraposition to the domain-generality account, recent research has suggested that experienced bilingual speakers may be able to automatize some of their language switching. This has been proposed in the "skill learning" account (Jylkkä 2017; 2020, Lehtonen et al., 2023), which assumes that EFs might be needed only when a particular task or behavior is new or unfamiliar, but that these become routinized with sufficient experience and then do not rely on domain-general EFs anymore. Thus, less experienced speakers, such as L2 learners with a lower proficiency, would be expected to exhibit stronger associations between EF and language switching performance compared to more experienced and highly-proficient bilinguals, who should be less likely to engage EFs for language control. This study tested this

hypothesis in a group of Finnish-Swedish bilinguals with different proficiency levels and bilingual experience. The participants (N= 86) were divided into three groups: an early bilingual group that had acquired both languages in childhood, an L2 group with high proficiency in Swedish, and an L2 group with lower proficiency in Swedish. The L2 groups had started learning Swedish in late childhood or adolescence. All participants completed an online experiment that included a Finnish-Swedish cued naming (CN) task with language switching, a Simon task measuring inhibitory control, a Swedish vocabulary test, and a language background questionnaire. In line with the predictions of the skill learning hypothesis, our results revealed that L2 proficiency modulates the relationship between EFs and language switching. Specifically, the Simon effect did not predict switching or mixing costs in the early bilingual and high proficient L2 group, but it was a significant predictor for CN switching in the lower proficiency L2 group. Given the comparable outcomes between early bilinguals and the high proficient L2 group, our results suggest that language proficiency might be a more important factor than age of acquisition when it comes to relationship of EFs and language control, and that language control mechanisms might become automatized with sufficient language experience. These results contribute to the bilingual advantage debate as they challenge the domain-generality hypothesis, and by extension, the cognitive training hypothesis. If the engagement of EFs for language control is limited to a reduced group of speakers, the idea that all bilingualism could train domain-general cognitive processes needs to be reconsidered.

Topic Areas: Language Development/Acquisition, Multilingualism

## Morphological processing in the preliterate bilingual brain

***Poster C95*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Morphological awareness, or the ability to understand and make use of units of words (morphemes), is an essential spoken language skill for language development and reading acquisition. Languages differ in morphological rules, thus languages may make up words in different ways. For example, Chinese makes up words mainly through compounding (i.e., snow-man), while English is more characterized by derivational morphology (i.e., read-er). As a result, young Chinese-English bilingual readers are found to show different brain mechanisms by showing enhanced left frontal activations when processing multi-morphemic words compared to English monolingual readers (Sun et al., 2022a, 2022b). Yet, what remains unknown is if these differences in brain functions between these readers come from their experience with the written languages, or if they can be rooted from before they learn to read. Indeed, behavioural evidence showed that children begin to recognize and make sense of word morphemes from as early as 4 years old. Thus, in the current study, we ask: How does the developing brain begin to support Chinese-English bilingual and English monolingual children’s emerging understanding of word morphemes prior to learning to read? Using fNIRS neuroimaging, we aim to measure functional brain activities during morphological word processing among preliterate children at 4-to-5 years old. Bilingual Chinese-English and monolingual English preliterate children completed a lexical morphology task that asked children to listen to three words and pick out the one (e.g., cupcake or stomachache) that “goes with” the target word (e.g., pancake). The ultimate full sample will be 120 (60 per group). Preliminary data (N = 18, M(SD)age = 5.18(0.5), 13 monolinguals) indicates that overall, both groups activate left frontal and middle temporal regions during the task compared to baseline. These regions are often associated with morpho-semantic processes, and results are consistent with prior research with reading-age children and adults. Moreover, Chinese-English bilinguals tend to engage more right frontal and middle temporal regions, whereas monolinguals tend to engage more left middle temporal regions during task versus baseline. If these results hold in the full sample, they may reflect potential differences in the strategies for breaking words into parts as well as accessing meanings for each part. The study will contribute to our understanding of how young bilingual and monolingual children process words with different morphological structures. This research will also further our understanding of how the brain adapts to different types of language input to support language acquisition and emerging literacy in children from linguistically diverse backgrounds.

Topic Areas: Language Development/Acquisition, Multilingualism

## Cognitive Effects of Learning a New Language in Healthy Older Adults: A Pilot Study

***Poster C96*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Aging often comes with cognitive decline or pathological cognitive impairment. Prevalent cognitive processes that often regress with aging include attention, memory, executive functions and processing speed (Albinet,et al., 2012), which can lead to a decrease in quality of life (Lee & Chung, 2012). There are not many promising pharmaceutical or non-pharmaceutical interventions to improve cognitive health at aging. Given cognitive demand of learning a new language (Ghazi Saidi et al., 2013, 2017a, 2017b), we hypothesis that learning a new language can boost cognition. Methods: This ongoing study assesses cognitive effects of learning a new language in older adults (age: 60-80). A series of cognitive assessments are administered to participants before and after a four-month language-learning program. Participants complete at least 90 minutes of a language learning intervention each day through an online language learning program for five days a week over the duration of four months. We monitored the amount of time participants spent on the language program and participants' average scores each week for completed lessons. Pres and post measures are compared using the repeated-measures t-test in SPSS. Results and Discussion: The preliminary results show significant changes to pre/post-measures of response time for the Stroop test, which measures selective attention, the Digit Symbol test, which measures processing speed, semantic fluency, which measures working memory, executive function, and word retrieval, and for the Montreal Cognitive Assessment (MoCA), which measures global cognition. Preliminary results of this study align with our previous studies in that language learning engages cognitive processes (Ghazi Saidi, et al., 2013; 2017a; 2017b). Evolving evidence suggests engagement in cognitive activities can improve cognition or slow the regression of cognitive health with aging (Wenisch, et al., 2007; La Rue, 2010; Saragih, et al., 2022). Conclusion: Learning a new language in monolingual older adults may contribute to their cognitive health. Reference : Albinet, C. T., Boucard, G., Bouquet, C. A., & Audiffren, M. (2012). Brain and cognition, 79(1), 1-11. Ghazi Saidi, L., Perlbarg, V., Marrelec, G., Pélégrini-Issac, M., Benali, H., & Ansaldo, A. I. (2013). Brain and language, 124(1), 56-65. Ghazi-

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Topic Areas: Language Development/Acquisition, Multilingualism

## Early Electrophysiological Signatures of Novel Language Learning in Heritage Speakers

***Poster C97*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Recent research has largely supported the view of bilingualism as a spectrum, a dynamic and nuanced experience with many sources of variability for linguistics outcomes (De Luca et al., 2020; Gullifer et al., 2020). The subfield of heritage speakers has greatly contributed towards this view because the heritage speaker (HS) experience itself within bilingualism is highly nuanced (Kupsich & Rothman, 2018). Only recently, however, have researchers started considering the impact of HS variability for online linguistic processing (see Bayram et al., 2020).To date only one study has utilized HSs as a model for investigating the impact of variability in previous language experience for third-language (L3) learning (Pereira-Soares, 2021). The present study aims to investigate the earliest neural and behavioral signatures of novel language learning in Spanish-English HSs to test two key questions: a) what are the earliest neural (EEG) signatures of an emerging lexicon for Spanish-English HSs, and b) are these effects modulated by distinct features in the bilingual profile unique to HSs. Method and design: This ongoing study (current n=18) utilizes a longitudinal design during which participants study a novel language, Dutch, for 10 days. The Dutch learning phase is preceded by a pre-test, and followed by a post-test The pre-test consists of a battery of neurolinguistic and cognitive tasks including: Verbal Fluency, Verbal Working Memory, an EEG Picture Naming task, and an EEG adaptive Flanker task, and the main EEG Semantic Categorization Task (SCT) which is used to measure the emerging neural sensitivity to the learned Dutch vocabulary.After the pre-test, participants complete a 10-day Dutch language learning experience via Rosetta Stone® (approximately 45-50 minutes) for 10 days. After completing the Dutch learning phase, participants complete the post-test identical to the pre-test task battery. Main task: during the EEG SCT participants are required to listen to Dutch words and make a decision based on specific semantic rules (i.e., does the word represent something natural or man-made, or is it bigger or smaller than a shoebox). Preliminary Results: The preliminary analysis indicates a modulation of the N400 component from pre to post test for the SCT task. More specifically, we observe an increase of the N400 for learned words compared to non-learned words, which may reflect ease of lexical access in long-term memory (Kutas & Federmeier, 2011) and/or serve are a marker for the formation of lexical representations after only 7-8 hours of L3 learning. Predictions: Data collection is still underway but, we predict to continue to see a modulation of the N400 from pre to post test as a marker of novel language learning at the word level. We also predict that the rate of change in effect size of the ERP results from pre to post test will be modulated by individual variability in the

bilingual language profile. Additionally, in the time-frequency domain, we predict differences in the time scale of oscillatory patterns, namely alpha and beta band frequencies, will also be modulated by individual variability.

Topic Areas: Language Development/Acquisition, Multilingualism

## EEG evidence for statistical learning in sleeping newborns

***Poster C98*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Since speech is a continuous stream with no systematic boundaries between words, how do pre-verbal infants manage to discover words? A proposed solution is that they might use the transitional probability between adjacent syllables, which drops at word boundaries to segment continuous sequences into word-like units. In a series of experiments, we used EEG to test this capacity and its limitation in sleeping neonates (one to three days old). For that, we developed and used EEG markers to assess statistical learning capacities in non-responsive population such as neonates. Finally, to explore the developmental trajectory of such cognitive capacity, we compared infants' initial competences with adult behavioral performances in the same tasks. Our first result was to confirm that statistical learning is automatic enough to be efficient even in sleeping newborns. Using neural entrainment methods, we could follow the learning curve through time. It gave us an estimation of the neonates' learning dynamic in such task. We also tested after learning memory representations of the pseudowords in multiple conditions. We showed that neonates specifically retained the first syllable of the extracted pseudowords. In a second experiment, we increased the difficulty of the segmentation task by investigating quadri-syllabic pseudowords instead of the usual tri-syllabic pseudowords always used in the literature. Crucially, the transition probability information was kept unchanged from our previous design. We revealed that despite successful tracking of transition probabilities in such sequence, neither neonates nor adults were able to successfully segment it. Strikingly, adding subtle prosodic cues such as subliminal pauses enabled both adults and infants to recover their segmentation capacities. These results showed that successfully tracking transition probability and segmenting pseudowords from a continuous sequence are two related but different processes. Thus, from birth on and despite immaturity, infants' brains are equipped with adult-like tools, allowing them to extract coherent word-like units from auditory streams, based on the combination of statistical and auditory parsing cues.

Topic Areas: Language Development/Acquisition, Speech Perception

## Infant-Directed Speech: An Optimal Signal for Early Speech Processing

***Poster C99*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Adults adjust their speech during face-to-face interactions with infants. The resulting speech register, known as infant-directed speech (IDS), is proposed to promote infants' early language development. Specifically, the exaggerated prosodic patterns and phonetic expansion characteristic of IDS are proposed to facilitate more efficient encoding and processing of the speech signal. This proposal is supported by recent evidence for more successful cortical tracking of IDS compared to adult-directed speech (ADS) in young infants. Cortical tracking refers to the synchronisation between the oscillatory neural activity and the temporal modulations in the amplitude envelope of the speech signal. The frequency bands of neural oscillations specifically relevant for speech processing are delta (<3 Hz) corresponding to phrase- and word-level prosodic rates in speech, theta (~5 Hz) corresponding to the syllabic rate, and gamma (~20 Hz) corresponding to the phonetic rate. Specifically, IDS is proposed to enhance cortical tracking of low frequency information (delta and theta), thus facilitating both infants' recognition of the phrasal- and word-level prosodic patterns of their native language, and later reliance on these patterns for extracting words from continuous speech. While infants' cortical tracking is more efficient for IDS than ADS, previous studies have not investigated how this benefit relates to infants' developing linguistic abilities. For this purpose, this short-term longitudinal study assessed (1) cortical tracking of IDS vs. ADS at 4 and 9 months, before and after infants begin to successfully segment words from continuous speech, and (2) the relation between the IDS benefit on cortical tracking of speech and infants' individual lexical processing abilities at 9 months of age. Thirty-two infants acquiring Basque completed two tasks: a cortical tracking task (at 4 and 9 months) and a lexical processing task (at 9 months). In the former, infants heard audio recordings of naturally-produced IDS and ADS while their continuous EEG was recorded. In the latter, infants watched images of familiar objects on a screen (e.g., apple and ball) while one of the objects was named (e.g., "where is the ball?), and their eye movements were recorded using eye-tracking. Data collection is complete, and analyses are currently in progress. We will calculate coherence between the neural oscillatory activity and the speech envelope in delta and theta. These frequency ranges will be defined as the rates at which stressed and unstressed syllables occur in the IDS and ADS stimuli. We predict a stronger IDS benefit (Coherence IDS > ADS in delta and theta bands) at 9 compared to 4 months, which will reflect the developmental transition to encoding prosodic patterns in the speech signal for efficient segmentation of continuous speech. Additionally, we predict that individual indices of IDS cortical tracking at 9 months will relate to infants' familiar word recognition efficiency. These findings would demonstrate that early speech processing and the emerging ability to extract meaningful linguistic information from continuous speech in the first year of life is supported by early neural maturation, infants' growing linguistic ability, and critically, the quality of speech that infants hear in early interactions with their caregivers.

Topic Areas: Language Development/Acquisition, Speech Perception

## Unveiling the Neonatal Structural Substrates of Speech Sound Encoding through Brain Morphometry

***Poster C100*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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During the third trimester of pregnancy, the human brain undergoes developmental changes, such as myelination, gyrification, and increased gray matter volume, which can be decoded and related to functionality using MRI and EEG at birth. Although adult studies indicate a correlation between specific auditory brain regions and hearing/language abilities, volumetric anatomo-functional correlates in neonatal populations remain unexplored. This study aims to investigate the relationship between the volume of language/speech perception brain regions and an auditory evoked potential termed Frequency-Following Response (FFR) at birth. This study involved 41 healthy term neonates who underwent EEG and MRI exams within a two-week interval. The FFR was elicited to a two-vowel stimulus (/oa/) and analyzed in terms of pitch tracking and encoding of both its fundamental frequency and temporal fine structure. MRI neuroimages were processed using the Developing Human Connectome Project structural pipeline to obtain volume indices of specific regions of interest (ROIs), including the corpus callosum, superior, medial, and inferior temporal gyrus, and insula, which were segmented into both left and right hemispheres and white and grey matter parts. Next, 2 raters carried out a manual parcellation of the corpus callosum following the Witelson method (satisfactory ICC). Statistically, we applied Pearson partial correlations to establish the relationship between volume indices and the FFR parameters. General Linear Models were subsequently constructed using statistically relevant FFR parameters as a response and significant ROIs as predictors. Statistically significant positive correlations with fundamental frequency encoding were observed in the white matter segments of the medial and inferior temporal gyrus (MITG) and the entire right medial superior temporal gyrus (STG) ($p < .05$). Furthermore, a strong positive correlation was found between neural lag and the posterior right white matter region of the STG ($p < .01$). Conversely, the medial right white matter segment of the STG exhibited a significant negative association with pitch tracking measures ($p < .001$). In terms of temporal fine structure encoding, the corpus callosum played a significant role, with negative correlations observed in the posterior parts (from anterior midbody to the isthmus), while the splenium showed a positive correlation ($p < .05$). The general linear model analysis revealed a significant negative main effect of the posterior midbody volume ($p =.01$, R^2=.32) on temporal fine structure encoding after log transforming it, controlling for sex, age at scan and birth weight. This study explored the relationship between volume of auditory/language regions and speech encoding function in neonates, contributing to the anatomical characterization of the FFR at birth. Our findings suggest that white matter regions within our ROIs play a more significant role than grey matter subregions in speech processing. Specifically, the posterior midbody of the corpus callosum had a negative contribution to temporal fine structure encoding. These findings provide initial evidence linking anatomical and functional aspects of speech processing using the FFR at birth. Funding: Project PID2021-122255NB-100 (MCIN/AEI/10.13039/501100011033/FEDER,UE), María de Maeztu Center of Excellence CEX2021-001159-M (MCIN/AEI/10.13039/501100011033), the 2021SGR-00356 Consolidated Research Group of the Catalan Government, and the ICREA Acadèmia Distinguished Professorship awarded to Carles Escera.

Topic Areas: Language Development/Acquisition, Speech Perception

## The neural development of auditory temporal modulation processing for phonetic perception in the first year of life

***Poster C101*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Before 10 months of age, infants are not yet attuned to the consonants of their native language, meaning that, compared to adults, they are sensitive to certain non-native phonological contrasts. The nature of the mechanisms shaped by age and exposure to the native language is yet to be discovered. The current project hypothesizes that auditory mechanisms supporting speech perception may play a crucial role in perceptual attunement. This experimental study explores the interaction between auditory and speech perception abilities during early development by using a psychoacoustic approach combined with electrophysiology. We used a psychoacoustic approach suggesting that the auditory system selectively decomposes the spectral and temporal modulations of speech. Such acoustic modulations can be artificially manipulated using vocoders to assess their role in speech perception. To explore the neural underpinnings of the processing of temporal modulations, and particularly of amplitude and frequency modulations (AM/FM), we used electroencephalography (EEG) to measure the cortical auditory evoked potentials (CAEPs) for native and non-native consonants in French-learning 6-month-old (N=21), 10-month-old (N=21) and French adult listeners (N=20). We used vocoders to process three syllables: French-voiced /aba/, French-unvoiced-unaspirated /apa/, and an English-unvoiced-aspirated /apha/. Three vocoder conditions were designed to preserve: i) original FM and AM, ii) original AM only, and iii) the slowest AM (< 8 Hz) only. The results showed that overall, all age groups exhibited different CAEPs between the original sounds and their FM degraded versions, but that degradation of faster AM cues did not further affect CAEPs. Different CAEP amplitudes were also observed between 6 and 10 months of age as a function of the vocoder condition and consonant. Specifically, at 6 months, infants showed sensitivities to FM degradation for the two native sounds. At 10 months, infants showed sensitivities to FM and further fast AM degradation for the non-native consonant. Adults' data were analyzed separately as a reference group. Their neural responses were also affected differently by acoustic degradation and consonants, and their pattern of responses was qualitatively closer to the one of 10-month-olds, that is, they showed sensitivities to FM and further fast AM degradation for the non-native consonant only. Thus, this study suggests that neural speech-auditory mechanisms evolve during perceptual attunement in the first year of life.

Topic Areas: Language Development/Acquisition, Speech Perception

## Action/Perception mechanisms in early speech perception: an EEG study

***Poster C102*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speech perception does not only recruit the auditory system but, in the (adult) human brain, entails parallel

analysis by the sensorimotor system (Skipper et al., 2017). Recent event-related potential (ERP) results, measured using electroencephalography (EEG), have shown analogous sensorimotor processing in young infants (Choi et al., 2021). Moreover, developmental improvements in the perception of specific speech sounds (e.g., p, t) have been detected following the onset of production of those same sounds (e.g. DePaolis et al., 2011). These results led to the hypothesis that babbling, the onset of speech production, is a fundamental step in the ontogenetic setting of action/perception loops for speech perception, and may lead to major changes in perception skills. However, such results have only been observed behaviorally, based on the analysis of attentional patterns (infants' looking times). Thus (despite indirect neurofunctional evidence, Imada et al., 2006), we do not know whether the perceptual improvements that are linked to production onset represent the signs of an actual neurofunctional reorganization of speech perception. Can we identify neurofunctional signatures following the establishment of the action/perception loop in speech perception? In an ongoing ERP study, we aim to compare electrophysiological signatures of phoneme processing before and after speech sounds are practiced in babbling. Ten-month-old infants undertake a multi-feature oddball paradigm recording with 11 active electrodes (F7, F3, Fz, F4, F8, C3, Cz, C4, P3, Pz, P4), presenting deviant stimulus that either fall into participants' production patterns ('deviant 1') or fall outside from participants' production patterns ('deviant 2'). These stimuli (pa, frequent stimulus; ta, type 1 deviant, and ka, type 2) have comparable acoustic properties and were selected based on a preliminary parental survey targeting speech sound production in this age range. As to this survey, the sound p was produced by 75% of total participants (n=15); the sound t by approximately 50% and the sound k by only one participant out of 15. Capitalizing on this pattern, we aim to recruit two groups of participants (n=25 each): group 1, made up by infants producing both the frequent stimulus p and one out of two deviants; group 2, made up by infants producing the frequent stimulus only. Group 1 allows assessing possible differences in the electrophysiological signature to produced (t) vs non-yet-produced (k) speech sounds; Group 2 represents a control group. Speech production skills are home-recorded from each participant using the LENA® system and analyzed based on human perceptual judgment. Preliminary results from 14 participants (Group 1=10, Group 2=4; MA=10m18d) were analyzed in a repeated measures ANOVA assessing the effect of Region (Central, Frontal); type of Deviant (1,2) and production Group (1,2). This preliminary analysis did not show any significant effect of type of Deviant or production Group, but stronger responses in the frontal region for all participants ($p=0.0001$, $F=28.594$, $\eta p2$ 0.704). Participant recruitment and testing are ongoing, in order to reach full group sizes. Moreover, importantly, perceptual analysis of home-recorded speech productions is being completed in parallel and is susceptible to change the participants' distribution in the two groups.

Topic Areas: Language Development/Acquisition, Speech Perception

## Early Development of Sound Processing: How does a prenatal bilingual environment impact the newborn's language encoding?

***Poster C103*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The trajectory of language acquisition has been extensively characterized and is dependent on perceptual and cognitive abilities, whose developmental pathway starts before birth through prenatal experience with auditory and speech information. Several studies have demonstrated that even fetal hearing experiences shape the infants' musical and linguistic preferences and that they are able to recognize the voice of their mother or even prefer their native language. As bilingualism, relative to a monolingual environment, has been demonstrated to enhance evoked responses to speech in children and adults, the present study sought to determine whether a bilingual environment during the third trimester of pregnancy could modulate the neonate's ability to encode speech sounds. For this purpose, we recorded the frequency-following response (FFR), an auditory evoked potential elicited to complex sounds, in a sample of 131 healthy-term neonates during their first days of life. Newborns were divided into two groups according to their prenatal language exposure as reported by their mothers through a questionnaire (53 exposed to a monolingual fetal acoustic environment; 78 bilingual-exposed). The FFR was recorded to an /oa/ stimulus and quantified as the spectral amplitude and signal-to-noise ratio (SNR) at the stimulus fundamental frequency (F0). Analyses disclosed that monolingual-exposed newborns exhibited larger SNR at F0 as compared to the bilingual group, as well as significantly greater spectral amplitudes to the vowels formant structure. Our results suggest that prenatal language experience has a modulatory effect on the neural responses at birth, and specifically, that monolingual fetal environment generates a less variable background for the neonates to encode and process speech sounds. Our results contribute to the current hypothesis that bilingual infants commence the process of language acquisition by separating languages from birth by demonstrating that, whilst the exposure of the fetus to a single language would produce more robust and larger amplitude responses at certain specific frequencies, bilingually exposed newborn's auditory system shows a major sensitivity to a wider range of frequencies without generating a particularly strong response at any of them.

Topic Areas: Language Development/Acquisition, Speech Perception

## Multimodal language processing in adults with moderate-severe traumatic brain injury

***Poster C104*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language is multimodal and situated in rich visual contexts. Language is also incremental, unfolding moment-to-moment in real time, yet few studies have examined how spoken language interacts with gesture and visual context during multimodal language processing. Gesture is a rich communication cue that is integrally related to speech and often depicts concrete referents from the visual world (e.g., size, shape, or movement of objects). Using eye-tracking in an adapted visual world paradigm, we examined how participants with and

without moderate-severe traumatic brain injury (TBI) use gesture to resolve temporary referential ambiguity. Participants viewed a screen with four objects and one video. The speaker in the video produced subject-verb-object sentences (e.g., “The girl will eat the very good sandwich”), producing either a meaningful iconic gesture (e.g., sandwich-holding gesture) or a meaningless grooming movement (e.g., arm scratch) during the verb “will eat.” We measured participants’ gaze to the target object (e.g., sandwich), a semantic competitor (e.g., apple), and two distractor items (e.g., piano, guitar) during the critical window between movement onset in the gesture modality and onset of the spoken referent in speech. We used dynamic generalized linear mixed models to predict fixations to the target (1) or not the target (0), with fixed effects for movement type (gesture vs. grooming movement), participant group (TBI vs. non-injured comparison), and their interaction. We included first-order autocorrelation AR(1) and time as covariates. This takes into consideration the tendency of participants to fixate the target over time within a trial and the serial dependency of fixation location from one timepoint to another. We found a significant main effect of movement type ($\beta = 0.61$, $z = 19.57$, $p < .001$), where non-injured participants were 1.84 times more likely to fixate the target when the speaker produced a gesture compared to a grooming movement. There was no main effect of group ($\beta = 0.29$, $z = 1.59$, $p = .11$), indicating that participants with TBI did not significantly differ from non-injured peers in their likelihood of fixating the target. A significant interaction between group and movement type ($\beta = -0.22$, $z = -5.00$, $p < .001$), indicated that the effect of movement type differed by group. Participants with TBI also demonstrated a significant effect of movement type ($\beta = 0.40$, $z = 13.48$, $p < .001$), however, the effect was attenuated in the TBI group. Participants with TBI were 1.49 times more likely to fixate the target when the speaker produced a gesture compared to grooming movement. We demonstrated evidence of reduced speech-gesture integration in participants with TBI relative to their non-injured peers. This study advances our understanding of the communicative abilities of people with TBI and could lead to a more mechanistic account of the communication difficulties people with TBI experience in rich real-world communication contexts that require the processing and integration of multiple co-occurring cues. This work has the potential to increase the ecological validity of language assessment and provide insights into the cognitive and neural mechanisms that support multimodal language processing.

Topic Areas: Signed Language and Gesture, Multisensory or Sensorimotor Integration

## How can the processing of sign language help the processing of spoken language? Evidence from priming

***Poster C105*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous studies have shown that when bilinguals read words in their second language, the corresponding words in their first language are automatically activated. However, whether this activation occurs without similar phonological or orthographic features between the languages remained unclear. Unlike two spoken languages, sign language and spoken language do not share the same articulatory system, and the phonological and visual forms of sign language are very different from those of spoken language. The current study aimed to investigate how the processing of the first language (sign language) could help the processing of the second language when deaf participants read the second language (Chinese) and how their second language proficiency would modulate this potential facilitatory effect. Deaf participants were presented with prime-target word pairs with the prime word in the sign language form and the target word in written Chinese (characters). The sign primes were 1) phonological similar to the sign equivalent of the target word (sharing two or three phonological parameters: handshape, movement, location), 2) semantically related to the target, or 3) unrelated to the target. Participants were asked to make speeded lexical decisions to the target words. Results showed that target words were responded to faster and more accurately when they were preceded by semantically or phonologically related signs than by unrelated control primes. Moreover, the phonological priming effect was negatively correlated with participants' proficiency in Chinese, with lower proficient participants showing larger priming effects. This pattern of results demonstrates that when deaf people see sign words, other sign words sharing phonological features are automatically activated. This activation could spread to lexical representations of the corresponding second language words, helping the processing of the latter. Deaf readers of the second language would benefit more because their slower processing of the second language would give them more time to receive this spreading activation. Keywords: sign language, written language, lexical representation, deaf reader

Topic Areas: Signed Language and Gesture, Phonology

## How does audiovisual prosody influence spoken language comprehension?

***Poster C106*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Natural face-to-face communication relies not only on speech but also on bodily signals such as manual gestures. Beat gestures represent rhythmic non-meaningful hand movements that typically accompany prosodic stress in conversation. Yet, it is still a matter of debate whether and how beats, as well as their co-occurrence with prosody (i.e. audiovisual prosody), influence language comprehension. On the one hand, beats may function as visual focus markers. Accordingly, EEG evidence suggests that beats facilitate phonological, semantic, and syntactic processing of spoken sentences. Hence, it is conceivable that beats drive attention towards the concurrent speech signal and thereby elicit deeper processing of the companion constituent. On the other hand, beats may allow inferences about the speaker's metacognition. Accordingly, bodily features such as gaze and eyebrow movements seem to influence how listeners grade the speaker's level of knowledge in question answering. Similarly, beats may trigger inferences of high speaker confidence and thereby elicit the expectation of correctness. In a behavioural study, we directly disentangled the two hypotheses. Further, we evaluated whether and how beats interact with prosodic stress to influence spoken language comprehension. Finally, we contrasted beats with grooming gestures that are closely matched in terms of kinematics but are not perceived as communicatively intended, nor meaningfully related to the speech they accompany. In a comprehension task, we presented participants with unique spoken sentences sometimes containing a slight semantic anomaly, which may go unnoticed depending on the level of processing of the corresponding constituent ("semantic illusion"). In a 2×2×3 repeated measures design, we independently manipulated semantic congruence (yes, no), prosodic stress (present, absent) and manual gesture (videos of a speaker performing beat, grooming or no gesture). Prosodic stress and manual gestures

were placed on the critical word that dictated the presence of a semantic anomaly. To probe the degree of semantic illusion, participants were instructed to focus on the meaning of each spoken sentence and report as accurately and fast as possible whether the sentence was true or false in a yes/no forced choice task. We evaluated participants' accuracy and response times to verify whether and how manual gestures and prosodic stress influenced the semantic illusion. If beats (and/or prosodic stress) functioned as focus markers, they would decrease the semantic illusion; if they elicited the expectation of correctness, they would instead increase the illusion. Preliminary results show an interactive effect of manual gestures and prosodic stress: participants showed a higher degree of semantic illusion when prosodic stress was combined with beats, compared to grooming and no gesture; the corresponding response times were also significantly faster, suggesting a quick resolution of participants' responses towards a bias for correctness. Thus, the combination of beats and prosody may trigger inferences of high speaker confidence, drive the expectation of correctness and thereby elicit shallower processing of the companion constituent, in line with Grice's cooperative principle in conversation. An ongoing fMRI study will elucidate which brain mechanisms are responsible for this effect, which highlights the influence of metacognition on language comprehension in multimodal face-to-face communication.

Topic Areas: Signed Language and Gesture, Prosody

## The dynamic modulation of multimodal cues in real-world language comprehension

***Poster C107*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Face-to-face communication contains rich multimodal cues: gestures serve pragmatic, semantic (meaningful gestures) or emphatic (beats) functions. Previous EEG studies have shown that both L1 and L2 comprehenders integrate and process gestures during comprehension (Özyürek, 2014 for review). Zhang et al. (2021) found that gestures and discourse-level linguistic information were dynamically integrated in the same N400 time-window. Meaningful gestures reduced N400 effects for less predictable words in context, suggesting that they were used to predict the meaning of upcoming words. However, beat gestures co-occurring with less predictable words were associated with larger N400 amplitudes. Here, we assess whether effects of gesture are also observed in naturalistic stimuli where the comprehender is not the addressee (i.e., participants watching video-clips of two adults talking about various objects). This contrasts with previous studies in which participants watched video-clips of an individual speaker (typically an actor/actress). 30 English-speaking participants watched 36 videos (mean duration = 55.61s, mean number of words = 128) of dyadic conversations between friends extracted from the ECOLANG corpus (Gu et al., in preparation) while 32-channel EEG data was recorded. The linguistic predictability of the speaker's words in the video-clips was quantified using semantic surprisal (negative log-transformed conditional probability of a word given its preceding context) computed using a bigram model trained on the ENCOW14-AX English corpus (Frank et al., 2015; Zhang et al., 2021). We annotated representational, pragmatic, beat, and pointing gestures. Lexical affiliates (i.e., words whose meaning was represented by the gesture) were coded for representational and pointing gestures (i.e., meaningful gestures). Words were coded for beat or pragmatic gestures if they co-occurred with these gestures. For each content word, we calculated the N400 as the averaged ERPs from all electrodes in the 300-600ms time-window (following Zhang et al., 2021). In a linear mixed-effects analysis (LMER), we predicted N400 based on surprisal, meaningful, beat, and pragmatic gestures. Control variables were baseline, word length, word order, and the relative electrode positions (X, Y, Z coordinates). Higher surprisal words induced more negative N400 ($\beta=-0.040$, $t=-10.186$, $p<.001$) as did words accompanied by beat gestures ($\beta=-0.005$, $t=-3.440$, $p<.001$); while meaningful gestures reduced the N400 ($\beta=0.015$, $t=12.324$, $p<.001$). Moreover, higher surprisal words combined with any type of gestures resulted in more negative N400: meaningful gestures ($\beta=-0.014$, $t=-8.694$, $p<.001$), beat gestures ($\beta=-0.012$, $t=-5.953$, $p<.001$), and pragmatic gestures ($\beta=-0.011$, $t=-10.388$, $p<.001$). Thus, in naturalistic contexts where a comprehender simply observes a conversation, multimodal cues are integrated with linguistic cues during processing, in line with previous studies (Zhang et al., 2021). In contrast to Zhang et al. (2021) who reported N400 reduction for high surprisal words accompanied by meaningful gestures, here higher surprisal words combined with any type of gestures resulted in more negative N400, indexing increased processing difficulty. This suggests that different neural and cognitive mechanisms engage in multimodal integration when observing (rather than participating as addressee) in conversation (see De Felice et al., 2021; Rice and Redcay, 2016).

Topic Areas: Signed Language and Gesture, Speech Perception

## Gesturing influenced by cognitive and linguistic factors

***Poster C108*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Gestures are all around us, and they help us communicate. We instinctively point to select a pastry or happily wave to get a friend’s attention. Nonetheless, a lack of gesture use can be observed in environments that could facilitate successful communication across cultural contexts (e.g., airports, hospitals, refugees), as well as in spaces that predominantly use sign languages. Using gestures is vital in areas where people come together who do not share a language. We investigated cognitive factors hypothesized to contribute to successful gesture use, including visual sign language experience, working memory, and attention. Using innovative online webcam eye-tracking technology, we studied participants remotely across the USA. Data were collected and analyzed from 26 hearing adults, 12 monolingual non-signers (English only), and 14 bimodal-bilingual signers (English and American Sign Language, ASL). In a 2 x 3 block design, receptive and expressive performance was measured for 3 categories of gestures: high semantic content (e.g., “eating food”, “taking a photo”), some semantic content (e.g., “shame on you”, “thumbs up”), and low semantic content (e.g., “triangle outline”, “circle outline”). We predicted that prior language experience would impact the likelihood of successful use and comprehension of gestures across the 3 gesture categories. Behavioral responses to gesture stimuli were time-locked with online webcam eye-tracking. Behavior and eye gaze area (visual attention area, pixels x pixels) were analyzed with linear mixed-effects statistical modeling in R. Eye gaze density was further analyzed in MATLAB. There were significant main and interaction effects. Both groups were most accurate when perceiving gestures with high semantic content (e.g., “eating food”) and when producing gestures with low semantic content (e.g., “triangle outline”). Signers were less accurate than non-signers when producing gestures with some semantic content (e.g., “shame on you”). For this condition, signers more often produced sign language instead of gestures. Signers were faster to produce responses than non-signers. Signers also used larger, denser visual attention areas than non-signers, except when perceiving gestures with some semantic content (e.g., “shame on you”, no difference). These findings suggest that successful gesture use relies on cognitive and linguistic factors. More semantic content may aid in mapping top-down concept knowledge when perceiving gestures, but it may be more difficult to express these gestures than those with less semantic content. Visual sign language experience yielded faster responses and larger, more dense visual attention areas. However, we observed significant interference of sign language semantics for gestures with only some semantic content. All participants were naïve gesturers; perhaps these outcomes could change with gesture training. These results provide new insight into the human capacity to communicate with gestures. Successful gesture use relies on semantic content (verbal working memory), prior language experience with visual sign language, and visual and executive attention. Therefore, the present work identifies factors that may increase a person’s likelihood to use and comprehend gestures. Ultimately, this knowledge will lead to the creation of optimal gesture learning contexts to best facilitate communication across languages and cultures.

Topic Areas: Signed Language and Gesture,

## Functional Localizers for American Sign Language Comprehension

***Poster C109*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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When using fMRI to test hypotheses about patterns of neural activation which underlie cognitive processes, researchers commonly constrain activation elicited by experimental tasks with a localizer task, which isolates neural activity unique to that cognitive process. Localizer tasks are commonly designed on a per-experiment basis, so results cannot be directly compared across studies. A solution is to create a standardized localizer task known to reliably activate neural areas of interest, which can then be used to define individual functional regions of interest (fROIs) in each participant. We developed localizer tasks for American Sign Language (ASL) comprehension which are analogous to spoken or written language localizer tasks that have been developed by other research teams (Fedorenko et al., 2010; Scott et al., 2017; Ayyash et al., 2021). Our localizer tasks elicit ASL processing at the lexical, sentential, and narrative levels, with the baseline condition being degraded (blurred) videos of the same stimuli. The lexical condition consists of lists of unrelated nouns or verbs, which also allow us to contrast activation patterns for comprehending each lexical class. The sentential condition uses the same or similar words in simple, thematically unrelated sentences. The narrative condition consists of excerpts from a story (Alice in Wonderland) with narrative and prosodic devices typical of ASL storytelling. We have scanned 15 deaf native or early signers with our localizer tasks. We used the group-constrained subject-specific approach developed in Fedorenko et al. (2010) to define group-level partitions. Here we compare the efficacy of our three localizer tasks in defining partitions which can be used for future studies. The three localizer tasks all activate similar frontotemporal and occipital regions but to different extents. The sentences > baseline contrast elicits the strongest activation, likely due to the added processing demands of

comprehending sets of thematically unrelated sentences as compared to individual words or a single familiar story. This contrast produces thirteen meaningful group-level partitions: five partitions over bilateral occipital areas, bilateral fusiform gyri, and left inferior frontal gyrus; seven partitions spanning the bilateral superior and middle temporal gyri; and one partition straddling the left middle frontal and precentral gyri. We used individually defined fROIs generated with this localizer task to assess neural activation associated with processing of syntactic structure (sentences > word lists), lexical items (word lists > baseline), and lexical class (noun vs. verb lists). Both sentential and lexical processing activated bilateral occipital gyri, fusiform gyri, and superior/middle temporal areas; sentential processing also activated left IFG and precentral gyrus. In the direct noun-verb contrasts, nouns did not activate any regions more than verbs, but verbs activated bilateral occipital and fusiform gyri, bilateral temporal areas (with more extensive activation in the left hemisphere), and left IFG and precentral gyrus. Our data indicate that a distributed network involving temporal, fusiform, and occipital regions (the latter possibly indicative of top-down linguistic processes) subserve lexical and sentential processing in ASL. Verbs more heavily engage this network compared to nouns, likely due to their greater semantic and syntactic complexity.

Topic Areas: Signed Language and Gesture,

## Exploring the role of the (pre)Supplementary Motor Area white matter system in cognitive control

***Poster C110*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language is a prime example of how cognitive control operates in everyday tasks as it requires the integration of multiple cognitive and linguistic processes, including attention, memory, semantic retrieval, and response selection. Brain regions involved in cognitive control, include (among others) the pre-supplementary and supplementary motor area ((pre)SMA), caudate, inferior and middle frontal gyri (IFG, MFG). The (pre)SMA is connected with the frontal cortex and caudate through white matter forming the frontal aslant tract (FAT) projecting towards IFG and MFG, and fronto-striatal tract (FST) projecting towards caudate. Its involvement in language production and/or cognitive control remains unclear. Notably, Huntington's disease (HD) caused by genetic factors leads to brain cortex and striatum degeneration resulting in difficulties with cognition and language, making HD an ideal candidate for exploring structure-to-function relationships of the (pre)SMA system. This study aims to explore the role of (pre)SMA connectivity in cognitive control. We investigated the microstructural properties of the (pre)SMA system in 32 controls and 41 HD individuals using probabilistic tractography from diffusion-weighted images. FAT (both IFG and MFG branches) and FST were defined using the regions of interest (ROIs), approach in both hemispheres. Measures of volume, fractional anisotropy (FA), and mean diffusivity (MD) values were extracted from the tractography results to be compared between the two study groups and then correlated with cognitive scores. The cognitive tests included: Trail Making Test (TMT B-A), Digit Forward and Backward from the Wechsler Memory Scale, and the Verbal Fluency Test. While comparing the MD values, group differences in the FAT and FST microstructure were observed in all the tracts except for the left FAT (IFG projection). No group differences were observed while comparing FA values. In HD participants scores of the TMT B-A test indicated a positive correlation with the MD values of the FAT (IFG projection; ρ(33)=.47, p=.004 and ρ(33)=.56, p=.0003 FDR corr.; left and right respectively), with the right FST (ρ(33)=.51, p=.0001 FDR corr.), and with the portion of the FAT that terminates on the MFG in the right hemisphere (ρ(33)=.42, p=.02 FDR corr.). In conclusion - our findings suggest the involvement of the right and left FAT (IFG projection) as well as right FST and FAT (MFG projections) white matter tracts in a task involving cognitive control, specifically cognitive flexibility, set-shifting, and attentional processing. Future studies in this research line will aim at disentangling the relationships between (pre)SMA system and cognitive control which is involved specifically in language tasks in both healthy subjects and in people with HD.

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

## Using predictive validity to compare associations between brain damage and behavior

***Poster C111*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Multivariate lesion-behavior mapping (LBM) estimates the association between patterns of brain damage and individual behavior. The LBM algorithm assigns weights to voxels in patients' lesion volumes which are then used to predict their behavior. A common problem is determining whether two behaviors are mediated by damage to the same vs. different brain regions (e.g., Western Aphasia Battery scores (WAB-AQ) vs. naming accuracy). Researchers often use an "Overlap Method" to compare LBM weights via intersection (finding areas common to both LBMs) or subtraction (finding areas unique to each LBM). Alternatively, researchers correlate LBM weights, extrapolating that high correlations suggest similar neural bases, whereas low/negative correlations suggest distinct neural bases. However, both methods lack validated decision rules for determining LBM distinctiveness and are disconnected from the goal of accurate prediction of behavior. We developed the Predictive Validity Comparison method (PVC) to determine multivariate LBM uniqueness based on predictive accuracy: two behaviors have distinct neural bases if and only if separately-fit LBMs provide unique predictive power. If a single LBM accurately predicts both behaviors, the behaviors cannot be assumed to have separable neural bases, regardless of the similarity/difference of the voxel weights. Methods. PVC Algorithm. PVC requires two behavioral scores and one lesion volume per patient. Two sets of multivariate LBMs are built according to a null hypothesis (behaviors assumed to have the same neural basis) vs. the alternative hypothesis (behaviors have separable neural bases). Under the null hypothesis a single LBM is fitted to a combined behavioral score. Under the alternative hypothesis separate LBMs are fitted to each behavior. Fitted LBMs are then used to predict behavior. Prediction accuracy is compared using Akaike Information Criterion (AIC): if the alternative hypothesis has lower AIC the data are consistent with the two behaviors having separable neural bases. Approach. We compared PVC with the Overlap and Correlation methods using two stroke lesion-behavior datasets (n = 52 from Ding et al., 2020, connected speech measures of words per minute vs. proportion pronouns to nouns; n = 131 MRRI data from Pustina et al., 2018, WAB-AQ vs. Philadelphia Naming Test accuracy) across a range of LBM hyperparameters. Simulations based on the MRRI data compared the methods with known ground truth. Results. Across two real datasets and extensive simulations, PVC was the most accurate method (average sensitivity = 99% vs. 100% specificity) at determining same vs. different neural bases for behaviors, followed by the Overlap method (72% vs. 100%) and the Correlation Method (71% vs. 97%). PVC judgements were unaffected by LBM sparseness (number of voxels in each LBM), whereas the Overlap and Correlation methods were strongly affected. Conclusions. The goal of the PVC method is to help researchers decide if two behaviors have distinct neural bases. Without clear, validated decision rules, researchers may draw conclusions from numeric similarities/differences in voxel-level weights that are irrelevant to predicting behavior. With PVC, researchers can make stronger conclusions about the neural separability of behaviors. An open-source, GUI-driven app implementing PVC is available for download from our website: https://sites.google.com/site/ttschnur/researchprojects/predictive-validity-comparison-for-lesion-behavior-mapping.

Topic Areas: Methods, Disorders: Acquired

## Critical-Region Lesion-Symptom Mapping

***Poster C112*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Lesion-symptom mapping (LSM) continues to be an important tool for inferring the necessity of brain areas for healthy behavior and cognitive processes. LSM has seen rapid development of methodological tools for making structure-function inferences, moving from raw lesion overlap maps to mass univariate statistical tests to multivariate models of the relationship between brain damage and functional consequences. The introduction of machine learning tools like support vector regression (SVR-LSM; Zhang et al., 2014) has started to move the field toward a more predictive approach. We continued this trend by developing the critical-region lesion-symptom mapping (CRLSM) approach. CRLSM begins with a mass univariate region-of-interest analysis that uses permutation and bootstrap tests to identify candidate regions of an atlas (AICHA), followed by “brute force” combinatorial cross-validation to identify a set of regions that are linearly related to behavioral performance. Essentially, we divide the lesion volume into two parts: critical and non-critical volume. We compared the new approach against the SVR-LSM approach using real lesion data and both simulated and real behavioral data. For simulated data, we used the JHU atlas to form a ground truth based on 81 lesion masks, where a frontal region (15) and a posterior temporal region (186) were the target neural substrates. Behavioral scores were simulated by calculating the proportion of damage to the critical region and applying Gaussian noise. We attempted to recover the neural regions using the CRLSM and SVR-LSM approaches. We compared Dice overlap statistics. For real data, we compared maps of the WAB Fluency and WAB Comprehension subscores collected from 91 participants with left hemisphere stroke. We expected fluency to be associated with frontal regions and comprehension to be associated with posterior temporal regions. In the simulation, the target network included 25,904 voxels. CRLSM identified 26,120 voxels, recovering 12,817 target voxels, with approximately equal coverage of both regions (Dice overlap = 49.3%). SVR-LSM identified 16,238 voxels, recovering 9,756 target voxels, mostly concentrated in the posterior region (Dice overlap = 46.3%). While the CRLSM approach was less conservative, it paid off by identifying more of the non-contiguous network. Adjusting the SVR-LSM threshold to identify 26,120 voxels led to better results (Dice overlap = 53.3%) but required (typically unavailable) knowledge of the critical network size. In the real data, fluency was predicted by inferior precentral gyrus damage and comprehension was predicted by middle and superior temporal damage. The Fluency map accounted for 32% of the variance in Fluency scores (average prediction error = .98 on a 1-10 scale); the Comprehension map accounted for 43% of the variance in Comprehension scores (average prediction error = 1.75 on a 1-10 scale). More variance was explained by lesion volume in the SVR-LSM map (Fluency = 53% and Comprehension = 46%), but most of this map implicated white matter. Our preliminary investigations of the CRLSM approach were encouraging, with simulated recovery of non-contiguous cortical networks and converging results of real data analysis with previous results. CRLSM reduces modeler decisions based on neurobiological theory and elegantly handles volume confounds and parasitic associations.

Topic Areas: Methods, Disorders: Acquired

## Interpreting EEG Scalp Effects in the Presence of a CSF-Filled Cavity from Stroke or Neurosurgery

***Poster C113*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Electrophysiology plays a pivotal role in our understanding of cognitive and sensorimotor functions, including changes in these functions following brain damage. Importantly, in certain cases (e.g., stroke or neurosurgery), not only functional but also structural brain changes may affect aspects of the measured electrophysiological signals, impacting the inferences one can draw from them. Previous studies have found EEG amplitude and scalp topography differences between neurotypical and neurological/neurosurgical groups, being interpreted at the cognitive level. These changes that appear functional are invariably accompanied by anatomical changes that need careful consideration. Impressed neuronal currents in the brain only indirectly result in electric potentials, as measured over the scalp with EEG. Critical to the EEG signal are the so-called volume currents, which flow through the various tissues in the head. The spatial distribution of the different tissues will critically affect the path that the volume currents will take, and thus impact the EEG signal. In particular, it is critical to consider the effects of the redistribution of CSF, especially because for lesion-based studies, the sources of interest are often those close to the lesion. We investigated the effect of CSF-filled cavities on simulated EEG scalp data. We compared situations where we simulated the same active source(s), but using different volume conduction models, i.e. the anatomical models that govern the volume currents, using the finite element method. The reference model was created from an anatomical image of an undamaged brain.

To this reference model, we added realistic CSF-filled cavities, taken from empirical lesion (stroke) data, gradually increasing in size. We then simulated EEG scalp potentials for known sources by “injecting” the same known signal through those different volume conduction models. We used this approach for 1) a single source (akin to early sensory components) about 6mm (close) or about 35mm (far) from the CSF-lesion cavity and 2) for a scenario with a distributed configuration of sources (akin to a cognitive ERP effect, e.g., N400 component). Magnitude and topography errors between the reference model and the lesion models were quantified using the Magnitude Difference Measure (MAG%) and Relative Difference Measure (RDM%), respectively. For the simulations of a single source closer to the lesion, the size of the CSF-filled lesion modulated signal amplitude with more than 17% magnitude error, and topography with more than 9% topographical error, in a monotonic fashion. Negligible modulation was found for the single source far from the lesion. For the multi-source simulations of the cognitive component, the size of the CSF-filled lesion modulated signal amplitude with more than 6% magnitude error, and topography with more than 16% topography error in a non-monotonic fashion. In conclusion, the impact of a CSF-filled cavity cannot be neglected for scalp-level data, especially for multi-source configurations, which is what most cognitive neuroscientists would like to study and understand. Especially when group-level comparisons are made, given heterogeneity in lesion size and shape, any scalp-level attenuated, aberrant, or absent effects are difficult to interpret without considering the confounding effect of CSF.

Topic Areas: Methods, Disorders: Acquired

## Cellular and Circuit Mechanisms of Right-hemispheric Language Functions in Aphasia

***Poster C114*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Disease or injury to the brain's left-lateralized cortical language network can lead to severe behavioral impairment of language functions. While the majority of these patients are chronically impaired, sub-functions can reorganize in healthy brain areas and compensate for loss of brain tissue. The mechanisms allowing for such functional reorganization in aphasia, involving in particular right-hemispheric language-homotopic areas, are not well understood. Similar to the general lack of understanding regarding the role of individual neurons and cell assemblies in the language system, this knowledge gap is due to the limited temporal and spatial resolution of non-invasive recording methods that currently dominate language research. We hypothesize that following left-hemispheric damage, single neurons as well as local and long-range networks in right-hemispheric language-homotopic areas play a significant role in regaining language functions. In order to investigate this hypothesis and promote our understanding of the circuitry and plasticity of the language system, we chronically implanted a patient with aphasia with intracortical microelectrode arrays into the right-hemispheric supramarginal gyrus, angular gyrus, inferior and middle frontal gyri. Our recordings allow us to collect neuronal data with sub-millimeter and sub-millisecond precision previously unattainable in aphasia research. Recordings are performed several times a week, while the patient engages in high-intensity language training of words with varying linguistic complexity (e.g. word frequency, word length, phonological complexity, phonological neighborhood size) and semantic and syntactic categories. We study heavily impaired as well as better preserved language functions in production and comprehension of single words. With recordings spanning many months, we will be able to describe changes in the functional recruitment and response profiles of individual neurons and their networks as potential correlates of behavioral improvements (e.g. naming accuracies and reaction times). We present preliminary findings of single units showing task-related responses, specifically variations of spiking activity with respect to stimulus features (e.g. visual vs. auditory modality, syntactic properties, semantic category, and phonological similarity), task phase (e.g. delay vs. production), and brain region.

Topic Areas: Methods, Disorders: Acquired

## Stimulating the language network at the subject level: What has more effect - the brevity of Mark Twain or sweeping sentences by Charles Dickens?

***Poster C115*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To enhance the safety and efficacy of craniotomy in patients with lesions in language-eloquent brain regions, obtaining reliable, functional maps of the language network and ascertaining language lateralization beforehand is beneficial. However, functional magnetic resonance imaging (fMRI) examinations of language are time-consuming and strain both the cognitive resources of patients and the economic resources of the diagnostic institution. Therefore, we tested the efficiency of newly generated German stimuli to optimize measurement times. Twenty-one healthy subjects (M = 40 years, Min = 20 years, Max = 61 years, 14 women) were tested in a 3T MAGNETOM Prisma Fit. During functional measurement, subjects read 4-, 8-, and 12-word sentences and pseudoword lists or texts and pseudoword texts, each followed by a decision task. We sourced our sentences from the extensive collection of literature classics available in the Gutenberg Project library. We controlled stimuli for the number of words, word length, number of syllables, number of letters, type-token ratio, and number of lemmas. Measurement times per condition ranged from 12 minutes for 4-word sentences to 8 minutes for 12-word sentences and texts. First, we quantified brain activity using a region-of-interest analysis with subject-specific, functionally defined language-sensitive brain regions (Fedorenko et al., 2010). Subsequently, we employed t-tests on the individual level to examine the impact of sentence length and text coherence on the magnitude of activation. On the individual level, texts and sentences resulted in robust activations of cortical and subcortical language-sensitive regions, including the inferior frontal gyrus, posterior middle frontal gyrus, superior frontal gyrus, superior and middle temporal regions, angular gyrus, and the cerebellum, in line with previous observations (Fedorenko et al., 2010; Lipkin et al., 2022; Mahowald & Fedorenko, 2016). Within each subject, texts evoked significantly larger effect sizes compared to sentences. Increasing sentence lengths also led to increasing effect sizes, but not as consistent as the text condition in each individual participant. Long sentences and coherent texts have the potential to convey complex

meanings in a richer context compared to short sentences. They activated the language network more strongly and saved up to four minutes of measurement time compared to short 4-word sentences. The choice of stimulus makes it possible to reduce the fMRI scan time by a third without losing signal. As efficiency and personalization continue to improve, integrating fMRI examinations into preoperative neuroradiological diagnostics is expected to become more frequent in the future and thus facilitate tailored therapies and enhance patient outcomes. References: Fedorenko, E. et al. (2010). New Method for fMRI Investigations of Language: Defining ROIs Functionally in Individual Subjects. Journal of Neurophysiology, 104(2), 1177–1194. Lipkin, B. et al. (2022). Probabilistic atlas for the language network based on precision fMRI data from >800 individuals. Scientific Data, 9(1), 529. Mahowald, K., & Fedorenko, E. (2016). Reliable individual-level neural markers of high-level language processing: A necessary precursor for relating neural variability to behavioral and genetic variability. NeuroImage, 139, 74–93.

Topic Areas: Methods, Disorders: Acquired

## The atypical lateralization of language during a reading task is manifested in IFG and STG, but not in the fusiform gyrus

***Poster C116*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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INTRODUCTION: Studies have consistently reported a strong hemispheric left-lateralization of language, but also that some healthy participants (mostly left-handed) present atypical lateralization of language in the right hemisphere. Lateralization of language is often determined based on the activation in the inferior cortex using verb generation or verbal fluency tasks. However, language consists of multiple cognitive processes like reading, auditory processing, or comprehension, which rely on different functional networks. Here, we employed a simple reading task to investigate the lateralization of language processing in left-handed participants with typical and atypical lateralization of language. Our hypothesis is that individuals with atypical lateralization of language will activate more the reading network in the right hemisphere. METHOD: Ninety-eight left-handed participants were included in this study (53 females, mean age = 23.41 sd = ± 4.68; mean EHI (Edinburgh Handedness Inventory) = 42.34 sd = ±5.25). The laterality of participants was calculated using the verb generation task (Villar-Rodriguez et al., 2020) with the bootstrap method implemented in the LI-toolbox for SPM12 (Wilke & Lidzba, 2007). We categorized our participants as typical (LI > 40) and atypical (LI < 40) based on the activity in the inferior frontal gyrus. No between-group differences were observed in age, sex or EHI. During the reading task, we employed a block design in which participants were asked to read aloud the words presented on the screen (task condition) or say the word “casa” when they saw the "#" symbol (control condition). We determined whole-brain differences in BOLD signal during reading task between typical and atypical groups (voxel-wise $p < 0.001$; FWE-corrected at $p < 0.05$). RESULTS: Whole-brain one-sample t-tests (voxel-wise $p< 0.001$; FWE cluster-corrected at $p< 0.05$) for typical and atypical participants revealed significant task activations in the Inferior Frontal Gyrus (IFG), Superior Temporal Gyrus (STG), anterior cingulate/SMA and VWFA. The typical > atypical comparison revealed that individuals with a typical lateralization for language showed increased the activation in the left supramarginal gyrus (x=-54 y=-28 z=26; ZE=4.25). The reversed

comparison revealed that the atypical group more showed more activation in the right inferior frontal gyrus (x=54 y=17 z=20; ZE= 4.39) compare to the typical group. There were no significant between-group differences in VWFA activation. CONCLUSION: Our results showed a mirrored pattern of activation in the inferior gyrus in participants with atypical dominance for language Also, the typical group had more activation in the left supramarginal gyrus compared to the atypical group. Importantly, our results revealed no between-groups differences in VWFA activation during word reading. Recent studies have shown an association between the development of an atypical lateralization of language and the development of the corpus callosum. Our results are consistent with this view showing mirrored changes only in areas dependent on this tract.

Topic Areas: Reading, Language Production

## The impact of mirative markers on reaction to unexpected words during sentence reading

***Poster C117*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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During sentence processing, unexpected words typically evoke neural and behavioral responses, such as longer reading times, compared to expected words. Mirative markers, e.g., “surprisingly”, are elements which linguistically encode a violation of expectation, and can be used for expectation-management during discourse (Delancey, 1997). The present study examined the modulatory effect of mirative markers on the response to semantically unexpected words presented in sentential context. 60 native-Hebrew speakers (48F:12M, 18 to 34 years old) with no diagnosed ADHD or dyslexia read 160 Hebrew sentences, in a self-paced reading paradigm. Participants controlled word-by-word presentation with button presses, and their reaction time to each word was recorded. We manipulated, in a 2X2 design, the presence of a mirative marker in the beginning of the sentence, and the semantic expectedness of a target word that appeared downstream. Specifically, sentences in the Mirative condition began with “I was surprised that”, while sentences in the Neutral condition began with “I saw that” (in Hebrew these terms both consist of a single word, 3 syllables long). Sentences were all of SVO form. The target word appeared in the 6th or 7th position in the sentence, and was followed by 3 more words until sentence termination, to avoid wrap up effects. Target words were matched for mean length between conditions. Sentences were chosen using a pre-test questionnaire with 20 respondents (none of whom participated in the study), who rated the expectedness of the target word in a 1-7 Likert scale. In the self-paced reading experiment, 20% of the sentences were followed by a 2-alternative forced-choice question in order to ensure participant comprehension. A linear mixed-effects model was fit to predict the log-transformed reaction time at target words, with fixed effects of expectedness and mirativity, random intercepts and slopes per participant and per sentence, and target word frequency and sentence number as control covariates. We found a significant interaction between expectedness and mirativity (beta=-0.05, se=0.02, $p<0.01$), such that the presence of a mirative marker decreased the RT for unexpected target words and increased RT for expected target words. Within the Neutral condition, but not within the Mirative condition, we found a significant simple effect of unexpectedness (beta=0.04, se=0.01, $p<0.001$).

Additionally, we found a significant main effect of unexpectedness at the word following the target (“spillover effect”) (beta=0.03, se=0.01, $p < 0.01$). We conclude that mirative markers prepare readers for an upcoming surprise, thereby modifying their expectations and leading to a reduction in their surprise-like responses to later events. This may be achieved by reducing the prediction error which an unexpected word usually elicits, thus lowering the processing cost. However, such a benefit may be limited in time, as evidenced by the longer RT for unexpected words in the "spillover" zone, even when the sentence was introduced by a mirative marker. Future planned studies will further examine the dynamics of expectation management and investigate the neural effects of mirative markers.

Topic Areas: Reading, Meaning: Discourse and Pragmatics

## Interactive and additive effects of word frequency and predictability: A fixation-related fMRI study

***Poster C118*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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It has been argued that the effects of word frequency and predictability are informative with regard to bottom-up and top-down mechanisms during reading. Word frequency is assumed to index bottom-up, whereas word predictability is assumed to index top-down information. However, findings regarding potential interactive effects are inconclusive. An interactive effect would suggest an early lexical locus of contextual top-down mechanisms where both variables are processed concurrently in early stages of word recognition. This would be in line with contemporary neurocognitive theories suggesting early interactions of higher and lower cortical regions influenced by bottom-up and top-down information. An additive effect, to the contrary, would suggest that the processing of contextual top-down influences only occurs post-lexically. We evaluated potential interactions between word frequency and predictability during silent reading by means of functional magnetic resonance imaging and simultaneous eye-tracking in 24 participants (10 male). As opposed to modeling the haemodynamic response in relation to singly presented words, we utilized participants’ first fixation events whilst they read whole sentences for comprehension (i.e., fixation-related fMRI). The eye movement analysis revealed exclusively additive effects. However, our neuroimaging results indicated both additive, as well as interactive effects. Specifically, we observed additive effects in higher-language regions, i.e., in left inferior frontal regions, whereas interactive effects were situated in cortically lower regions, i.e., the left occipito-temporal cortex. Our findings suggest that word frequency and predictability are processed concurrently during lexical processing. In other words, top-down information influences visual word recognition at the stage of lexical retrieval. Especially, the interaction in the left occipito-temporal cortex goes in line with the notion that reading entails a predictive component serving language comprehension.

Topic Areas: Reading, Meaning: Lexical Semantics

## Individual word representations dissociate from linguistic context along a cortical unimodal to heteromodal gradient

***Poster C119*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language comprehension involves multiple hierarchical processing stages across time, space, and levels of representation. When processing a word, the sensory input is transformed into increasingly abstract representations that are integrated with the linguistic context. While neuroimaging research has traditionally focused on mapping individual brain regions to the underlying subprocesses, recent studies suggest that whole-brain distributed patterns of cortical activation might be highly relevant for efficient cognition. Specifically, recent theories propose that the sensory- and memory-dependent processes underlying language comprehension are structured along a principal cortical gradient from unimodal to heteromodal brain regions. We investigated the gradient's role in sentence reading, using multiple linear regression on open functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) recordings from 102 participants. We found that the gradient is recruited differentially for the processing of individual word representations (visual, orthographic, and lexical) in contrast to properties reflecting a word's relation to its linguistic context (semantic similarity and position within the sentence): Word representations gradually involved the unimodal end to a stronger extent, while contextual representations gradually increased towards the heteromodal end of the gradient. Individual word representations showed opposite effect directions on brain activation in fMRI and MEG, for example, reduced brain activation for more vs. less frequent words in fMRI, and the reverse pattern in MEG. Nevertheless, the association of individual word representations with the unimodal end of the gradient was consistent across both neuroimaging modalities. MEG revealed that the observed distinction along the gradient persisted through time, suggesting parallel processing across word representation levels and context. Our findings indicate the gradient captures the neural organization of language by providing a gradual dissociation between word vs. contextual representations. Furthermore, the gradient reveals convergent patterns across neuroimaging modalities (similar location along the gradient) in the presence of divergent responses (opposite effect directions).

Topic Areas: Reading, Meaning: Lexical Semantics

## Left fusiform activity explains variability in fixation durations during natural reading: Evidence from co-registered MEG & eye-tracking

***Poster C120*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Eye movements during reading are influenced by the linguistic and cognitive demands of what is being read, indicating that brain networks controlling eye movements, and those controlling the recognition of words, must cooperate. Historically, however, neuroscientific studies of reading have tended to use rapid serial visual presentation (RSVP), thereby eliminating eye movements. This has resulted in a paucity of evidence concerning how brain activity gives rise to eye movement behavior during reading, and makes it unclear if neurocognitive accounts of reading, informed by RSVP studies, generalize to the behavior of interest. Here, we used co-registered MEG and eye-tracking to examine the brain systems that support visual

word recognition while participants freely read short stories with eye movements, with a focus on identifying brain responses that explained fixation durations. Methods: Thirty-two participants naturally read 216 short stories, each consisting of two sentences, while concurrent MEG and eye-tracking data were collected. Stories were annotated with the properties of each word (e.g., letter bigram frequency, lexical frequency, surprisal), enabling us to identify brain responses, time-locked to fixations, that were modulated by these properties. Responses were analyzed using linear deconvolution to disentangle overlapping activity and localized to the cortical surface using minimum norm estimation with high resolution anatomical MRIs. Linear mixed effects models and nested model comparisons were used to identify neural responses that correlated with each property of the fixated words and to identify brain responses that explained variability in the duration of fixations before they terminated, beyond what could be explained by psycholinguistic properties of the words alone. Finally, in a follow-up study, a separate sample of participants read the same short stories presented one-word-at-a-time in RSVP, allowing us to compare the influence of word properties on brain responses across the two reading modalities. Results: We first replicated past results demonstrating that a progression of left occipitotemporal activity supports visual word recognition. We then examined where in this progression each of the properties of fixated words modulated responses. During natural reading, word length correlated with activity in primary visual cortex bilaterally (50-200 ms) while lexical frequency correlated with activity in the left fusiform gyrus (100-170 ms after fixation onset). In contrast, letter bigram frequency and lexical surprisal did not correlate with responses in the ventral visual word pathway. We next extracted responses from occipitotemporal areas and asked if activity at these stages correlated with how long the eyes lingered on the currently fixated word – possibly indicating that word processing at this stage influences oculomotor control. Consistent with the proposal that it houses a bottleneck on visual word recognition, only the left fusiform gyrus showed this pattern, with longer fixations associated with more negative amplitudes, 75-105 ms after fixation onset. Finally, a comparison of natural reading versus RSVP revealed a stark contrast in how word frequency and surprisal correlated with brain activity across the two paradigms, with widespread correlations between these properties and brain activity observed only in the slower, one-word-at-a-time RSVP reading.

Topic Areas: Reading, Meaning: Lexical Semantics

## Planned Work – Are attentional and/or language networks causally involved in native English speakers' bias to represent action sentences congruently with English's reading direction (left-to-right)?

***Poster C121*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Early research suggested that humans have a universal preference for left-to-right (LTR) spatial exploration and information processing due to hemispheric specialisation (Beaumont, 1985). Later studies supported this theory by showing attentional LTR bias in a variety of spatial tasks (e.g., Ossandón et al., 2014). The attentional LTR bias was also seen in psycholinguistics research, specifically in the processing of action sentences, where speakers of languages with an LTR reading direction processed the sentences faster when the agent was on the left and the object on the right (Chatterjee et al., 1999). However, the universality of this attentional LTR bias was challenged by cross-linguistic studies involving speakers with a right-to-left (RTL) reading direction, who were found to process faster action sentences with the agent on the right (i.e., implying an RTL direction) (Maass & Russo, 2003; Dobel et al., 2007). Suitner and Maass (2016) and Chatterjee (2010) proposed two hypotheses to explain these findings. Both theories maintain that the universal attentional LTR bias influences language processing and that the bias can be influenced by repeated experiences that strengthen (for LTR readers) or weaken (for RTL readers). Suitner and Maass (2016) claim that the attentional network of the brain drives this LTR language bias, whereas Chatterjee (2010) argues that the language network is involved in its formation. Neither theory, however, predicts or addresses the specific brain areas involved in and affected by universal attentional bias. Determining whether the LTR language bias contributes to effective language comprehension and whether it is causally related to attentional and/or language networks could have clinical implications for treating language processing difficulties. In our proposed study, we intend to test these two theories and answer the questions: is visuospatial attention driving the LTR language bias? (Suitner and Maass, 2016), and is the reading network critical for the LTR language bias? (Chatterjee, 2010). To that end, we will employ a standardized complex sentence-picture verification task and use eye-tracking and transcranial magnetic stimulation (TMS) to temporarily interfere with brain processing. We plan to stimulate the following brain networks: 1) Attentional network areas (e.g., the posterior parietal cortex) that were demonstrated to be critical for directing attention during visual processing of written language (Turker & Hartwigsen, 2021; Leff et al., 2001), as well as in various visuospatial and scanning tasks (Pourtois et al., 2001; Muggleton et al., 2006). 2) Language network areas (e.g., ventral anterior temporal lobe) that were proposed to be involved in action semantics processing (Quandt et al., 2017), and thus are likely to play a role in the formation of directional asymmetry as part of action semantics processing. We hypothesise that TMS stimulation of the attentional network will affect scanning patterns (i.e., attentional LTR bias) and total reaction times, whereas stimulation of the reading network will result in slower responses when the agent is on the left (i.e., weaken the LRT language bias) due to disruption of appropriate semantic integration. We do not anticipate either network stimulation having a significant effect on task accuracy rates.

Topic Areas: Reading, Meaning: Lexical Semantics

## Do readers pre-activate phonology when reading for comprehension?

***Poster C122*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Making predictions about upcoming input is an essential part of language processing. Previous research has shown that highly predictable words and those associated in meaning are much easier to recognise due to the pre-activation of semantic category features (e.g., Federmeier & Kutas, 1999; Metusalem et al., 2012). However, the extent to which form features are pre-activated is still debated (e.g., Ito et al., 2016). The current experiment investigated whether readers also predictions based on phonological features in a sentence reading-for-comprehension task. We recorded the EEG of 22 skilled readers of English while they saw 224 high-cloze (>79%) probability sentences (e.g., “Pete broke his arm and had to wear a ...”) one word at the time at the centre of the computer screen. The sentence endings were manipulated across four conditions: 1.

Congruent (cast), 2. Semantically incongruent (wall), 3. Pseudohomophonic non-word (kast), and 4. Orthographic control non-word (yast). Low-cloze (<30%) probability congruent filler sentences were included, so only 30% of the items contained a pseudoword. Participants were asked to answer a comprehension question after each sentence. Mass univariate time-course analysis showed a widely distributed larger negativity for the semantically incongruent (wall) than the congruent (cast) word endings between 300 and 600 ms post-target onset. This finding shows pre-activation of semantic features. Our analyses also showed a larger negativity for the pseudohomophone (kast) than for the congruent ending, but only between 330 and 430 ms post-target onset, and in a small number of left hemisphere electrodes. In contrast, the orthographic control non-word (yast) was more negative than the congruent ending (cast) from 240 to 480 ms in most centro-parietal electrodes bilaterally. The larger N400 effects for both the pseudohomophone and the orthographic control conditions indicate that readers can accurately detect dissimilarities in form between the predicted and the presented items via bottom-up word recognition. However, the differences in the latency and scalp distribution of both effects show that pre-activation of phonological features modulates this bottom-up process in order to facilitate sentence comprehension. Moreover, the pseudohomophone condition showed a stronger post-N400 LPC than the orthographic control condition, indicative of monitoring and re-analysis. The semantically incongruent condition however did not show an LPC. Our findings demonstrate that skilled readers preactivate phonology in a reading task that does not require an explicit judgement on formal features of words. Our effects are congruent with the facilitation previously reported for non-words that were orthographically similar to predictable words (Laszlo & Federmeier, 2009; Kim & Lai, 2012), thus suggesting that skilled readers may preactivate specific lexical items during reading highly predictable sentences for comprehension (see Ito et al., 2016, for a different view). Finally, although readers can detect that the pseudohomophone differs from the expected word, they engage in further re-analysis, perhaps treating the pseudohomophone--but not the orthographic control--as a misspelling (LPC pseudohomophone effect).

Topic Areas: Reading, Meaning: Lexical Semantics

## Quantification of reading circuits in the ventral occipitotemporal cortex

***Poster C123*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Successful reading requires neural processing and communication between different regions of the brain. There is substantial evidence that one of the regions necessary for reading is located in the ventral occipitotemporal cortex (vOTC). This region was first functionally identified and denominated visual word form area (VWFA). Recent evidence from our group combining functional, structural, and quantitative MRI has shown that the VWFA can be segregated into at least two sub-regions: one involved in visual feature extraction in the posterior occipitotemporal sulcus (pOTS), and one implicated in integrating with the language network in the middle occipitotemporal sulcus (mOTS). However, due to the heterogeneity of functional localizers used across studies, it is difficult to know if the same cortical region is being analyzed and if the results of the analyses are comparable or not. This is of critical importance to be able to compare the same regions across neurobiology of reading experiments. The aim of the present work was to develop a multimodal vOTC word recognition localizer, replicable across different labs and studies. Our experiment consisted of a dense sampled (10 times, 10 subjects) cohort, scanned in a Siemens 3T Magnetom PrismaFit scanner with a 64-channel head coil. Participants underwent four different functional MRI scans: (i) mOTS and pOTS localizer; (ii) Adapted fLoc functional localizer; (iii) Classical 8-bar retinotopic analyses, with checkers, words, and false fonts revealed inside the bars (2 repetitions each); (iv) Adapted retinotopy analyses based on preliminary results. After performing these four fMRI tasks, participants were administered quantitative MRI (qMRI), and diffusion-tensor-imaging (DWI) scans, as well as T1- and T2-weighted structural images. Results revealed at the individual subject level that combined multimodal MRI measurement can reliably segregate the vOTC reading circuits into two functional subregions, across different sessions. Furthermore, we developed a shorter acquisition sequence to identify vOTC reading circuits that will be made available to the scientific community. Moreover, preliminary results using machine learning techniques showed that the same regions can be localized maintaining around ¾-s of the intra-subject variability. In sum, here we propose a new protocol to harmonize inter-lab and inter-experimental visual word recognition and reading studies, which is critical to advance our understanding of the role of the vOTC in neurobiology of reading.

Topic Areas: Reading, Methods

## How do we read complex words? A neurocognitive morphology priming study.

***Poster C124*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Reading involves quickly and accurately recognizing long and complex words, such as inter+nation+al+ly. Past research has shown that morphology is an efficient facilitator of recognizing polysyllabic words (Gold & Rastle, 2007). Yet, prior research has been limited to visual stimuli. To understand reading development, it is important to investigate the role of auditory processing that precedes and predicts reading acquisition. The present study offers a systematic inquiry into the audio-visual priming effects of morphology, phonology, and semantics in polysyllabic word reading using functional Near Infrared Spectroscopy (fNIRS). The purpose of the study was to uncover the neurocognitive bases of audio-visual lexical priming and to develop child-friendly protocols that can be used to study literacy development and dyslexia. Fifteen native English-speaking adults with normative reading abilities (U.S.A.; Mage = 21.35, SDage = 3.22) completed an audio-visual lexical priming task. As a preliminary step to developmental research, all stimuli held an early age of acquisition. The experiment used an event-related design: Participants first heard an auditory prime (1200ms), followed by a visual word presentation (2300ms; ISI = 100ms). Participants decided if the visual word was a real word or a nonword (e.g., valley-bleb) and had 2500ms to respond. The three experimental conditions were phonology (e.g., spinach-spin), morphology (e.g., teacher-teach), and semantic (e.g., garbage-trash), with a control condition of unrelated targets (e.g., rotate-coast). fNIRS data were collected and analyzed using General Linear Modeling. All participants completed the task with high accuracy, M = 97.71%, SD = 1.79%. Reaction times indicated that the morphology condition had the strongest priming effect, (M = 631ms, SD = 143ms) followed

by phonological priming (M = 693ms, SD = 158ms) and semantic priming (M = 704ms, SD = 143ms). Neuroimaging findings supported existing models of word processing, with MTG response suppression for semantics and STG for phonology. Morphology led to reduced activation in the left IFG, left MTG, right STG, and right IFG relative to control, $p < .05$. Comparing morphology to semantics further revealed reduced activation in the left IFG, right STG, and right IFG, $p < .05$. Comparing morphology to phonology, participants showed activation in the left IFG and right IFG, and a reduction in activation in the left STG, $p < .05$. These findings demonstrate how morphology produces salient priming effects through suppression of the hemodynamic response in the perisylvian brain regions. Our investigation of audio-visual priming effects revealed patterns of results that were generally consistent with those previously obtained for the visual-only lexical priming tasks. The target condition of interest, morphology, in light of its critical facilitative effects in complex word reading, yielded significant priming effects by eliciting the quickest response time (relative to both semantics and phonology) as well as combined activation throughout the perisylvian language regions. The findings inform theories of word processing as well as highlight the importance of morphological competences in word reading and its explicit formal instruction for both emerging readers as well as English second language learners.

Topic Areas: Reading, Morphology

## ERP evidence for the role of morphology in word recognition by deaf and hearing readers

***Poster C125*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Phonological awareness is a strong predictor of reading ability in hearing individuals, but phonological information is not as easily accessible for deaf people. Morphology, which takes advantage of spelling to meaning connections, provides an alternative route to reading which deaf readers may prioritize. Grainger and Ziegler (2011)'s dual-route model of orthographic processing describes a morpho-semantic route in which coarse-grained, whole-word recognition allows for fast access to semantic information, and a morpho-orthographic route through which complex words can be broken down into their component parts. The event-related potentials (ERP) visual masked priming paradigm is sensitive to both routes of processing, with graded effects of priming for morphologically complex prime-target pairs (hunter-HUNT), pseudo-complex pairs (corner-CORN), and simplex pairs that were orthographically, but not semantically related (scandal-SCAN) (Morris, 2007). In the current study, we adopted this paradigm to investigate how deaf readers utilize morphological processes while reading different types of primes. Deaf and hearing participants completed a go-no-go lexical decision task while viewing prime-target pairs in which the prime was preceded and followed by a visual mask. If deaf readers rely more on morphology than hearing readers, they may exhibit greater morphological priming, indicated by greater reductions in the N250 ERP component (orthographic processing) and the N400 component in related vs. unrelated trials. In line with the results of Morris et al. (2007), complex primes (hunter-HUNT) elicited the strongest priming effects across both groups in the N400 window with smaller but statistically significant priming effects seen for the pseudo-complex and simplex pairs.

Comparisons between the groups revealed that for both complex and pseudo-complex items hearing readers produced larger N250 and N400 priming effects than deaf readers. There were no group differences for either component in the simplex condition. The hearing readers demonstrated the typical central-anterior N250 priming effect between 200 and 300 ms and a more central-posterior N400 priming effect between 300 and 500 ms for both complex and pseudo-complex pairs, suggesting that they engaged in an initial morphological decomposition process (N250) when presented with either a complex (e.g., “hunter”) or pseudo-complex primes (e.g., “corner”). Deaf readers, on the other hand, produced a more central-posterior pattern in the N250 window which is more suggestive of an early N400 effect as opposed to a typical N250. They also continued to produce a similarly distributed N400 effect in the 300-500 ms window for complex and pseudo-complex pairs. The more posterior N250 and following N400 pattern is in line with the hypothesis that deaf readers rely more on a whole-word, morpho-semantic based processing route, such that they process pseudo-complex primes like “corner” as whole words, and do not decompose them into the apparent morphological components. (Morris, J., Frank, T., Grainger, J., & Holcomb, P. J. (2007). Semantic transparency and masked morphological priming: An ERP investigation. Psychophysiology, 44(4), 506-521.)

Topic Areas: Reading, Morphology

## How learning to read Braille in visual and tactile domains reorganizes the sighted brain

***Poster C126*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Braille reading leverages cross-modal plasticity, emphasizing the brain's ability to reallocate functions across sensory domains. This plasticity engages motor and sensory areas and reaches language and cognitive centers. Specifically, in Braille-reading blind individuals, the visual cortex activates during tactile stimulation. Additionally, regions traditionally involved in visual reading, like the visual word form area (VWFA), activate during Braille reading. Despite these insights, our understanding of cross-modal plasticity requires further exploration. No study has used a complex reading task to monitor neural activity shifts during the first three months of Braille training. Since neuroplasticity can occur within days, understanding neural reorganization during early Braille learning stages is critical. Moreover, activation patterns have not been assessed in both visual and tactile domains using comparable tasks. Furthermore, implicit reading has yet to be studied in tactile Braille. These gaps underscore the need for a more in-depth examination of neural reorganization patterns during the early stages of Braille learning. Our study involved 17 people who learned Braille for 7 months and 18 passive controls. The experimental group participated in 7 sessions (1 week before the course, on the first day of the course, after 1 week of learning, after 6 weeks, after 3 months, after 7 months, and after a 3-month-long hiatus from learning). The controls were invited for 6 sessions. To go through all of the materials designed for the course, the participants had to spend at least 52.5 hours of self-practicing.

Participants' Braille proficiency peaked after 7 months of learning at an average of 14.4 words in the visual domain and 6.8 in the tactile domain, emphasizing tactile modality's complexity. Using the Lexical Decision Task (LDT) in an fMRI scanner, we observed increased activity within the reading network regions, including the inferior frontal and supramarginal gyri, 1 week into learning in tactile and visual LDT. Interestingly, VWFA activation - considered an indicator of cross-modal plasticity - was not detected until six weeks into the course, suggesting that proficiency in tactile reading influences the onset of cross-modal plasticity. It is worth noting that once this activation was achieved, the peak level of VWFA engagement remained stable, even after a three-month hiatus in learning. Furthermore, implementing an implicit reading task (6-dots detection task) revealed increased neural activity within the reading network, including the VWFA, among participants learning Braille compared to their passive control counterparts. This provides novel insights into the effects of implicit reading on neural activity during tactile Braille learning. Our study explores the temporal dynamics of cross-modal plasticity during early Braille learning and shows that the VWFA activity peak occurs faster in the visual domain compared to the tactile domain. It also showed sighted subjects' ability to process Braille implicitly. These results enrich our understanding of neural adaptation mechanisms during learning. Furthermore, they underline the potential utility of employing different types of reading tasks (explicit and implicit) in future studies to provide a more comprehensive understanding of neural reorganization in processes involved in learning tactile Braille.

Topic Areas: Reading, Multisensory or Sensorimotor Integration

## Cross-modal transposed letter priming effects are evidence for the bimodal processing of words

***Poster C127*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The processing of orthographic information is dependent on the orthographic depth of the writing system, leading to cross-linguistic differences in reading and reading-related behaviors (e.g., Goswami, 2010; Landerl et al., 1997; Rau et al., 2015; Ziegler & Goswami, 2005). Moreover, a recent line of studies found that the processing of spoken words does not only involve phonological, but also orthographic information, and can thus be classified as a bimodal process (e.g., Chéraux et al., 2007; Perre et al., 2009; Perre & Ziegler, 2008; Ziegler & Ferrand, 1998). A paradigm that has been widely used to study orthographic processing is transposed letter (TL) priming. TL non-words constructed by exchanging the positions of two letters within a word (e.g., jugde – judge) have been found to prime their base words better than orthographic controls (e.g., jupte – judge) (e.g., Perea & Carreiras, 2006; Perea & Lupker, 2004). TL effects have been replicated for different languages, different scripts as well as L1 and L2 speakers and are taken as evidence for flexible letter position coding during visual word recognition (e.g., Meade et al., 2022; Perea et al., 2011). In accordance with the Bimodal Interactive Activation Model (Grainger & Ferrand, 1994, 1996), we argue that if word processing is bimodal in nature, we should be able to use a visual TL prime to prime an auditory target word. Because orthographic processing is dependent upon the orthographic depth, we might observe processing differences between English, a deep orthography, and German, a shallow orthography. Here, we present an EEG study, in which for the first time we used cross-modal transposed letter (TL) priming with a visual prime and an auditory target to investigate the bimodal processing of words in English and German. We tested late German-English bilinguals in their L1 and their L2 and presented cognate words in three conditions: a TL condition (e.g., GADREN – [gɑɹdən]), an identical condition (e.g., GARDEN - [gɑɹdən]) and an orthographic control condition (e.g., GABPEN - [gɑɹdən]). ERP results showed that for both languages, TL priming led to significantly reduced amplitudes compared to an orthographic control condition, but this effect emerged around 150 to 200 ms for the English group at fronto-central electrode sites and at around 300 to 400 ms for the German group at parietal electrode sites. Thus, orthographic effects influenced processing at an earlier point in time in English compared to German and showed a different topographic distribution. Effects in both languages were accompanied by higher inter-trial phase coherence in the gamma range. Our study is the first to show TL priming effects in a cross-modal paradigm which confirms bimodal activation of word representations during spoken word processing in English and German. Moreover, our results indicate that the neuronal mechanisms involved in bimodal processing of orthography and phonology differ in their temporal and topographical characteristics between the two languages. We conclude that the activation of orthographic information during spoken word recognition affects English, a deep orthography, at an earlier level of processing than German, a shallow orthography.

Topic Areas: Reading, Phonology

## Inter- and Intra- Hemispheric Interactions in Reading Ambiguous Words

***Poster C128*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The present study investigates the functional connectivity between language regions in the two hemispheres, while processing written words with multiple meanings. Previous studies suggest that processing ambiguous words relies more heavily on the right hemisphere, and therefore on inter-hemispheric interactions, compared to processing unambiguous words. However, we suggest that this depends of the type of ambiguity. Specifically, we compared unambiguous words to two types of ambiguous words: homophonic homographs, in which a single orthographic representation is mapped into a single phonological representation with multiple meanings (e.g., 'bank'); and heterophonic homographs, in which a single orthographic representation is mapped into different phonological representations with different meanings (e.g., 'tear'). The later are very frequent in Hebrew orthography, in which many of the vowel are not represented in the script. We used effective connectivity analysis via Dynamic Causal Modeling (DCM) on previously published fMRI data (Bitan et al., Neuropsychology, 2017), to study inter- and intra- hemispheric connectivity among three bilateral regions. Two bilateral regions in the inferior frontal gyrus (i.e. pars opercularis and pars orbitalis) typically associated with phonological and semantic processing, respectively, and bilateral visual word form areas, known to be involved in orthographic processing. Our results for unambiguous words showed positive inter-hemispheric connections between the left and right frontal regions, which speaks against the hypothesis of transcallosal suppression during language processing. However, they show evidence of hemispheric competition at the level of orthographic processing. We also found direct connections from the VWFA to the left orbitalis, consistent with connectionist reading models suggesting direct orthographic to semantic activation. For heterophonic homographs, we observed increased top-down connectivity from the left opercularis to the VWFA within the left hemisphere, highlighting the importance of re-activation of orthographic representations by phonological ones for considering alternative meanings. Finally, processing of homophonic homographs, more than other words, relies on inter-hemispheric connectivity, which differentially affects the activation of the dominant and subordinate meanings. These findings provide novel insights into the different interactions among regions in the two hemispheres during the processing of ambiguous and unambiguous words.

Topic Areas: Reading, Phonology

## Investigating the neural underpinnings of reading enjoyment

***Poster C129*** *in Poster Session C, Wednesday, October 25, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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While prior neuroimaging investigations have shed light on the neural circuits implicated in various aspects of reading (such as decoding and the integration of print with semantic meaning), a knowledge gap persists regarding the specific brain regions engaged when we enjoy reading. We hypothesised that reading for pleasure would be associated with increased functional activity in striatal regions associated with reward processing. In the scanner, we presented neurotypical adults (N= 30, 16 females) with 40 book extracts, using the Becker-deGroot-Marshak paradigm. Each extract was presented for 40 seconds. Participants could place bids to buy the books presented (£0, 0.33p, 0.66p, £1). Bids placed were used to establish the desirability of each book (i.e., a bid of £1 indicated a book was highly desirable). We plan to conduct a whole-brain analysis comparing haemodynamic activity for desirable extracts relative to non-desirable extracts and more ROI analyses focusing on the dorsal and ventral striatum. The outcomes of this study will allow us to understand the underlying mechanisms of reading enjoyment in neurotypical adults. This will provide a framework and design to understand these mechanisms in other populations, for example, with poor readers.

Topic Areas: Reading,


# Poster Session D

## Neuromodulatory Effects of Transcranial Magnetic Stimulation on Language Performance in Healthy Participants: Systematic Review and Meta-Analysis

***Poster D1** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: The causal relationships between neural substrates and human language have been investigated by a promising non-invasive technique—transcranial magnetic stimulation (TMS). However, the robustness of TMS neuromodulatory effects on language performance in healthy participants is still largely unspecified. This study aims to systematically examine the efficacy of TMS on healthy participants' language performance. Methods: For this meta-analysis, we searched PubMed, Web of Science, PsycINFO, Scopus, and Google Scholar from database inception until October 15th, 2022 for eligible TMS studies on language comprehension and production in healthy adults published in English. The quality of the included studies was assessed with the Cochrane risk of bias tool. Potential publication biases were assessed by funnel plots and the Egger Test. We conducted overall as well as moderator meta-analyses. Effect sizes were estimated using Hedges'g (g) and entered into a three-level random effects model. Results: Thirty-seven studies (797 participants) with 77 effect sizes were included. The three-level random effects model revealed significant overall TMS effects on language performance in healthy participants (RT: $g = 0.16$, 95% CI: 0.04-0.29; ACC: $g = 0.14$, 95% CI: 0.04-0.24). Further moderator analyses indicated that (a) for language tasks, TMS induced significant neuromodulatory effects on semantic and phonological tasks, but didn't show significance for syntactic tasks; (b) for cortical targets, TMS effects were not significant in left frontal, temporal or parietal regions, but were marginally significant in the inferior frontal gyrus in a more fine-grained analysis; (c) for stimulation parameters, stimulation sites extracted from previous studies, rTMS, and intensities calibrated to the individual resting motor threshold are more prone to induce robust TMS effects. As for stimulation frequencies and timing, both high and low frequencies, online and offline stimulation elicited significant effects; (d) for experimental designs, studies adopting sham TMS or no TMS as the control condition and

within-subject design obtained more significant effects. Summary: Overall, the results show that TMS may robustly modulate healthy adults' language performance and scrutinize the brain-and-language relation in a profound fashion. The findings serve to (a) clarify the efficacy of TMS effects on healthy participants' language performance, including both comprehension and production abilities; (b) enrich the results found by previous TMS meta-analyses on aphasics; (c) inform future TMS studies in the neurolinguistic field with respect to optimized designs and parameters. However, due to limited sample size and constraints in the current meta-analysis approach, analyses at a more comprehensive level were not conducted and the results need to be confirmed by future studies.

Topic Areas: Language Production, Methods

## Electrophysiological properties of the comprehensive language paradigm (CLaP)

***Poster D2*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Studies investigating language commonly isolate a single language modality or process, focusing on either comprehension or production. We aim to combine both in the new Concise Language Paradigm (CLaP), tapping into processes of comprehension and production within each trial. Word retrieval has been studied with context-driven picture naming in which participants listen to an incomplete sentence that is followed by a picture that concludes the sentence; the sentence preceding the picture is either constrained or unconstrained. In CLaP we added experimental conditions of auditory time-reversed sentences and scrambled pictures, the latter created by diffeomorphic transformation, making them unrecognizable without changing basic visual properties. The trial structure is identical across conditions, presenting an auditory stimulus (constrained, unconstrained, or reversed sentences) followed by a visual stimulus that is to be named (original/normal or scrambled photographs of objects). This paradigm allows us to investigate sentence comprehension for meaningful versus time-reversed sentences, and context-driven or bare picture naming. The CLaP thereby reduces task-related confounds between conditions. Looking at cortical activity recorded with electrophysiology (EEG and MEG), context-driven picture naming yields replicable power decreases in the alpha-beta frequency range (8-25 Hz) prior to picture onset in the left hemisphere. In addition to this contrast, using the CLaP we examined ERPs locked to sentence and to picture onset to investigate neural responses to auditory speech compared to a low-level acoustic control (i.e., time-reversed sentences), and object recognition compared to a low-level control (i.e., scrambled pictures). We tested 21 young healthy speakers with EEG. Statistical comparisons were made using non-parametric cluster-based permutation. Sentence-locked ERPs revealed cortical auditory responses to constrained and unconstrained sentences (i.e., meaningful speech) between 270 and 370 ms after sentence onset, significantly differing in amplitude from the responses for time-reversed speech. Following this initial evoked response, reversed sentences significantly diverged from meaningful speech with sustained amplitude differences. We replicated the expected context effect of power decreases (8-25 Hz) during the pre-picture interval. Comparisons with low-level control reversed sentences (preceding bare picture naming) clarified that the context effect is characterised by power decreases for constrained compared to unconstrained sentences sustained throughout the interval. Picture-locked ERPs showed that visual evoked potentials (VEPs) significantly differed between conditions in the amplitude of the P2 component (200-300 ms). VEPs also differed for bare and scrambled naming in the N1 component (starting at 170 ms), whereas for constrained and unconstrained naming the amplitude differed throughout the whole VEP (100-300 ms). These results suggest that the VEP, and especially the P2 component, is modulated not only by the physical characteristics of the visual stimuli but also by lead-in sentence constraint and speech intelligibility. These first results of the CLaP show promising opportunities to use this paradigm in combination with electrophysiology. By virtue of the well-matched contrasts across conditions it allows us to further investigate language comprehension and production, and their relationship, in a well-controlled setting in neurotypical and neurological populations.

Topic Areas: Language Production, Methods

## It takes two: Preliminary findings of dual-task imaging using two functional Near-Infrared Spectroscopy systems in younger and older healthy adults

***Poster D3*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Neuroimaging wearables show promise in increasing our understanding of real-world brain function in healthy aging and disease. However, research to date falls short in validating new devices against commercially available systems and in describing brain-behavior relationships during dual-task paradigms that mirror real life, such as recounting a story while walking. In this presentation, we will describe preliminary findings in which we: 1) compare functional Near-Infrared Spectroscopy (fNIRS) data quality obtained from one commercial (NIRx) device and a new, wireless mobile optical brain imaging (MOBI) system and 2) determine differences between younger and older healthy adults in brain-behavioral relationships during dual-task fNIRS imaging. Method: Forty healthy adults (20 people ages 18-30, 20 people ages 55-75 years old) will participate. During fNIRS imaging, participants listen to and immediately retell a series of 10 ~35s stories, evenly split between Stand and Walk conditions. Participants walk at a comfortable pace or stand on a treadmill while a motion capture system measures spatiotemporal gait/postural parameters. The NIRx system includes two daisy-chained 8x8 NIRx NIRSport2 devices with 16 sources and 16 detectors. The bilaterally symmetrical 42-channel montage covers several regions of interest (ROIs), including rostrolateral (RLPFC) and dorsolateral (DLPFC) prefrontal cortices, premotor (PMC) and primary motor (M1) cortices, the inferior frontal gyrus (IFG), mid to posterior superior and middle temporal gyri (mMTG, pMTG, mSTG, pSTG), and supramarginal gyrus (SMG). A series of flexible diamond-shaped circuits containing source/detector pairs comprise the MOBI; the optode arrangement of the MOBI mirrors the NIRx montage. For aim #1, data quality will be assessed using the QT-NIRS Toolbox (Hernandez & Pollonini, 2020). Channels will be flagged as bad if scalp-coupling and peak spectral power indices fall below the standard thresholds for more than 30% of data acquisition windows. For aim #2, activity within ROIs will be extracted for the contrasts WalkListen>StandListen and WalkRetell>StandRetell. Story comprehension accuracy and discourse production composite measures reflecting microlinguistic (e.g., proportion of nouns, verbs, articles) and macrolinguistic (e.g., global coherence, number of main ideas) skills will be calculated for Walk and Stand conditions. Gait will be measured by the peak force of the vertical ground reaction force. LASSO regressions will be used to identify activity within ROIs for the contrasts of interest that predict the Walk vs. Stand behavioral differences during story listen and retell. Preliminary Results: Thus far, data from 10 individuals (9 younger, 1 older) have been obtained with the NIRx system and processed using Homer3 (Huppert et al., 2009). Across the group level, activity was observed in the left anterior superior frontal gyrus, portions of bilateral DLPFC, LIFG-pars triangularis, bilateral PMC and ventral M1, bilateral mMTG, and LmSTG for WalkListen>StandListen. For WalkRetell>StandRetell, activity was noted in portions of bilateral DLPFC, PMC, SMG, and LmMTG. Discussion: This study is motivated by the need to expand understanding of aging behavior and brain function during naturalistic language contexts. During the sandbox presentation, additional data will be presented and feedback from attendees about crucial methodological concerns (e.g., motion correction techniques) will be elicited.

Topic Areas: Language Production, Methods

## Blueberries and bunkbeds: what compounds can tell us about the time course of language production

***Poster D4*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The aim of the present study is to contribute to understanding how language production unfolds over time by investigating ERP responses during the planning of compound nouns. In the language production literature, one common view is that a conceptual level of encoding is followed by a morphosyntactic level and then finally by a phonological one, concluding in actual articulation (see e.g., Levelt et al. 1999, Ferreira and Slevc 2007, Krauska 2022 a.o.). In the last decade or so, ERP studies of picture naming tasks inspired by these models have experimentally investigated the timeline of language production. For instance, Strijkers et al. (2010), examining data from Spanish-Catalan bilinguals, identified a 150-200ms window for the start of lexical access in production. Perret and Laganaro (2012), comparing a spoken versus written picture naming task, observed a divergence between the two modalities at around 260ms, which they identified as the beginning of the phonological phase for language production. However, it has been proven difficult to separate the morphosyntactic stage from the phonological one, given that production experiments usually concentrate on the naming of single words with limited morphosyntactic complexity. Compounds (e.g., ‘bunkbed’) are complex morphological objects composed of a head (‘bed’) and a modifier (‘bunk’) and thus provide the perfect testbed to investigate how linguistic complexity is dealt with in language production. EEG recordings will be conducted while participants name pictures whose labels are compounds, after hearing an auditory prime. There will be 4 different kinds of primes: semantic, morphological, phonological and unrelated. In the semantic condition, the prime and the target compound are related in meaning (‘dormitory’-‘bunkbed’), while in the morphological condition the prime is the same as the head of the compound ('bed'-'bunkbed'). In the phonological condition the prime shares the onset and the nucleus of the first syllable with the head of the compound ('bent'-'bunkbed'). Our analysis will focus on the ERPs from the onset of the picture to be named, during the planning stage in which speakers prepare their response prior to commencing articulation. Morphosyntactic and phonological planning should be facilitated in the morphological prime condition relative to the unrelated prime condition, due to the overlap at both those levels of representation. The crucial comparison will be between the phonological prime condition and the morphological prime one. If morphosyntactic planning precedes phonological planning, we predict that prime facilitation effects in the ERP should begin earlier in the morphological condition than in the phonological condition, thus pinpointing the time course of the morphosyntactic level postulated in language production models. In sum, the present work intends to contribute to the field's understanding of how production unfolds over time by using compound nouns which show morphological complexity at the world level.

Topic Areas: Language Production, Morphology

## Neural Mechanisms of Song vs Speech Production: Insights from Aphasia and Intracranial Recording

***Poster D6*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Despite extensive exploration into the neural mechanisms of language, there is no conclusive explanation for why language expression through song is spared relative to speech in certain individuals with aphasia. To investigate this phenomenon, the current study takes an innovative approach in examining how the brain expresses language through song versus speech. We will explore behavioral patterns and the structural and functional neuroanatomy of singing, merging evidence from two distinct patient cohorts and two different methodologies: individuals with post-stroke aphasia (n=30), and neurosurgical patients without aphasia with implanted electrodes (n=20). Both cohorts will be tested on the same set of speech and language tasks with different processing demands: motor speech, word retrieval, and a sentence priming task. Each task will be presented in both spoken and sung modalities. In participants with aphasia, we will analyze error patterns and inspect damaged neural structures associated with specific performance profiles, while in the neurosurgical cohort, the analysis will shift to temporal dynamics and sites of activity underlying each task. The novel combination of behavioral and lesion analysis in people with aphasia and intracranial electroencephalography (iEEG) in neurosurgical patients will provide unique insights into the behavioral and neural mechanisms of singing. First, people with aphasia will be tested on the three tasks to determine how singing affects their production of single words and sentences. Previous studies have documented improvements with singing, but it is not clear whether these gains are due to overcoming motor speech deficits or linguistic processing disorders such as word retrieval and syntax. The different tasks will evaluate potential singing benefits within each of these domains. In addition, we will analyze high-resolution structural MRI and diffusion-weighted imaging from this group to define the cortical regions and white matter integrity that differentiate people with aphasia with and without preserved singing. Finally, participants with surgically-implanted intracranial EEG electrodes for pre-surgical evaluation of pharmacologically-refractory epilepsy will be studied while singing and speaking. iEEG measures brain activity with millimeter accuracy and millisecond temporal precision allowing us to define spoken and sung network dynamics and investigate both left and right hemisphere activity during singing and speaking. Thus, the combination of MRI and iEEG with detailed behavioral analysis will provide novel behavioral, neuroanatomical, and electrophysiological information on how spoken and sung language interact and diverge. We will present preliminary results from both the iEEG and the aphasia cohort.

Topic Areas: Language Production, Multisensory or Sensorimotor Integration

## Touch typing changes the way you speak: interactions between modalities of language production

***Poster D7*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Separate studies have shown that speaking and writing are supported by similar brain networks and have a common cognitive architecture. However, a systematic comparison of the oral and written modalities in different elicitation contexts (e.g., picture naming vs. dictation) is still missing. Moreover, despite the high prevalence of keyboards, a range of expertise in typing skills exists, a potential discriminating factor being the ability to touch type (i.e., type without looking at your hands). The aim of this study was to systematically examine how performance varies across Output Modalities (speaking and typing) of language production as a function of several production contexts or Input Types (picture, written word, and auditory word) and expertise (touch vs. non-touch typists). Forty participants produced 240 words, half of them through speaking, the other half through typing (counterbalanced between participants), in the three indicated input types ¬–picture, written word, and auditory word (i.e., total of 40 words in each of the six experimental design cells). In addition, they performed word and non-word repetition and copying. Crucially, they performed a blind dictation typing task (typing with the hands occluded). Based on their accuracy in blind typing, participants were categorized as touch (N = 17) or non-touch (N = 23) typists for the analysis on the main experimental task. In the main experimental task, significant effects of input type and output modality were observed on performance indices (RTs and accuracy rates). Performance was higher in speaking than typing, and was better with written input than auditory input, and the lowest with a picture input. Blind typists exhibited better accuracy rates in typing but not in speaking. On RTs, there was a significant difference between touch and non-touch typists, with shorter RTs for touch typists in both typing and speaking. In speaking, the effect of group interacted with input modality, such that the difference between touch and non-touch typists was stronger following auditory input (repetition), than other input types. The production durations of touch typists were significantly shorter in typing but longer in speaking, and did not interact with input type. This pattern of effects was replicated in independent tasks of repetition and copying, with touch typists again

presenting shorter RTs in both tasks. Our results suggest that overall performance was better for speaking than typing, which follows lifetime experience. The expertise that touch typists have acquired led them to perform better in typing, but also in speaking tasks. Their mastering of language production through typing seems to have consequences upstream in the production system facilitating oral language production as well. Such a systematic evaluation of linguistic processes across several input types and output modalities appears crucial to understand the general organization of the language system in different contexts of expertise.

Topic Areas: Language Production, Writing and Spelling

## Neural and Cardiovascular Determinants of Tip-of-The-Tongue States in Healthy Ageing

***Poster D8*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Katrien Segaert[1], Kamen Tsvetanov[2], Jack Feron[1], Kelsey Joyce[1], Ahmed Gilani[1], Eunice Fernandes[3], Allison Wetterlin[3], Linda Wheeldon[3], Sam Lucas[1], Foyzul Rahman[1]; [1]University of Birmingham, UK, [2]University of Cambridge, UK, [3]University of Agder, Norway

Introduction: Tip-of-the-tongue occurrences, a temporary inability to access a known word, are common in healthy older adults. Existing imaging studies have linked these occurrences to structural and functional differences associated with healthy ageing. Lifestyle factors, such as cardiorespiratory fitness, have also been linked to tip-of-the-tongues among older adults. However, the integration of neuroimaging and cardiorespiratory measures in understanding these failures is currently lacking. Here, for the first time, we report how brain-based and lifestyle factors both uniquely and synergistically explain word-finding failures experienced by older adults. We assessed the effects of age, grey matter density, cardiorespiratory fitness, cerebral perfusion, and fMRI BOLD effects to explain tip-of-the-tongue occurrences in healthy older adults. Methods: 78 right-handed healthy older adults (Mage = 65.53, range 60-81; 39/39 male/female) completed a definition-based tip-of-the-tongue-fMRI, T1-weighted anatomical, and cerebral perfusion (pseudo-continuous arterial spin labelling) MRI sequences. Separately, we collected cardiorespiratory fitness (VO2 peak) data using an incremental treadmill test. BOLD-fMRI data were modelled on 'Tip-of-the-tongue' vs 'Know' responses and standard FSL preprocessing was applied to structural and perfusion data. We examined the link between brain and fitness measures as predictors of tip-of-the-tongues using a commonality analysis. Commonality analysis is a statistical approach that decomposes variance in a dependent variable (here, tip-of-the-tongues) into unique variance that is native to each predictor in the model while also computing the shared variance apportioned to two or more predictors; referred to unique and common variance, respectively. Results: Whole-brain results revealed a functional tip-of-the-tongue network (Tip-of-the-tongue >Know), which included the bilateral inferior frontal, superior frontal and angular gyri, the left planum temporale, temporal pole and right posterior middle temporal gyrus. Commonality analysis revealed that tip-of-the-tongue occurrences were best explained by a synergistic effect of age, fitness, and functional recruitment (e.g., precuneus). This suggests that age and individual differences in fitness explained variance in tip-of-the-tongue rates, and fitness was associated with differential recruitment of language regions. These findings persisted above and beyond contributions of loss in brain structure (atrophy). We found that age-related atrophy in the hippocampus also explained variability in TOT rates. We did not find an association with perfusion surviving correction for multiple comparisons. Conclusion: Individual differences in fitness in ageing was associated with differential recruitment of tip-of-the-tongue functional networks. This differential recruitment explained the variance observed in tip-of-the-tongue rates. Moreover, the conjunction of age, cardiorespiratory fitness, and functional recruitment determined tip-of-the-tongue rates above and beyond contributions of atrophy and brain perfusion.

Topic Areas: Language Production,

## Broca is alive and well: an articulation-selective area in the left inferior frontal gyrus, distinct from nearby language and Multiple Demand areas.

***Poster D9*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: In 1861, Broca made a strong empirical claim: that an area in the left inferior frontal gyrus (LIFG) selectively supports speech articulation. Broca asserted selectivity relative to both high-level language processing and general intelligence. Over the years, Broca's claim received a lot of criticism. However, many critics a) have relied on analytic approaches that average brains in a common space, which often leads to a misleading picture because of inter-individual variability in functional topographies, and b) have relied on paradigms that conflate speech and language. fMRI studies that rely on individual-subject analyses ('precision fMRI') have shown that the left IFG contains language-selective and domain-general Multiple Demand (MD) areas (Fedorenko et al., 2012; Blank et al, 2014; Fedorenko & Blank, 2020). But these language-selective areas support high-level comprehension and production (Fedorenko et al., 2010; Meneti et al., 2011; Hu, Small et al., 2022), not speech motor control. So how does Broca's claim of an articulation-selective area fit into the picture? Using precision fMRI, we first replicate the language/MD dissociation in the LIFG in a large dataset (Experiment 1) and then present evidence of articulation-selective areas distinct from both the language and MD areas (Experiment 2). Experiment 1: Participants (n=489) completed two 'localizer' tasks (extensively validated paradigms that work at the individual-subject level): (1) a language network localizer, based on the contrast of sentence vs. nonword reading (Fedorenko et al., 2010); and (2) a Multiple Demand network localizer, based on a harder vs. easier spatial working memory (WM) task (Fedorenko et al., 2013; Assem et al., 2020). Within an LIFG mask, we defined language and MD functional regions of interest (fROIs) in each individual using a portion of the data from each task and then examined these fROIs's responses in independent data. We robustly replicated the language vs. MD dissociation: language fROIs responded strongly to sentence comprehension, but did not respond to the spatial WM task; MD fROIs responded strongly during spatial WM (more strongly during the harder condition) but showed little response during sentence comprehension. Furthermore, language and MD fROIs showed almost no overlap at the voxel level.

Experiment 2: Participants (n=40) each completed the localizers from Experiment 1 and additionally, an articulation localizer based on the contrast of overt syllable repetition vs. finger tapping. We defined putative articulation fROIs in each individual using a portion of the data from the articulation localizer (articulation>finger-tapping). These areas i) responded robustly to articulation in independent runs, and ii) showed little or no response during language comprehension (during listening or reading) or during the spatial WM task (see also Basilakos et al., 2018). Language and articulation fROIs showed a small amount of overlap at the voxel level, but the majority of voxels responded selectively to language vs. articulation. Conclusions: Our results strongly support Broca's original claim (also, Hillis et al., 2004) of the existence of an articulation-selective area in the LIFG, which does not play a role in high-level language processing or general intelligence.

Topic Areas: Language Production,

## Structural and functional mechanisms of reorganization for language compensation in patients with diffuse low grade gliomas in the left hemisphere

***Poster D10*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Diffuse low grade gliomas (DLGGs) within the left hemisphere can significantly disrupt language functions. Emerging research suggests that the brain may have the ability to compensate for some of the loss of language function through neural plasticity. However, there is a lack of studies exploring structural and functional mechanisms of plasticity in the same sample of patients from a longitudinal approach. This study aims to fill this gap by investigating structural and functional plastic changes before and after surgery in a cohort of 15 patients with left DLGGs. Our goal is to track changes in the structural and functional dynamic of the language network in order to cope with the lesion and maintain language functions. First, to account for cognitive state and the optimal behavioral performance after surgery, patients completed cognitive evaluations both before and after surgery, encompassing assessments of general cognitive state (MMSE), intelligence measures (KBIT) and language ability (BEST). Then, to evaluate changes in structural plasticity, we measured grey matter volume before and after the surgical intervention through voxel-based morphometry analysis (VBM) on high-resolution MRI T1-weighted images. As per functional changes, we estimated the BOLD response associated with language production during a picture naming task (MULTIMAP) that included objects and verbs. To specifically disentangle longitudinal effects related to language processing, we focused our analysis in 10 brain regions known to subserve language production and comprehension: pars orbitalis, pars opercularis, pars triangularis, middle frontal gyrus, middle temporal gyrus, middle part of the temporal pole, superior temporal gyrus, superior temporal lobe, supramarginal gyrus, angular gyrus. For this spatial constraint, we parcellated the brain following the automatic labeling atlas (AAL). Behaviorally, we observed no differences within patients after comparing cognitive performance pre and post surgery. Patients demonstrate intact neurological and behavioral functioning in the post-surgical stage. This persistent behavioral pattern after the surgical intervention provides evidence of language compensation mechanisms after resection. Structurally, we found that volume decreased in areas located throughout the brain, including ipsilesional and contralesional areas. Moreover, activation patterns seem to be dependent on the lesion location. Despite differences across patients, longitudinal contrasts (post- vs. pre- surgery) as tested in individual GLM analysis showed a spread of activation including the recruitment of perilesional, ipsilesional, and contralesional areas. Overall, we find both structural and functional evidence of reorganization in order to cope with the lesion that enables patients to maintain language function. These results provide valuable insights into the compensatory mechanisms for language impairment in patients with left DLGGs. A deeper understanding would allow us to respect the structural and functional changes that are emerging to sustain cognitive abilities during treatment and the surgical intervention, resulting in a better prognosis for these patients.

Topic Areas: Language Production,

## Oscillatory dynamics of spoken language production

***Poster D11** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: While the brain regions involved in word production have been identified, the neural mechanisms underlying conceptual and lexical retrieval remain unclear. Here, we used mangentoencephalography (MEG) during a picture naming task to examine the oscillatory dynamics of spoken word production. Picture naming is commonly used to test word production as it captures all levels of processing from semantics to lexical retrieval and articulation. Methods: 27 healthy older adults (age ≥50 years) completed an overt picture naming task during a MEG scan. Stimuli consisted of black and white line drawings of objects randomised to a clear (naming) or scrambled (control) condition. Stimuli were presented on the screen for 2s, preceded by a 2.5s fixation period. Participants were instructed to name the clear stimuli and respond ‘no’ when the scrambled stimuli appeared. The naming condition consisted of monosyllabic words with high naming agreement. The scrambled condition controlled for low-level visual input and motor output, but did not involve any object recognition and lexical retrieval processes. MEG analyses were conducted using SPM on response-locked epochs. Sources of the oscillatory activity were reconstructed using a beamformer. Neural oscillations within the spoken language network were identified by contrasting source reconstructed time-frequency data in the naming > control condition. We report results at a statistical threshold of FWE-corrected $p < 0.05$ at cluster and voxel level. Results: Sensor-level time-frequency results showed that picture naming, relative to control, induced delta/theta (2 – 6 hz) synchronisation 1.4s preceding response, followed by an alpha/beta (8 – 20 hz) desynchronization 0.6s preceding response. Source-level results showed delta/theta and alpha/beta activity were left hemisphere dominant. Delta activity localised to a fronto-temporo-parietal language network, including the left inferior frontal gyrus, supramarginal gyrus and superior temporal gyrus. Theta activity localised to regions of attention control in the medial-frontal gyrus and to areas of lexical retrieval in the superior/medial temporal gyrus and lingual gyrus. Beta desychronisation was widespread throughout the left hemisphere, involving both motor and language regions, while alpha appeared to desynchronise along the ventral ‘object recognition’ pathway in the visual cortex and inferior temporal gyrus. Significance: In this study, we identified the oscillatory signatures of conceptual and lexical retrieval during overt picture naming. Delta activity engaged a long-range fronto-temporo-parietal language network, while theta activity modulated attention and lexical processing mechanisms. We show that beta oscillations modulate memory, as well as motor, aspects of spoken word production. Finally, studies to date have been unclear on the differential role, if any, of alpha/beta activity in language production – our findings suggest that alpha activity may selectively engage the mapping of visual information to semantics in the left basal language areas. Future work will explore whether these oscillatory dynamics are altered in aphasic patients with anomia (picture naming difficulties) and if they can be modulated to improve speech abilities.

Topic Areas: Language Production,

## Pronoun resolution via reinstatement of referent-related activity in the delta band

***Poster D12** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Human language offers a variety of ways to create meaning, one of which is referring to entities, objects, or events in the world. One such meaning maker is understanding to whom or to what a pronoun in a discourse refers to. To understand a pronoun, the brain must access matching entities or concepts that have been encoded in memory from previous linguistic context. Models of language processing propose that internally stored linguistic concepts, accessed via exogenous cues such as phonological input of a word, are represented as (a)synchronous activities across a population of neurons active at specific frequency bands. Converging evidence suggests that delta band activity (1-3Hz) is involved in temporal and representational integration during sentence processing. Moreover, recent advances in the neurobiology of memory suggest that recollection engages reinstatement of neural dynamics that occurred during memory encoding. Integrating from these two research lines, we here predicted that neural dynamic patterns, especially in delta frequency range, underlying referential meaning representation would be reinstated during pronoun resolution. By leveraging neural decoding techniques (i.e., representation similarity analysis) on a magnetoencephalogram (MEG) dataset acquired during a naturalistic story-listening task, we provide evidence that delta-band activity underlies referential meaning representation. Our findings suggest that, during spoken language comprehension, endogenous linguistic representations such as referential concepts may be retrieved and represented via reinstatement of dynamic neural patterns.

Topic Areas: Meaning: Discourse and Pragmatics,

## Do listeners use speakers’ iconic hand gestures to predict upcoming words?

***Poster D14** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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During face-to-face conversation, people rapidly take turns talking and use hand gestures that depict semantic meaning in addition to speech. In this pre-registered EEG study, we investigated whether listeners use speakers’ hand gestures to predict upcoming words. Participants listened to questions asked by a virtual avatar. Each question was accompanied by an iconic gesture (or control self-adaptor movement) that preceded a short silent pause and a target word. During the pause, participants showed stronger alpha and beta desynchronization in the Gesture versus the Adaptor condition, which have been reported as markers of anticipation. Moreover, gestures facilitated semantic processing of target words, as shown by less negative N400 amplitudes. A Cloze test with separate participants showed that seeing the gestures improved explicit predictions of the target words. However, how much each gesture improved predictions in the Cloze test was not related to the alpha and beta desynchronization in the EEG experiment. Altogether, these results suggest that listeners can indeed use speakers’ iconic gesture to predict upcoming words, which may facilitate coordination during conversational turn-taking by enabling earlier response planning. However, the results also raise interesting questions about the extent to which pre-stimulus alpha and beta desynchronization reflect predictive processing, thus feeding into a topical debate in the field of language and cognitive neuroscience.

Topic Areas: Meaning: Discourse and Pragmatics,

## The role of anticipatory attention during spoken language comprehension and its encoding in alpha amplitude modulations.

***Poster D15** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Spoken language rapidly conveys information over time. Psycholinguistic models posit that listeners pre-allocate attention to the key points in time when the most relevant information is expected to occur. In particular, discourse focus cues such as a preceding question (e.g., “What hat was the man wearing?”) have been shown to lead to faster reaction times and better memory for focused words in the following sentence (e.g., “The man on the corner was wearing the DARK hat”; focused word in all caps). However, the underlying neurocognitive mechanisms remain unclear. The goal of this ongoing project is to examine how discourse focus guides attention toward upcoming linguistic information by observing changes in EEG neural dynamics associated with attentional allocation, including anticipatory alpha suppression. Participants heard an Early Focus question (“Which man was wearing the hat?”) or a Late Focus question (“What hat was the man wearing?”), focusing either an Early Target or a Late Target word in the following sentence (“The man on the CORNER was wearing the DARK hat”; target words in all caps). We predict that alpha amplitude prior to the

Early and Late Target words varies as a function of whether they were focused through the preceding questions. Additionally, we test whether discourse focus influences depth of semantic processing by measuring the N400 elicited by the Early and Late Target words. Depth of processing was also assessed through a memory test after each block. Preliminary behavioral findings for a subset of 7 participants replicate prior studies, suggesting greater memory for words that had been focused by the preceding questions. Further analyses will test whether memory for the target words and the amplitude of the N400 correlate with pre-target alpha amplitude. Neural and behavioral results for the full dataset will be presented. Overall, this study integrates interdisciplinary lines of research by investigating the role of anticipatory attention mechanisms in language comprehension.

Topic Areas: Meaning: Discourse and Pragmatics,

## Being addressed: ERP evidence for the self-relevance of second person pronouns from naturalistic auditory story processing

***Poster D16*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The processing of first person pronouns in a narrative evoked an early (150-250ms) positive ERP response, and it has been suggested that this enhanced positivity reflects increased sensitivity of the cortex to potentially self-relevant information (Brilmayer et al., 2019). However, all pronouns referred to referents in the story. That is, this study only allows conclusions about the processing of pronouns that are potentially self-relevant to others, i.e. refer to other selves. Yet, the study is uninformative with respect to pronouns that refer to the participant. In the present study, we analyzed two EEG studies with data from 72 participants (32/40) listening to two different audiobooks. We chose these texts because of the stories' narrative characteristics: In one story ("Tschick"), all occurrences of 2sg pronouns refer to characters in the story due to its dialogue structure; in the second story ("Auferstehung der Toten"), the listener (i.e. the participant) is the most likely referent (~ 30%) of these pronouns because the auctorial narrator addresses the listener . This allows a comparison of the ERP response of 2sg pronouns that potentially refer to the listener with personal pronouns that do not. In our analysis we investigate whether the positive ERP effect of self-relevance is independent of a particular linguistic person (or linguistic token) and extends from the first to the second person, and if so, whether the effect is independent of the referent of the pronoun (listener/story character). The EEG data were recorded using 64 channels at 500 Hz sampling rate and were preprocessed in MATLAB using the EEGLAB toolbox. We decomposed the data into independent components and removed artifact components identified by ICLabel. Afterwards, we used time-resolved regression (unfold toolbox) to calculate overlap-corrected, single-subject averages in a time window of -500 to 1000ms relative to the onset of the critical pronouns for each study separately. The resulting beta-coefficients were then used to reconstruct the (overlap-corrected) single-subject ERP to 2nd person pronouns. Consistent with our hypothesis, the ERPs to 2nd person pronouns in "AdT" show a positive effect relative to "Tschick" with a peak amplitude of ~200ms. Using linear mixed-effect models in R, we modeled the ERP amplitude in the same time window as Brilmayer et al. (2019), i.e. 150-250ms relative to pronoun onset. In addition to the factor audiobook, we included two continuous topographical predictors based on two-dimensional coordinates (laterality, saggitality). The random effect structure included random slopes for the topographic predictors without interaction by subject. Among others, the model suggests a highly significant effect of audiobook at left and right posterior electrodes in the 150-250 ms time window, predicting a more positive ERP response for second person pronouns in “AdT” as compared to “Tschick”. Overall, the results of our analysis provide evidence that the positive ERP effect found for first person pronouns generalizes to second person pronouns, given that they are potentially self-relevant to the listener (when addressed by the narrator). We assume that the positivity reflects attentional processes leading to increased sensitivity of the cortex to the self-other distinction.

Topic Areas: Meaning: Discourse and Pragmatics,

## Attention warps semantic representations across the human cerebellum

***Poster D17*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Humans effortlessly shift their attention between different objects and events in the environment. These shifts are not limited to spatial attention but also include conceptual shifts; for example over the course of a conversation. As a limited resource, attention must be allocated in response to task demands. In neuroimaging studies, the effect of attention can be evaluated by examining representational changes across the brain. These studies have shown that, in most cortical regions, including regions associated with goal-directed attention, there is an expanded semantic representation of the attended topic. One exception is observed in regions associated with the ventral attention network where attention results in a reduced semantic representation of the attended topic (Cukur et al, 2013). This work has also shown that attentional effects become larger at relatively more central stages of the processing hierarchy (Cukur et al, 2013; Kastner et al, 2000). Thus, regions in early sensory areas such as V1 show a modest attentional effect while more cognitive regions later in the processing stream show much larger attentional effects. Previously it has been shown that during language perception, the cerebellum primarily represents semantic information (LeBel et al, 2021). However, it remains unclear how attention modulates semantic representations across the cerebellar cortex. In the present study we asked if attentional modulation in the cerebellum looks like attentional modulation in sensory cortical areas with a relatively small magnitude of change, or if the magnitude of attentional modulation is larger, similar to higher order cortical areas. In addition, we asked how the direction of attentional modulation varies across regions within the cerebellum. We collected BOLD fMRI data from four participants who watched short movie clips without sound. In separate runs, participants were instructed to covertly attend to either “people” or “vehicles” while maintaining central fixation (120 minutes of data per participant). The videos were labeled with a 985 dimensional semantic space that was derived from word co-occurrence rates. Banded ridge regression was used to model the relationship between the semantic features and the BOLD response for each voxel. The resulting model weights indicate how semantic information is represented in each voxel. Separate models were fit for each attentional condition. We then measured the attentional shift for each voxel by comparing the similarity of the estimated semantic representation across the two attention conditions. Attentional shifts of visual semantic representations in the cerebellum were of similar magnitude as those observed in higher-order cognitive regions of the cerebral cortex. Furthermore, the direction of the attentional shifts varied across the cerebellum with a bias of the semantic tuning shifting away from the attended semantic target. Moreover, the shifts in the posterior lobe, especially in regions associated with higher-level cognition, were larger in magnitude and away from the attended category suggesting that the semantic tuning in the cerebellum shifts differentially from the cortex during attention.

Topic Areas: Meaning: Lexical Semantics, Computational Approaches

## Pathogen stress associates with human collective semantic changes in language

***Poster D18*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The neurobiology studies of semantics mainly focus on the biological principles underlying the backbone semantic structures in the human brain. While semantic representation is commonly assumed to be (at least partly) derived from sensorimotor interaction with the external world, whether and how it is dynamically modulated by salient external variables is poorly understood. Here, we study one such salient variable: pathogens. Infectious diseases have been a major cause of death throughout human history. The human cultural evolution framework assumes that these stress variables have broadly shaped human psychology. To address whether and how the human collective semantic space is shaped by pathogens, we conducted three studies using large-scale text analyses: one cross-sectional study and two longitudinal studies. We focused on the backbone semantic dimensions identified based on decades of neuroimaging, neuropsychology, and cognitive studies, including sensory-motor, time, space, number, cognition, emotion, and social dimensions (i.e., neurocognitive dimensions). Study 1 investigated the cross-sectional associations between pathogens and semantic variations in 43 countries. To assess the intensity of neurocognitive semantic dimensions, we analyzed word frequencies derived from millions of texts on social media platforms in each country. We found a positive association between pathogen severity and the intensity of sensory-motor-related dimensions, which could not be accounted for by alternative socio-cultural factors such as cultural tightness or general economic wealth. Instead, the previously highlighted associations between pathogens and cultural tightness were mediated by human sensory-motor semantic processing. Study 2 examined the longitudinal associations between pathogens and changes in the intensities of backbone semantic dimensions. Historical word frequency data (Google n-gram) and pathogen data spanning the past 100 years in four countries were analyzed: the United States, the United Kingdom, Italy, and China. Variations in pathogen severity over time were linked to significant changes in the usage frequency of sensory-motor-related words. To establish potential causality, we conducted Granger causality tests and difference-in-difference analyses. The pathogen-leading patterns were observed in Italy and China. Study 3 extended the findings of Study 2 by utilizing independent decade-wise word embedding data (Corpora of Historical America, COHA) in the United States, which allowed us to examine broader concepts in terms of their representation patterns along the neurocognitive semantic dimensions. Again, we found that word representations along the sensory-motor

dimension in the embedding space shift in response to pathogen changes. Taken together, these results highlight the universal dynamic mechanisms of collective semantics, indicating that pathogen stress potentially drives sensorial-oriented semantic processing. These findings clearly mark the beginning of understanding human semantic memory from the perspective of the response-to-stress variable. Additionally, they raise new questions about the neural mechanisms, the consequences on a broad range of behaviors, the potential accumulation processes of such changes, and their role in the cultural evolution of human cognition.

Topic Areas: Meaning: Lexical Semantics, Computational Approaches

## Learning and application of speaker-specific semantic models

***Poster D19*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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We are better at understanding familiar than unfamiliar speakers. The mechanism underlying this familiar speaker benefit is still unclear. In this study, we combine computational models with behaviour to test whether listeners learn and apply speaker-specific semantic models to aid comprehension of incoming speech. To do this, we created a stimulus set of sixty vocoded auditory morphs between two words, each of which was semantically coherent with one of six semantic contexts derived from GloVe embeddings, yielding twenty words per context. Perception of these morphs as one word or the other was controlled in a validation experiment (N = 40). In the main experiment, participants (different N = 50) were shown faces of speakers that were matched with one of the six contexts, followed by binaural presentation of a morph and a two-alternative forced-choice between the two original words. Speaker-specific feedback was given such that one speaker could always be associated with one semantic context. Afterwards, participants were asked about their response strategy, i.e., whether they responded based on what they considered to be the correct answer or purely based on what they had heard. We expected that, should listeners acquire and apply speaker-specific semantic models, participants develop a bias towards reporting the option that was more coherent with the semantic space of the speaker. We found that only participants who reported having responded based on what they considered to be the correct answer for the current speaker, rather than what they had heard, showed a bias towards reporting the word that was more coherent with the general speaker-specific semantic context derived from GloVe. Using a free-energy approach, we computed time-resolved estimates of idiosyncratic (i.e., aligned with individual responses) and general (i.e., aligned with GloVe) speaker-specific semantic spaces that participants should have learned. Here, we found that all participants, including those who had given responses based on what they had heard, showed a strong bias towards reporting the word that was more coherent with their idiosyncratic speaker-specific semantic spaces. We verified this preference of idiosyncratic over general semantic spaces in embeddings obtained from GPT3 and BERT. Further, idiosyncratic speaker-specific semantic spaces gravitated towards those derived from GloVe over time, but convergence was slower in participants who reported to have given responses based on what they had heard. This delay in convergence disrupted the word-context associations derived from GloVe and explained why these participants showed a bias towards reporting the word that was more coherent with the idiosyncratic speaker-specific semantic spaces, but not those originally derived from GloVe. We conclude that humans learn speaker-specific semantic models that aid comprehension of incoming speech. These speaker-specific

semantic models are idiosyncratic and may not correspond to general semantic spaces obtained from global word co-occurrence statistics. Therefore, our results contribute particularly to data-driven semantic approaches that have recently been popularised. Specifically, our results suggest that data-driven models, such as GloVe, GPT3 or BERT, do not sufficiently capture the high idiosyncracy of semantics and highlight the need for fine-tuning approaches.

Topic Areas: Meaning: Lexical Semantics, Computational Approaches

## Towards the neurocognitive mechanisms supporting Semantic Feature Generation.

***Poster D20** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Semantic Feature Analysis[1] (SFA) is one of the most commonly used treatments for word production deficits in aphasia[2]. The goal of SFA is to improve spoken word production by guiding people with aphasia to produce semantic features related to a target. Generation of semantic features is hypothesized to be a key active ingredient of SFA[1]. The mechanism of action of SFA is hypothesized to be spreading activation between amodal representations[3]. However, it remains unclear whether SFA's mechanism of action could be better explained by more contemporary theories[4] suggesting that concepts are represented by multimodal co-activation of sensory, motor, affective, and temporal experiences that they are associated with. To begin to address this knowledge gap, we have used representational similarity analysis (RSA) to reveal the similarity structure between publicly-available covert feature generation BOLD data[5] and experiential-model feature vectors accounting for 48 sensory, motor, and affective experiences[6] (henceforth Exp48). Method: We reanalyzed BOLD data generated from seven right-handed adults (4 female, 3 male; age 19-32) who covertly generated semantic features for 60 concrete nouns[5]. Lexical-conceptual representations were operationalized with publicly available experiential feature vectors[6]. Only 30 of the 60 objects included in the fMRI analysis were also included in Exp48, so the analyses were conducted across 30 rather than 60 nouns. RSA with a searchlight approach were used to reveal the similarity structure between the neural data and the Exp48 feature-vectors. One-sample t-tests were performed at each voxel to evaluate whether there was a difference between the RSA-derived correlations across the seven participants compared to zero. Results: The participant-level RSA results indicated substantial subject-to-subject variability in the similarity structure between the neural data and Exp48 across the left and right hemispheres. One-sample t-tests of the RSA correlations across the seven subjects revealed robust similarity estimates within the left IFG, MFG, AG, MTG, STS, MTS and the right AG, STS and STG. Discussion: The group-level findings accord well with the semantic network proposed to support concept knowledge by the reactivation of sensory, motor, and affective modalities [7]. By the time of the conference, we expect to be able to present updated results evaluating the relationship between the neural data elicited by covert semantic feature generation and competing taxonomic, distributional, and experiential semantic models. The proposed analyses may shed light on which semantic model is most consistent with the mechanism of action supporting SFA, which may

inform future studies aimed at optimizing this popular treatment. 1. Boyle, M. Topics in Stroke Rehabilitation 17, 411–422 (2010). 2. Tierney-Hendricks et al. American journal of speech-language pathology 1–30 (2021). 3. Collins et al. Psychological review 82, 407 (1975). 4. Barsalou et al. Trends Cogn Sci 7, 84–91 (2003). 5. Mitchell et al. Science 320, 1191–1195 (2008). 6. Binder et al. Cognitive Neuropsychology 33, 130–174 (2016). 7. Binder et al. Cerebral cortex 19, 2767–2796 (2009).

Topic Areas: Meaning: Lexical Semantics, Computational Approaches

## Differences in word learning ability and subsequent memory performance between Primary Progressive Aphasia variants

***Poster D21*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Guillem Olivé Cadena[1,2,3], Maria F Porto[1,2,3], Gemma Cardona[1,2,3], Anna Gerloff[1,3], Sonia Marques-Kiderle[4,5], Lucía Vaquero[6], Claudia Penaloza[1,2,3], Ignacio Illan-Gala[4,5], Alberto Lleó[4,5], Miguel Ángel Santos-SAntos[4,5], Antoni Rodríguez-Fornells[1,2,3,7]; [1]University of Barcelona, Spain, [2]Bellvitge Biomedical Research Institute-IDIBELL, Spain, [3]Institute of Neurosciences, Spain, [4]Hospital de la Santa Creu I Sant Pau, Spain, [5]Centre of Biomedical Investigation Network for Neurodegenerative Diseases, Spain, [6]Complutense University of Madrid, Spain, [7]Institució Catalana de Recerca i Estudis Avançats-ICREA, Spain

Background: Previous studies have proposed that processing and learning words from different grammatical categories (i.e., nouns and verbs) is subserved by distinct neural regions/networks (Shapiro et al., 2005; Mestres-Missé et al., 2010), although the evidence appears to be inconclusive regarding the origin of this distinction. Here, we addressed this issue by comparing Primary Progressive Aphasic (PPA) patients and healthy controls in their ability to learn novel nouns and verbs in a contextual word learning task that requires the acquisition of word meanings via inference from a verbal context. Aims: The primary aim of this study is to test the ability to learn the meaning of new words in PPA patients compared to age-matching controls. We further wanted to examine whether differences in learning and memory performance arose for different word classes between groups. Finally, we aimed to compare if patients with different PPA variants showed distinct word learning or memory performance. Methods: We adapted the contextual new-word learning task from Mestres-Missé et al. (2010). Participants were required to discover the meaning of 24 novel nouns or verbs across several sentences. Learning was assessed using (i) a free-response test that required participants to write the hidden meaning of the trained pseudowords, and (ii) a 4-alternative forced choice (4AFC) test that required them to choose the right meaning for the trained words among 4 alternatives. Subsequent memory for learnt items was tested on a 4AFC test at a short and long term, as well as a recognition test of previously presented new-words. Our preliminary sample consisted of 22 healthy older control participants, 9 non-fluent variant PPA (nfvPPA) patients, and 9 logopenic variant PPA (lvPPA) patients. The experimental task was validated with 30 younger control participants and compared to the older controls to evaluate age-related differences in noun- and verb-learning in healthy individuals. Generalized Linear Mixed Models were used to assess performance differences between patients and controls in learning and memory tests for nouns and verbs. Also, paired t-tests were used to assess differences between noun and verb learning and memory scores within group separately. Results: Preliminary results revealed a clear effect of group in learning measures for both nouns and verbs, with a significant higher performance of controls compared to both PPA

groups, and nfvPPA patients showing significantly better learning accuracy than lvPPA. However, these group differences were not present for memory measures, as controls performed better than patients but no differences were found between PPA variants. When taking each group separately, no differences were found between noun and verb learning or memory scores. Discussion: Given that temporo-parietal left regions are the site of maximal neural damage in lvPPA patients, as opposed to the posterior frontal-insular left damage in nfvPPA patients (Gorno-Tempini et al., 2011), these initial results suggest potential differences in the neural correlates underlying the acquisition of meaning (both for nouns and verbs) and support the involvement of temporo-parietal left regions in contextual word-learning.

Topic Areas: Meaning: Lexical Semantics, Control, Selection, and Executive Processes

## The role of the right hemisphere in control and social dimensions of verbal semantics: Insights from an ALE Meta-analysis of 360 Functional Neuroimaging Studies

***Poster D22*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Language processing has been associated with a bilateral albeit left-lateralised network of brain regions, including the anterior temporal lobe [ATL], inferior frontal gyrus [IFG], posterior middle temporal gyrus [pMTG], and angular gyrus [AG]. However, the involvement of the right frontoparietal and temporal regions (henceforth the ‘right language network’) is not ubiquitous in language tasks and, to date, the role of the right hemisphere for language is not well understood. In this study, we tested two hypotheses regarding the role of the right language network for verbal semantic processing. One possibility is that some of the regions within the right language network support the same semantic function as in the left hemisphere. Nevertheless, they would be particularly engaged when control demands increase. Accordingly, the upregulation of function in these brain areas should be observed only when control demands increase. Another non-mutually exclusive possibility is that the involvement of some parts of the right language network reflects the processing of the social content of the stimuli. If true, then these brain areas should be engaged particularly when stimuli require social cognition processing. To address these hypotheses, we conducted an Activation Likelihood Estimate meta-analysis of 357 functional neuroimaging studies focussing on verbal semantic tasks. To establish which portions of the right language network were particularly sensitive to increased control demands, we compared active regions correlated with hard versus easy task conditions. Task difficulty was established by word or homonym frequency, number of distractors, reduced contextual support, and semantic incongruency, among other criteria. We analysed 1146 activation coordinates. The results revealed that increased semantic control demands modulated activation of the left IFG, left pMTG, and right IFG. Interestingly, right IFG was not included in the verbal semantic network (semantic versus non-semantic stimuli contrast), suggesting that right IFG might be recruited only when semantic demands increase. Then, to establish which portions of the right language network were particularly sensitive to the social nature of the stimuli, we analysed 4150 activation coordinates taken from neuroimaging studies using verbal stimuli with versus without social content. In detail, we analysed separately and contrasted activations derived from verbal semantic tasks using (1) word stimuli without social content (versus non-semantic baseline) and (2) sentences/word stimuli referring to social concepts and likely engaging theory of mind processes (versus non-semantic active baseline). Results revealed that left ATL and left pMTG were activated irrespective of the nature of the stimuli. However, right ATL and right pMTG were activated only by verbal stimuli with social content. Whilst right AG was not modulated by the type of stimuli, left AG showed a functional fractionation depending on the social content of the stimuli. In detail, stimuli with social content activated anterior-ventral portions of the left AG and the temporal parietal junction. Instead, stimuli without social content activated posterior-dorsal portions of the left AG. The current data show that control and social dimensions are critical to understanding the role of the language regions in the right hemisphere.

Topic Areas: Meaning: Lexical Semantics, Control, Selection, and Executive Processes

## Probing the functional relevance of pre-SMA and aIFG for controlled semantic processing with transcranial magnetic stimulation

***Poster D23*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Recent studies indicate that domain-general cognitive control areas contribute to semantic processing in the human brain. However, consensus is still lacking about the precise extent of the multiple demand network (MDN) for cognitive control, its boundaries relative to core semantic processing regions, and the nature of its involvement in semantic cognition. Meta-analytic mappings of the MDN and the semantic processing network show areas of overlap, especially by the left inferior frontal gyrus (IFG) and the pre-supplementary motor area (pre-SMA). In particular, the pre-SMA has been associated with controlled semantic processing, possibly supporting the core semantic area in left anterior IFG in the context of challenging semantic tasks. However, its relevance for domain-general and semantic operations is still unclear. Our project investigates network interactions between a core semantic area and a MDN area in the context of controlled semantic processing. To this end, we used neurostimulation to focally perturb the activity of pre-SMA and left anterior IFG and tested outcomes on semantic fluency (at high and low semantic control load demands) and non-semantic fluency performance. Methods: We performed a transcranial magnetic stimulation (TMS) experiment, based on an offline dual-site paradigm. The effects of left anterior IFG inhibition (1 Hz rTMS), left pre-SMA inhibition (1 Hz rTMS), and combined inhibition of both areas (1 Hz rTMS to aIFG followed by cTBS to pre-SMA) were tested. We additionally included a sham condition as baseline for each subject, replicating the procedures of the dual-site session. A total of 24 healthy young subjects (mean age: 30, age range: 20-40) were included and completed all four experimental sessions. Subjects first received the respective stimulation condition and subsequently completed a battery of three tasks (offline stimulation), including a semantic fluency task, a non-semantic fluency task (5-point figural fluency task), and a picture naming task. The semantic fluency task was designed to modulate the required level of semantic control, featuring low-difficulty and high-difficulty categories intermixed across trials. The figural fluency task was included as the main control task, sharing executive processes that are common to the semantic fluency task, but requiring the generation of geometrical figures, as opposed to words. The picture naming task was intended as an additional control, accounting for bottom-up semantic cognition processes, with lower control load demands compared to semantic fluency. To mitigate practice effects, novel stimuli were presented in each session for each task; stimuli sets and TMS condition orders were counterbalanced across subjects. Individual stimulation intensities were defined at the beginning of the first session via determination of the individual resting motor threshold (RMT). Repetitive TMS was delivered at 100% of RMT. Results: Accuracy scores and reaction times were extracted for each task. The analysis of the behavioural performance is ongoing. Linear mixed-effect models will be fitted for each measure to test the effects of task, semantic control load, target site, and stimulation, as well as potential interactions.

Topic Areas: Meaning: Lexical Semantics, Control, Selection, and Executive Processes

## Artifact concepts are more reliably represented than animal concepts across the cortex

***Poster D24*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Brain damage can result in severely impaired ability to retrieve general knowledge about items belonging to a particular category (e.g., animals) in the face of relatively preserved knowledge for other categories (e.g., man-made artifacts, fruits/vegetables, and body parts). One observation that remains unexplained is that cases of disproportionate semantic impairment for animals are much more common than cases of disproportionate impairment for artifacts (Capitani et al., 2003). It has been proposed that this asymmetry is due to differences in the representational nature of these categories in the healthy brain, such that artifact representations rely on a broader range of semantic features, including function and motor schemas. We assessed this proposal using representational similarity analysis (RSA) of fMRI data. We hypothesized that if, relative to animal concepts, artifact concepts are represented in terms of a more diverse set of features, their underlying neural activity patterns would be more discriminable from one another compared to animal concepts, resulting in a more reliable representational geometry across participants. Methods: We recruited 11 participants. Eight participants completed both scanning days (six presentations of the stimulus set). Two participants completed one day of scanning (three stimuli presentations), and one participant was excluded due to errors during task administration. We used a rapid event related design with 150 animal concepts and 150 artifact concepts matched on 13 lexical variables. Image data were pre-processed using fMRIprep, and beta-values for each of the 300 concepts were estimated using 3dREMLfit. Our primary analysis used an ROI derived from a meta-analysis of semantic language processing, and follow-up analysis examined other ROIs. We assessed the strength of the semantic representations using two approaches. First, we calculated a consistency based Intraclass correlation coefficient for both animal and artifact neural RDMs. Second, using word vectors based on a distributional semantic model (GloVe), we compared the RSA correlations obtained for the two categories. Results: The reliability coefficient for the artifact neural RDMs (ICC = .0076, 95% CI = [.0047 - .011]) was larger than for RDMs containing only animal concepts (ICC = .0019, 95% CI = [-.001, .0047]). We also found that RSA correlation values were higher for artifact than for animal concepts ($p < .05$, Wilcoxon test). Follow-up analysis using a different semantic mask and Glasser parcels showed a similar pattern. Conclusion: We found that artifact concepts have a more reliable representational geometry across the cortex than animal concepts. Our findings lend support to the hypothesis that, relative to animal concepts, artifact concepts depend on a wider variety of semantic features and cortical areas.

Topic Areas: Meaning: Lexical Semantics, Disorders: Acquired

## Language, tools, body parts, and faces: A neural genetic investigation

***Poster D25*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Language plays an essential role in the evolution of homo sapiens, serving as a foundation for thinking and communication. Such ability is supported by a widely distributed brain network encompassing the temporal, parietal and frontal regions. Inspired by the various hypotheses that language evolution was related to the processes of using tools, gesturing, or social interactions, we investigated whether and how the neural correlates supporting these processes have shared genetic components. To this end we took advantage of the Human Connectome Project (HCP) dataset which had fMRI data with monozygotic twins and dizygotic twins performing tasks processing language and three types of objects associating with tool, gesture, and social information. First, the brain areas activated by language and showing genetic effects was obtained using the language task (listening to stories) twin dataset (342 subjects, 113 pairs of monozygotic twins and 58 pairs of dizygotic twins). Six language clusters that showed significant genetic effects were found, including the bilateral anterior temporal lobe, the left superior temporal gyrus, the right superior temporal gyrus, the bilateral primary auditory cortex, the left frontal-parietal cortex, and the bilateral dorsal caudate. The HCP working memory task twin dataset (334 subjects, 106 pairs of monozygotic twins and 61 pairs of dizygotic twins) that included pictures of tools, body parts, and faces was then used to examine whether the language genetic clusters also showed genetic effects in terms of brain sensitivity to these domains (body parts approximating gesture processing and face social processing, with place as a control condition). The results showed different language genetic clusters' responses to different domains were genetically influenced: the bilateral dorsal caudate regions' responses to both tools and body parts; the right superior temporal gyrus to tools were genetically influenced; the bilateral anterior temporal cortex to body parts. Further common path model analysis confirmed the shared genetic effects across language, tool, and body parts processing in the bilateral dorsal caudate and between language and tool processing in the right superior temporal gyrus. Using gene expression data in the Allen Brain datasets and SVM classification approach we found that the language genetic clusters had distinct genetic profiles compared to the rest of the brain, and also differed from each other. Taken together, these results uncover the complex genetic patterns of language neural processes, shedding light on the evolution of language and its shared origins with other cognitive capacities.

Topic Areas: Meaning: Lexical Semantics, Genetics

## Exploring the EEG marker for syntactic structure building: evidence from Mandarin

***Poster D26*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Although much research has focused on EEG markers for syntactic violations (i.e., LAN, P600), there is less consensus on an EEG marker for syntactic structure building. While several MEG studies have identified potential markers (Matchin et al., 2019; Law & Pylkkänen, 2021; Matar et al., 2021), EEG studies remain relatively lacking (Neufeld et al., 2016; Fló, Cabana & Valle-Lisboa, 2020). One challenge for such studies is varying syntactic complexity while holding semantic-conceptual content constant. In our current study, we aim to overcome this issue by comparing Mandarin Chinese expressions that differ in syntactic complexity, but share an opaque/idiomatic meaning likely to correspond to only one conceptual unit. We plan to run two pairs of such comparisons: Experiment 1: syntactically simple vs. complex verbs. In Experiment 1 we compare disyllabic inseparable verbs (syntactically simple) and "separable verbs" (syntactically more complex; Chao, 1968; Packard, 2000). "Separable verbs" are verb-like expressions that are syntactically separable, suggesting that they are syntactically complex; inseparable verbs are syntactically inseparable, suggesting that they consist of only 1 syntactic unit or are at least less complex. For example, for the separable verb zao4fan3 (造反, make-reverse, "rebel"), one can say 造了三次反 (zao4le0san1ci4fan3, /zao4/-ASP-three-CL-/fan3/, "rebelled three times"), where the two parts of the separable verb are syntactically apart. On the contrary, syntactic separation is unacceptable for inseparable verbs like tao2pao3 (逃跑, escape-run, "escape"): *逃了三次跑 (tao2le0san1ci4pao3, /tao2/-ASP-three-CL-/pao3/). Critically, both types of verb are semantically opaque. We embed these two types of verbs in neutral (i.e., low-prediction) sentential contexts with segment-by-segment presentation, e.g., 小范/很想/{造反，}/所以/他秘密组织了一支军队 (Fan/really wants to/{rebel,}/therefore/he organized a troop secretly. Critical segment in curly brackets.) The task is to judge whether the last part of the sentence is congruent, and we will compare the ERPs elicited by inseparable vs. separable verbs. Experiment 2: syntactically simple vs. complex nouns. Following the approach of distributed morphology, most Chinese compound nouns have internal syntactic structures (syntactically complex nouns, e.g., bai2cai4 [白菜], white-vegetable, "Napa cabbage"; Cheng & Liu, 2020), except for many transliteration-based loan words, which only consist of one unit (syntactically simple nouns, e.g., ji2ta0 [吉他], /ji2/-/ta0/, "guitar"; cf. Wei et al., 2023). We embed these two types of disyllabic nouns too in neutral sentential contexts, also with a continuation judgement task, e.g., 因为/{吉他}/是/木质的/乐器，/所以/很容易损坏或受潮。(Because/{guitar}/is/wooden /instrument,/therefore/easy to break or get wet.) We will compare the ERPs elicited by syntactically simple vs. complex nouns. We expect to finish subject recruitment and data analysis by SNL 2023.

Topic Areas: Syntax and Combinatorial Semantics, Reading

## Continuous Theta-Burst Stimulation (cTBS) on the Left Posterior Inferior Frontal Gyrus Revealed a Trend of Selective Inhibition on Complex Syntactic Processing in Mandarin Chinese

***Poster D27** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Objective: Human language is hierarchical in nature. The hierarchical structures of the sentences are assumed to be built up via Merge, a binary syntactic operation that combines two elements to form a new constituent. The left posterior inferior frontal gyrus (LpIFG) is proposed to support Merge, a shared syntactic region across languages. However, whether LpIFG plays a causal role in syntactic processing in Mandarin Chinese, and whether the causality would be modulated by the syntactic complexity rather than the working memory effects were unspecified yet. Therefore, we set out to answer these questions by administering the transcranial magnetic stimulation (TMS) with the inhibitory continuous theta-burst stimulation (cTBS) protocol over LpIFG to assess the behavioral changes of Mandarin Chinese syntactic processing. Methods: 32 healthy adult Chinese native speakers underwent this within-subject experiment, composed of a stimulation session and a sham session with the order counter-balanced across participants (the interval between the sessions was 7 days). In the cTBS session (i.e., the stimulation condition), the TMS was administered to LpIFG with the cTBS protocol that triplets of TMS pulses at 50 Hz were delivered at 5 Hz, giving a 40 s train of 600 pulses in total. The sham stimulation (i.e., the sham condition) was performed by flipping the coil over with the settings of cTBS. In each session, participants were required to process syntactically-complex sentences with relative clauses embedded [i.e., the complex syntactic processing condition, including subject relative clause (SR) and object relative clause (OR) processing sub-conditions], semantically-matched coordinate sentences (i.e., the simple syntactic processing condition), and word lists (i.e., the word-list condition). As for the syntactic processing conditions, participants should judge whether the content of the probing sentence was correct according to the previously-presented sentence, and in the word-list condition, participants were asked to recall and to judge whether the word and its given position were matched, that is, a working memory task. Results & Discussion: The behavioral changes ("real cTBS - sham", denoted as "Δ") were compared in the conditions. The Δkurtosis of reaction time (RT) was significantly reduced and the Δcoefficient of variation was increased under the complex syntactic processing condition, especially when the subject relative clauses were embedded in the sentences (i.e., the SR processing sub-condition). No Δd-prime differences were identified. These results suggested that (1) inhibition of the left pIFG activity might cause the change in the stability of syntactic processing, the more complex, the more unstable (thus with a larger variation of the RT distribution), (2) the processing differences were not qualitative as implied by the null results of Δd-prime, possibly since cTBS on the healthy participants would not cause a real impairment on the behavioral performances, and that (3) the causal role of the left pIFP should be specific to syntactic processing (as shared by Mandarin Chinese), but not to the working memory capacity. To sum up, this study demonstrated the causal role of LpIFG as a core syntactic region universally backing up complex syntactic processes across languages.

Topic Areas: Syntax and Combinatorial Semantics, Reading

## Extralinguistic factors affecting language comprehension: the automatic and interactive double nature of syntax. A decade of findings.

***Poster D28*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Syntactic processing has often been considered an utmost example of unconscious automatic processing. In this line, it has been demonstrated that masked words containing syntactic anomalies are unconsciously processed by our brain, triggering event-related potential (ERP) components like the ones triggered by consciously presented syntactic anomalies, thus supporting the automatic nature of syntax. In addition, several studies also point out that regardless of the level of awareness, relevant extralinguistic information like emotions, pupil size of the speaker, facial expressions, social presence, and personality modulate syntactic processing, thus demonstrating the interactive, flexible, and context-dependent nature of syntax. The main aim of the present work is to discuss a decade of studies supporting the automatic and interactive double nature of syntax considering both classical and recent models of language comprehension. Among the discussed syntax models, only one considered this double automatic and interactive nature (Pulvermüller et al., 2008), but it restricts automaticity up to 150 ms after the onset of the critical stimulus, while evidence shows that this window might be extended to up to 300-400 ms. Regarding the interactive nature of syntax, modulations of LAN and P600 components are observed by several extralinguistic variables relevant to communication. However, the direction of the modulations is very variable across studies. We hypothesize that different tasks, contexts, and even individual differences might activate different processing types and mental modes leading to different predictions resulting in the variety of the observed modulations. In conclusion, future research and language comprehension models should consider these syntax characteristics.

Topic Areas: Syntax and Combinatorial Semantics, Reading

## Brain age predicts sentence processing declines in healthy aging beyond chronological age and domain general working memory abilities

***Poster D29** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Sentence processing abilities decline with age and are thought to be explained by declines in general working memory (WM) abilities (van Boxtel & Lawyer, 2020). However, there is strong evidence for the existence of language-specific brain regions adjacent but spatially distinct from domain-general regions (Fedorenko et al., 2011). This raises questions about the extent to which aging declines on sentence processing and general WM abilities diverge, potentially reflecting differential changes to these brain systems. We analyzed data from 154 subjects aged 20-80 who completed a variety of behavioral and neuropsychological assessments, including a simplified self-paced reading task (SPR) with materials adapted from Fedorenko et al. (2007), as part of the Aging Brain Cohort at the University of South Carolina (Newman-Norlund et al., 2021). The SPR task involves presentation of two sentence types, region-by-region, which were identical except for the relative clause: subject-relatives (e.g., the janitor who frustrated the plumber lost the key on the street), and object-relatives (e.g., the janitor who the plumber frustrated lost the key on the street). Following each sentence, a comprehension question was presented. We removed subjects who had average reaction times (RT) in the critical region three or more standard deviations above the mean (Fedorenko et al., 2007), leaving 152

subjects, analyzing RT in a repeated measures ANOVA. We analyzed the NIH Toolbox List Sorting WM task (Tulsky et al., 2013) as a control for more general cognitive abilities, requiring subjects to reorder sequences presented visually and auditory simultaneously, designed to assess both phonological and visuospatial components of WM ability. For 123 subjects, we were able to compute gray matter, white matter, and cerebrospinal fluid components from high-resolution T1 images. We retained top components accounting for 80% of variance in PCA. We estimated brain age, effectively a measure of how old a subject's brain looks independently of their real chronological age, using the BrainAgeR pipeline (github.com/james-cole/brainageR) v2.1, which was trained on n = 3377 healthy individuals (mean age = 40.6 years, SD = 21.4, age range 18-92 years) from seven publicly-available datasets. When including chronological age, brain age, education, and WM ability as covariates, there were significant interactions between structure and chronological age, $F(1,117) = 7.474$, $p = 0.007$, and between structure and brain age, $F(1,117) = 4.420$, $p = 0.038$. WM ability was significantly predicted by chronological age, $t(3,119) = -2.441$, $p = 0.016$ and education, $t(3,119) = 1.998$, $p = 0.048$ but not brain age, $f(3,119) = -0.224$, $p = 0.823$. These results suggest that the online speed with which people handle structural complexity in SPR declines with age independently of general WM ability, consistent with the hypothesis that sentence processing relies on separate/additional neurological resources relative to domain-general cognitive abilities (Caplan & Waters, 1999; Fedorenko, 2014; Matchin, 2018). Finally, brain age appears to be important independent predictor of age-related sentence processing declines, sensitive enough to detect effects of structure for self-paced reading but not redundant with chronological age or domain-general processing abilities.

Topic Areas: Syntax and Combinatorial Semantics, Reading

## Early and late ERP effects to minimalistic syntactic differences during speech perception

***Poster D31*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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While syntactic structure processing is taken as a fundamental part of language comprehension, its underlying neural dynamics remain disputed. This may be due to previous research relying on violation paradigms or complex or ambiguous syntactic structures to probe brain activity, which results in secondary cognitive activity that cannot be confidently attributed to syntax per se. Therefore, in this study we investigate the spatiotemporal dynamics of syntactic processing by relying on a simple minimalist paradigm where we compare three-word noun phrases matched for semantic content but with a different syntactic structure. Specifically, we contrast the processing of the last (critical) word between pairs of noun phrases, which is crucially physically identical, but has a different syntactic role between conditions. In condition (1) "joli buisson fleuri" ("beautiful bush flowering") the critical word is a modifier to the head and in condition (2) "buisson joliment fleuri" ("bush beautifully flowering") it is both a head and a modifier. In terms of semantics the only change is that the prenominal adjective in (1) turns to its adverbial form in (2), keeping the semantic-compositional content as close as possible between conditions. In this ongoing study we have tested 24 French native speakers and recorded brain activity in response to those naturally spoken auditory stimuli, with high-density EEG. We contrasted the two conditions with a parametric t-test and those preliminary results suggest a syntactic effect can be observed in both early and late time windows with the early effect lasting between 100 and 140ms and the later effect taking place between 350 and 500ms after onset of the critical word. Next steps in the analyses will be to compute the sources for these effects and to compare them to the predictions made by leading brain-language models. For the kind of minimalistic contrast we use models have diverging predictions. While some expect early activity in frontal followed by later activation in posterior brain areas (e.g. Friederici 2011; 2017), other models predict the inverse pattern with early posterior and later frontal activity (e.g., Hagoort, 2013; Pylkkänen, 2019); yet other models expect activity to be distributed between frontal and posterior areas of the language network for both the early and the late time windows (e.g., Pulvermüller, 2018; Strijkers & Costa, 2016; Fedorenko et al., 2020). Our approach will therefore provide a critical test to constrain future neural models of syntactic structure processing.

Topic Areas: Syntax and Combinatorial Semantics, Speech Perception

## Temporal prediction and the neural tracking of linguistic structures

***Poster D32*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Neurophysiological evidence suggests that brain activity tracks linguistic structures during speech comprehension at multiple timescales. Using the frequency-tagging paradigm, it has been shown that low-frequency neural responses synchronize their phase to the occurrence of acoustic (syllables) and syntactic (phrases and sentences) information (Ding et al., 2016). Unfortunately, this paradigm relies on the periodic (time-fixed) presentation of continuous speech streams. Hence, it conflates the temporal prediction of both acoustic and syntactic events. Clarifying the impact of temporal prediction is fundamental to understand whether similar neural mechanisms support the tracking of different types of linguistic information. To address this, our magnetoencephalography (MEG) experiment assesses the role of temporal prediction in the neural tracking of linguistic structures. We develop a novel version of the frequency-tagging paradigm that selectively manipulates the temporal predictability of acoustic and syntactic events. Our stimuli consist of acoustic streams (synthesized speech originally preserving natural time-varying durations) composed by 10 consecutive simple sentences (4 bi-syllabic words: adjective-noun-verb-noun) in German. Temporal predictability is accomplished by imposing periodicity (i.e., selectively matching the duration) at relevant boundaries progressively across linguistic levels (syllables/phrases/sentences). This manipulation results in 4 conditions, going from predictable (periodic, time-fixed) syllables-phrases-sentences to unpredictable (aperiodic, time-varying) syllables-phrases-sentences. Importantly, the speech envelope power spectrum only shows modulations at the frequency of syllables (4 Hz, progressively reduced in more aperiodic conditions). German speakers (n = 30) listen to our stimuli while performing a sentence-recognition task. To estimate neural tracking in our sensor-level MEG data, we analyze the non-uniformity of frequency-specific instantaneous phase angles (i.e., phase synchronization) at corresponding linguistic boundaries per participant, using the Rayleigh test. Our results show that phase synchronization to syllable boundaries is significantly stronger for predictable than unpredictable events, showing a right-hemisphere lateralization only when syllables are predictable. For phrase boundaries, phase synchronization is also significantly stronger for predictable than unpredictable events, remaining unaffected by the simultaneous presence or absence of acoustic predictability. However, phase synchronization to sentence boundaries is comparable across conditions, suggesting that neither acoustic nor syntactic predictability impacts sentence-level tracking. Importantly, unlike acoustic tracking, syntactic (both phrase- and sentence-level) tracking effects display a left-hemisphere lateralization. Taken together, our results seem to point out a dissociation between the neural tracking of (un-)predictable acoustic and syntactic boundaries. First, predictable syntactic events are tracked similarly, independently of the predictability of acoustic information, possibly suggesting non-identical neural mechanisms across linguistic levels. Second, in line with this possibility, the asymmetric hemispheric patterns indicate that acoustic and syntactic tracking are subserved by distinct neural substrates. Third, the finding of tracking effects for sentences (but not phrases) in unpredictable contexts suggests that temporal prediction mechanisms might be more robust for time-varying syntactic events with longer durations. To conclude, by implementing a novel frequency-tagging paradigm, we provide new evidence for the differential impact of temporal prediction mechanisms in the neural tracking of acoustic and syntactic events. Our results reveal a dissociation between the simultaneous tracking of acoustic and syntactic structures.

Topic Areas: Syntax and Combinatorial Semantics, Speech Perception

## Do surprisal and entropy affect delta-band signatures of syntactic processing?

***Poster D33*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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When we understand language, we recognize words and combine them into sentences. How do we do this? In this work, we used a naturalistic listening paradigm and magnetoencephalography (MEG) to explore the hypothesis that listeners use probabilistic information about words to infer abstract sentence structure. Lexical probability has proven to be a strong predictor for neuroimaging and behavioral data. For example, higher surprisal values tend to lead to slower reading times (e.g., Aurnhammer & Frank, 2019), oscillations in the delta, beta, and gamma bands track lexical surprisal (Weissbart et al., 2020; Gillis et al., 2021), and transitional probabilities can induce low-frequency power modulations (Bai et al., 2022; Batterink & Paller, 2017). At the same time, syntactic structure building is crucial for comprehension (e.g., Coopmans et al., 2022). Several frequency bands show signatures of this process, particularly the delta (Brennan & Martin, 2019; Bai et al., 2022; Kaufeld et al., 2020; Lo et al., 2022; Li & Hale, 2019; Meyer et al., 2017; Ten Oever et al., 2022) and gamma bands (Nelson, 2017; Peña & Melloni, 2012). We test a framework in which lexical distributional information is a cue for latent linguistic structure (Martin, 2016; 2020). We ask whether the neural encoding of linguistic structure changes as a function of the distributional properties of a word. We used temporal response functions (TRFs) to compare responses to syntactic annotations of the stimuli between words with high and low surprisal/entropy values. If distributional information affects the computation of syntactic structure, the neural encoding of syntactic structure should differ between high- and low surprisal and entropy words. If they do not differ, distributional and structural information may exist alongside each other, but are unrelated to each other in their neural encoding. We analyzed MEG data of 24 native speakers of Dutch who listened to three fairytales with a total duration of 49 minutes. To create syntactic features, we manually parsed all stories using a simplified minimalist approach and obtained bracket counts – a metric of syntactic depth – according to 'top-down' and 'bottom-up' parsing strategies (Brennan et al., 2016; Nelson et al., 2017; Coopmans et al., 2022). We then divided the bracket counts according to the median lexical surprisal/entropy values (obtained with GPT2) into 'high [surprisal/entropy]' and 'low [surprisal/entropy]' sets. Using TRFs, we estimated the response to each of these syntactic features and compared the responses from 'high' sets with the ones in 'low' sets. Preliminary results suggest that surprisal and entropy affect delta-band responses to syntactic information. Both metrics affect the response to bottom-up bracket counts, with effects for entropy seen mainly early in the time-window (before 500ms after word onset), and effects of surprisal spanning the entire time-window (until 1000ms after word onset). These and further findings may suggest that the brain uses probabilistic information to reach a structured, meaningful representation of the input. The findings are consistent with models that see language comprehension as a probabilistic process of mapping perceptual input onto abstract, deterministic representations (Martin, 2020; Hale et al., 2022).

Topic Areas: Syntax and Combinatorial Semantics, Speech Perception

## The Relationship Between Right Hemisphere White-Matter Tracts and Information Content in Parkinson's Disease

***Poster D34*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Communication impairments are common in Parkinson's disease (PD). The nature of this impairment is multifaceted, encompassing motor control, cognition, and language-specific domains. Although PD is associated with impairments at the motor and single-word production levels, little is known about its effect on connected speech. Early work has shown deficits in discourse productivity, fluency, lexical diversity, and information content. However, the structural correlates of these deficits have not been evaluated. In this study, we sought to evaluate the association between discourse abilities in PD and the degeneration of basal ganglia and language-specific fiber tracts. Methods: We collected discourse samples of the Cinderella story from 19 patients with PD who were being evaluated for deep brain stimulation candidacy. Discourse samples were transcribed and coded in CLAN and discourse metrics were extracted, including measures of discourse productivity (total utterances and mean length of utterance), fluency (words per minute, retracings, repetitions, and pauses), word-level and utterance errors, lexical diversity (type-token ratio) and information

content (propositional density and open to closed class ratio). Diffusion Kurtosis Imaging (DKI) using 30 diffusion encoding directions and three b-values (0,1000,2000 s/mm2) was acquired on a Siemens Verio or Skyra 3T MRI scanner. DKI scans were processed with the open-source PyDesigner pipeline and tractography was performed using DSI studio's autotracking across 12 major white-matter bundles associated with language production on each hemisphere. Diffusion metrics extracted along defined tracts included fractional anisotropy (FA), mean diffusivity (MD), and mean kurtosis (MK). Pearson correlations were used to determine the relationship between the diffusion metrics of tracts and the discourse metrics. For significant correlations, follow-up multiple linear regressions were conducted including motor speech ratings as a predictor to determine if the relationship between tract integrity and discourse remained after controlling for motor speech. P-values associated with each model and independent variable were adjusted using the false discovery rate. Results: Information content metrics, such as propositional density and open-closed ratio correlated with degeneration of right-hemisphere tracts. Specifically, the integrity of the third segment of the superior longitudinal fasciculus (SLF-III) was negatively associated with an open-closed ratio (MD: r=-0.709; p=0.048; MK: r=0.645; p=0.036) and positively associated with propositional density (MK: r=-0.636; p-value=0.036) while the right superior corticostriatal pathway was negatively associated with open-closed ratio (MK: r=0.719; p=0.036) and the right arcuate fasciculus was positively associated with propositional density (MK: r=-0.631; p=0.038). Conclusion: Our data provide preliminary evidence regarding the role of right hemisphere white matter tracts in connected speech in PD. Specifically, our results suggest that in PD, degeneration of the SLF-III and the superior corticostriatal pathway are associated with a decline in information content metrics. The latter also hints towards the non-motor role of the basal ganglia in language production. Further studies with larger samples and control groups are needed to assess the role of the right hemisphere in connected speech in PD.

Topic Areas: Disorders: Acquired, Meaning: Discourse and Pragmatics

## The Synergistic Role of Basal Ganglia in Semantic Comprehension and Tool Knowledge Processing: Evidence from brain damaged patients

***Poster D35*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The emergence of language and tools is a significant milestone in human evolution. In a recent study (Thibault et al., 2021) found that there are shared neural patterns in the basal ganglia during tool use and language processing. The present study aims to comprehensively investigate the collaborative patterns of different subregions within the basal ganglia in language comprehension and tool knowledge processing. Additionally, we also explore the similarities between these two cognitive processes for the connections of these subregions with other brain regions. A total of 99 patients with brain injuries and 51 healthy controls were recruited in this study. Neuroimaging data, including T1 and FLAIR T2, and diffusion tensor images (DTI), were collected. Brain lesion images were manually delineated. All participants completed classic language tasks, including the word version of Pyramids and Palm Trees Test (word PPT), picture version of PPT (picture PPT), oral picture naming, and word reading. Moreover, they performed a series of tool knowledge processing tasks that assessed four object attributes: form, function, manipulation, and motion. To control for the influence of demographic variables, the accuracy of each patient's performance in each task was transformed into standardized t-scores as behavioral measures (Han et al., 2013). The lesion degree of gray matter regions was measured as the percentage of lesion volume within regions of interest (ROIs), including six subregions of the basal ganglia (left and right caudate nucleus, putamen, and pallidum). The integrity degree of white matter tracts was calculated using the fractional anisotropy (FA) value of the tracts between two brain areas. In order to determine the differential impact of the same brain region or connection on different behavior performances, the method proposed by Matchin et al. (2022) was employed to evaluate the significance of differences in the slope of the gray matter lesion degree (or white matter integrity)-behavior regression curves, indicating the interaction effects. The interaction analysis of gray matter lesions observed significant interactions in the left caudate nucleus and the left pallidum in the comparisons between word PPT vs. reading, word PPT vs. picture PPT, and manipulation vs. motion tasks. In these interactions, the decline of performance with increasing lesion burden on the first task was significantly greater than that on the second task. Similar effects were observed for the left putamen in the comparisons between word PPT vs. reading, tool function vs. animal function, and tool function vs. tool motion. The interaction of white matter integrity showed widespread similarities across three contrasts: tool vs. animal in oral picture naming, word PPT vs. word reading, and manipulation vs. motion tasks. These similarities included connections between the basal ganglia with the frontal, insula and occipital area. The findings suggest that the left putamen is selectively involved in extracting knowledge related to tool function, while the left caudate nucleus and left pallidum are selectively involved in processing knowledge related to tool manipulation and semantic similarity of written words, respectively. Semantic comprehension and tool knowledge processing share a similar connectivity pattern in the left basal ganglia. This implies that the left basal ganglia may contribute to both semantic understanding and tool knowledge representation. The synergistic interaction of the left basal ganglia in these two cognitive processes provides new neurobiological evidence for the co-emergence of tools and language in human evolutionary history.

Topic Areas: Disorders: Acquired, Meaning: Lexical Semantics

## Mary’s book and big shoes: Production of noun-modifier phrases in individuals with acute post-stroke aphasia

***Poster D36*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Acute post-stroke aphasia typically is assessed by examining patients’ understanding and use of simple sentences and nouns. However, modifiers and bound morphemes can be the subject of considerable difficulty for individuals with aphasia. The recently developed Morphosyntactic Generation (MorGen) test has been used in individuals with post-stroke (Matchin et al., 2021; Stockbridge, Walker, et al., 2021) and progressive (Stockbridge, Matchin, et al., 2021) aphasia to target noun, modifier, and bound inflectional morpheme production in two-word phrases. Here, we report on the first examination of the MorGen in hyperacute-acute aphasia. We aim to (1) examine the MorGen's concurrent validity with other common tests of aphasia; (2) describe MorGen performance in people with acute aphasia; and (3) associate MorGen performance with the extent of lesioned vascular territories in acute stroke. Methods: Sixty-two adult English speakers within the first 14 days of left hemisphere ischemic stroke and 61 healthy control participants completed the MorGen. The MorGen produces constituent accuracy scores for patients' use of nouns, proper names, color, number, size, and bound morphemes marking the plural and genitive in two-word phrases. Patients also were tested using the Western Aphasia Battery (WAB), Boston Naming Test (BNT), and Hopkins Action Naming Assessment. Clinical MRIs were analyzed for the extent of lesion in the vascular territory of left anterior, middle, and posterior cerebral, posterior choroidal and thalamoperforator arteries. We used repeated measures multivariable analysis of variance to compare groups and multivariable logistic regression to identify associations between lesions and accuracy. Results: Performance on the MorGen demonstrated consistently high, significant positive correlations with that on the WAB, BNT, and Hopkins Action Naming Assessment ($p<0.001$). Individuals with a recent stroke performed more poorly than healthy individuals across all capacities targeted by the MorGen when controlling for differences in education, $F(3.6)=2.73$, $p=0.04$, $\eta P2=0.03$. Exploratory follow-up analyses suggested that patients with fluent aphasia performed significantly better than those with non-fluent aphasia in their use of nouns, modifiers, and plural marking, but not proper names or genitive marking. Patients who scored within functional limits on the WAB were distinguishable from controls, particularly in variability of performance on modifiers. Lesions in the territory of the temporal branch of the posterior cerebral artery (PCA) were associated with poorer accuracy for nouns, size, and color. Lesions in anterior cerebral artery (ACA) territory were associated with poorer accuracy for numbers ($R2=0.36$, $F(4)=3.42$, $p < 0.008$). When divisions of the middle cerebral artery (MCA) were considered together as a single predictor with ACA, PCA, and posterior choroidal artery, the model significantly predicted plural performance ($R2=0.40$, $F(4)=7.40$, $p < 0.001$). Both the MCA and ACA were significant independent predictors of plural performance. The same predictors resulted in a model that predicted possessive marking ($R2=0.27$, $F(4)=4.25$, $p=0.005$), but no single region was a significant independent predictor. Conclusions: This work highlights the value of the MorGen as a tool for post-stroke language evaluation that complements the skills captured in more widely-used assessments such as the WAB and BNT.

Topic Areas: Disorders: Acquired, Morphology

## NEUROFUNCTIONAL CORRELATES OF MORPHOSYNTACTIC PROCESSING AND THEMATIC ROLE ASSIGNMENT

***Poster D38*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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INTRODUCTION The left ventro-lateral prefrontal cortex and temporo-parietal areas have been traditionally associated with language processing. Recent lesion-symptom studies in persons with aphasia (PWA) post-stroke showed that lesions in the left temporo-parietal cortex, but surprisingly not in the left prefrontal cortex, affect the comprehension of semantically reversible sentences (e.g., The child is kissed by the mother). This result challenges the traditional view that left prefrontal regions are critical for sentence comprehension.

However, most studies focused on thematic roles (TR; i.e., who does what to whom), and failed to consider morphosyntactic processes (MS; i.e., inflections, agreement), that are also critical for sentence processing. In a systematic literature review and coordinate-based meta-analysis, we analyzed papers on the neurofunctional correlates of language processing in PWA. METHODS We included all papers published until October 2022, that applied a lesion-symptom mapping analysis on samples of PWA with TR/MS deficits following a brain lesion caused by stroke, neurodegeneration, or gliomas. A whole-brain, coordinate-based meta-analysis on lesion-symptom correlation studies was carried out using the GingerALE software (version 3.0.2). RESULTS The literature search initially yielded 2199 papers, 43 of which were considered eligible for the systematic review on the correlation between brain lesions in PWA and TR/MS impairments. The 43 eligible papers reported a total of 50 experiments. Of these, 25 investigated tasks that required TR assignment, whereas 15 investigated MS-related tasks; 10 experiments investigated both processes. With respect to the processing modalities, 27 experiments investigated comprehension, 20 investigated production, and the remaining experiments investigated both modalities. Twenty-seven of the 43 eligible papers also reported voxel-based anatomical coordinates and were thus included in our meta-analysis. The coordinate-based convergence of the effects reported across these 27 papers (corresponding to 28 experiments focusing on TR and/or MS) yielded significant (cluster-level $p<0.05$ FWE corrected) meta-analysis clusters in the left IFG, MFG, insula, precentral and postcentral gyri, MTG, STG, and SMG. A finer-grained meta-analysis directly comparing MS versus TR processing showed a greater involvement of the left IFG for MS, and of the left STG/SMG for TR, however only at an exploratory significance level ($p<0.05$ uncorrected). CONCLUSION The amount of literature sampled in our review and meta-analysis is quite limited. As a further concern, most studies on TR disorders focused on sentence comprehension and most studies on MS difficulties investigated sentence production, thus confounding the types of processes with the processing modalities. In addition, there is substantial heterogeneity in the experimental paradigms used to assess the two sets of processes and in the etiologies considered, which may differently affect linguistic phenotype and ease of damage compensation. Although these lesion-symptom mapping results must be taken with great caution, they inform future experimental choices aimed at disentangling the functional neuroanatomy of TR and MS processes.

Topic Areas: Disorders: Acquired, Morphology

## Neurodegeneration of the left supramarginal gyrus induces compensatory neural changes during phonological decisions

***Poster D39*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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*BACKGROUND: Previous functional neuroimaging studies have consistently indicated that the left supramarginal gyrus (LSMG) is part of the core phonological network with observed increases in LSMG activation during phonological relative to semantic decisions. Moreover, its causal involvement in phonological processing has been ascertained in studies demonstrating selective disruption of phonological decisions following inhibitory transcranial magnetic stimulation over LSMG. Inhibition of LSMG activity during phonological decisions has also been shown to induce transient neural changes in remote brain regions. These findings motivated us to examine whether LSMG atrophy induces compensatory neural changes during phonological decisions in logopenic variant primary progressive aphasia (lvPPA), a neurodegenerative syndrome characterized by progressive loss of phonological abilities. *METHODS: All study participants completed three fMRI tasks in which they decided whether (i) two pseudowords rhymed (phon), (ii) two words were related in meaning (sem), or (iii) two false font strings were identical (baseline). First, we identified a functionally defined LSMG region-of-interest (ROI) by comparing activation during phon>sem in a group of 16 healthy controls. Second, we segregated 16 mild-moderate lvPPA participants into two groups according to degree of tissue loss in the LSMG-ROI: (1) those with greater than 50% damage (lvPPA-LSMG-atrophy group, n=6; mean LSMG-ROI damage=74%); and (2) those with less than 50% damage (lvPPA-control group, n=10; mean LSMG-ROI damage=18%). *RESULTS: All groups performed significantly above chance on all tasks. As expected, lvPPA participants performed less accurately than healthy controls on phon and sem tasks. An fMRI conjunction analysis of phon>baseline across groups highlighted that lvPPA-LSMG-atrophy participants primarily recruited the left frontal part of the normal phonological network, although other areas such as the posterior LSMG were also activated. Adjacent to the normal phonological network, lvPPA-LSMG-atrophy participants showed increased activation in a region within the left anterior middle frontal gyrus (LaMFG-ROI) relative to healthy controls and lvPPA-control participants. Furthermore, this LaMFG-ROI was more engaged during phon>sem in the lvPPA-LSMG-atrophy participants only, resulting in a significant group by task interaction. Interestingly, we found greater LaMFG-ROI activation with increasing LSMG-ROI atrophy. To dismiss the possibility that greater LaMFG-ROI activation in lvPPA-LSMG-atrophy participants may exclusively be driven by increased cognitive effort during inaccurate phon responses, we carried out a post-hoc analysis where accurate and inaccurate responses were modeled separately. Our post-hoc analysis revealed a significant increase in LaMFG-ROI activation in lvPPA-LSMG-atrophy participants during accurate phon trials relative to (i) accurate baseline trials and (ii) accurate sem trials. *CONCLUSIONS: When making phonological decisions, lvPPA participants with LSMG atrophy recruited a substantial portion of the normal phonological network. Outside this network, lvPPA-LSMG-atrophy participants showed enhanced activation within the LaMFG relative to healthy controls. This effect was both lesion- (lvPPA-LSMG-atrophy>lvPPA-control) and task-specific (phon>sem). We hypothesize that the LaMFG may play a compensatory role by exerting top-down control over the phonological computations carried out in LSMG, which have become noisier due to the disruptive effect of neurodegeneration. Future studies should investigate whether non-invasive neurostimulation of LaMFG improves phonological processing in the context of LSMG neurodegeneration.

Topic Areas: Disorders: Acquired, Phonology

## Phase synchronization during phonological short-term memory

***Poster D40*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Language relies on rapid and dynamic neural processes. Distinct cortical regions, distributed across the temporal, parietal, and frontal lobes, store linguistic (semantic phonological, orthographic) representations, subserve automatic and controlled retrieval and selection of information, and enable short-term verbal memory. A fundamental mechanism thought to subserve information transfer across a functional network such as the language network is neuronal oscillatory activity. Neural oscillations are ubiquitous in the brain and are shown to support local neuronal communication, and coordinated or synchronized oscillatory activity between regions is thought to enable interregional communication. One mode of communication is via synchronization of phases of oscillatory activity. Phase describes a relationship between two (or more) signals that share the same oscillatory frequency. Synchronization of phases from two brain regions is hypothesized to reflect a mechanism by which distant task-relevant regions integrate information across a functional network. For example, several studies show that phase synchronization in the theta/alpha band (5-10 Hz) between prefrontal and temporal regions critically supports visual working memory. But the role of phase synchronization across the language network underpinning specific language functions after stroke remains largely understudied. Our focus in the current study is on elucidating oscillatory connectivity that underlies phonological short-term memory (pSTM) in older healthy individuals and stroke survivors with aphasia (SWA) using magnetoencephalography (MEG). Our long-term goal is to apply this knowledge to treat pSTM impairments after stroke with targeted STM therapy paired with neuromodulatory treatments such as transcranial alternating current stimulation (tACS) that influence brain oscillatory connectivity. We have collected pilot MEG data from 7 older healthy volunteers (out of 20) and 9 SWA (out of 15), who have completed a pSTM paradigm during MEG involving a delayed match-to-sample task with spoken consonant-vowel strings and a TONES control task involving pitch discrimination. The pilot data are currently being analyzed to evaluate the oscillatory connectivity correlates of pSTM. Phase synchronization in the theta and alpha (4-12 Hz) bands is computed using weighted phase lag index with respect to temporoparietal (TP) regions, which include the posterior superior temporal gyrus, planum temporale and adjacent posterior supramarginal gyrus. These TP regions are implicated in phonological retrieval, and the maintenance of auditory-verbal stimuli in STM over extended delay periods. During pSTM, the phonological representations are thought to be maintained by constantly refreshing them via internal articulatory rehearsal processes. We expect that these rehearsal processes would be supported by phase synchronization between TP and posterior frontal and insular regions, including the pars opercularis and Rolandic operculum. We also plan to explore cross-frequency coupling between theta phase and gamma amplitude within TP regions as a potential mechanism supporting pSTM. The MEG experiments and analyses, as planned in the current study, will elucidate key nodes and frequencies of oscillatory connectivity associated with phonological STM functions in healthy individuals and SWA. The data will identify potential targets for tACS paired with STM therapies to exogenously augment connectivity across specific phonological subnetworks in future studies.

Topic Areas: Disorders: Acquired, Phonology

## Dissociating reading and auditory comprehension in persons with aphasia

***Poster D41*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Rationale: Language comprehension is often affected in individuals with post-stroke aphasia. However, deficits in auditory comprehension are not fully correlated with deficits in reading comprehension and the mechanisms underlying this dissociation remain unclear. This distinction is important for understanding language mechanisms, predicting long-term impairments, and future development of treatment interventions. Using comprehensive auditory and reading measures from a large cohort of individuals with aphasia, we evaluated the relationship between aphasia type and reading comprehension impairments, the relationship between auditory vs. reading comprehension deficits and the crucial neuroanatomy supporting the dissociation between reading and auditory deficits. Methods: Scores from the Western Aphasia Battery Revised (WAB-R) from 70 participants with aphasia after a left-hemisphere stroke were utilized to evaluate both reading and auditory comprehension of linguistically equivalent stimuli. Univariate ANOVAs were used to assess the relationship between auditory comprehension and aphasia types and linear models were employed to test the relationship between reading and auditory comprehension deficits. Lesion symptom mapping (LSM) was used to determine the dissociation of crucial brain structures supporting reading comprehension deficits controlling for auditory deficits and vice-versa. Results: Participants with Broca's or global aphasia had the worst performance on of reading comprehension. Auditory comprehension of the same tasks explained 26% of the variance in reading comprehension for sentence completion and 44% for following sequential commands. Controlling for auditory comprehension, worse reading comprehension performance was independently associated with damage to the inferior temporal gyrus, fusiform gyrus, posterior inferior temporal gyrus, inferior occipital gyrus, lingual gyrus, and posterior thalamic radiation. Conclusion: Auditory and reading comprehension are only partly correlated in aphasia. Reading is an integral part of daily life and directly associated with quality of life and functional outcomes. This study demonstrated that reading performance is directly related to lesioned areas in the boundaries between visual association regions and ventral stream language areas. This behavioral and neuroanatomical dissociation provides information about the neurobiology of language and mechanisms for potential future treatment interventions.

Topic Areas: Disorders: Acquired, Reading

## Using an automated segmentation of the language pathways for neurosurgical planning

***Poster D42*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Presurgical brain imaging provides neurosurgeons with tools to better plan their access strategy to a brain tumor (Potgieser et al., 2014). To date, diffusion MRI data is often measured pre-surgically, followed by deterministic tractography and manual segmentation of white matter tracts (Wakana et al., 2007). Replacing manual segmentation with automatic segmentation and quantification tools is desirable because it is faster, cheaper, and more objective. This would allow expanding these methods to other patient populations. Automatic procedures for segmentation and quantification of white matter tracts have been applied to data from neurological populations (Deng et al., 2021). However, to our knowledge, such methods have not been systematically compared with manual segmentation procedures in patients with brain lesions. Validating automatic segmentations against manual methods is a critical step before adopting the automatic tools as part of the clinical protocol. In this study, we quantitatively compared automatic and manual tract segmentations in 31 patients with temporal, frontal or parietal lesions (mean age: 43y ±14, 18 males, 26 with left hemisphere lesions). Diffusion MRI data were collected in a 3T Philips scanner, using a diffusion-weighted, single-shot EPI sequence (32 diffusion directions at b = 1000 and 1 volume at b = 0 s/mm^2, voxel size: ~2*2*2mm^3). For each patient we identified four language-related tracts and their right hemisphere homologs: the arcuate fasciculus, inferior fronto-occipital fasciculus, inferior longitudinal fasciculus and uncinate fasciculus. For automatic segmentation, we used the Automatic Fiber Quantification (AFQ) package (Yeatman et al., 2012). Manual segmentations followed a published protocol (Wakana et al., 2007). Both methods showed a similar identification ratio: The automatic method identified 229/248 tracts, the manual method identified 225/248 tracts. Visual inspection of individual tracts showed a good fit between the methods generally, and, in some cases, higher sensitivity of the automatic methods. Quantitative estimates (fractional anisotropy and mean diffusivity) derived from automatic and manual segmentations of left hemisphere tracts were very highly correlated (r = 0.92-0.99). Some right hemisphere tracts showed slightly lower correlation values (r = 0.77-0.99). Anisotropy profiles of manually and automatically identified tracts overlapped closely in most of the left hemispheric tracts, while the right hemispheric tracts and the left uncinate fasciculus showed significant differences between the methods. In sum, the results so far provide encouraging data that support using automatic segmentation methods in patients with brain lesions, followed by visual inspection and minimal manual editing. In most patients, the lesions were located in the left hemisphere. Therefore, differences found in segmentations of the right hemispheric tracts are of lesser significance for presurgical planning. Future studies will examine the effects of lesion location, size, type and grade on the fit between tract segmentation methods.

Topic Areas: Disorders: Acquired,

## The importance of the starting point: the role of aphasia severity in the prediction of early and chronic recovery in post-stroke aphasia

***Poster D43*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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INTRODUCTION: research in aphasia in the last decade has highlighted the importance of prediction models to help clinicians in patient’s follow-up management. For example, several anatomical predictors, such as white matter diffusion measures, have been suggested. Furthermore, chronic prediction models abound in literature because of easier logistics and the search of longer-term applicability. However, diffusion methodology and chosen measures vastly differ among studies, and the earlier phase of recovery is usually neglected. Here, we intended to explore how early recovery differs from chronic recovery in a cohort of participants with post-stroke aphasia. Our second aim is to study the prediction of both early and chronic aphasia recovery using language assessments and white matter-derived measures. METHODS: twenty-three participants (8 female, 71 y.o. ± 13.01) presenting acute aphasia following a non-lacunar stroke in the left hemisphere were recruited. A magnetic resonance imaging (MRI) and language assessment were conducted in the acute (2±1 days), subacute (10±3 days) and chronic phase (> 6 months). We measured aphasia severity with a Composite Score (CS) assessing naming, comprehension, and repetition at each time point (CSacute, CSsubacute, CSchronic) and recovery phases (Early Recovery [CSsubacute - CSacute,] and Chronic Recovery [CSchronic - CSsubacute]). The MRI was acquired on a 3T-Siemens scanner, including a T1-weighted (T1w) and a diffusion weighted imaging (DWI) sequence. Tractographies from bilateral Arcuate Fasciculus (AF), SLF (Superior Longitudinal Fasciculus), IFOF (Inferior Fronto-Occipital Fasciculus), and UF (Uncinate Fasciculus) were reconstructed, and fractional anisotropy (FA), axonal diffusivity (AD), and mean diffusivity (MD) were extracted. We used T-tests to compare the different scores, and multivariate regression analyses for each timepoint language score and recovery score with age, education, and lesion size as covariates. RESULTS: the amount of recovery was not different between early and chronic phases (t = -0.39, p = 0.7). At the early phase, prediction of subacute language status (CSsubacute) reached a R2 = 0.74, with baseline language assessment (CSacute) as the best predictor, with measures from left AF and lesion size as other significant predictors. However, early recovery was only partially predictable (R2 = 0.48), the best predictors being diffusion measures from the left AF and the left IFOF. At the chronic phase, prediction of chronic language status (CSchronic) reached a R2 = 0.76, with diffusion measures from left IFOF, left SLF and right SLF as the best predictors. Prediction of chronic recovery reached a R2 = 0.78, with diffusion measures from left IFOF, left SLF and right SLF and CSsubacute as best predictors. No moderation effect was found in the early recovery phase. CSsubacute showed a moderation effect in chronic phase on white matter measures (left IFOF and left SLF). CONCLUSION: similar trajectory of score changes was observed over the two recovery phases. Prediction in early stages depends greatly on the baseline language status, whereas prediction of chronic recovery seems related to anatomical factors but dependent on severity. These results highlight the need to study the different recovery phases to obtain a full picture of the role of these factors in post-stroke aphasia recovery.

Topic Areas: Disorders: Acquired,

## Investigating the impact of aphasia on language comprehension and simple

## arithmetic

***Poster D44** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The nature of the relationship between language and basic mathematical ability is unclear. Prior research finds mixed evidence of whether common neural mechanisms underlie language and arithmetic processing. In individuals who suffer a stroke, language impairments (aphasia) and mathematical impairments (acalculia) are frequently comorbid. Only one prior study by Baldo & Dronkers (2007) has used voxel-based lesion-symptom mapping (VLSM) to explore commonalities between arithmetic and language comprehension in a sample of post-stroke participants. They found that arithmetic and language comprehension were associated with both converging areas (inferior frontal gyrus) and distinct areas (left inferior parietal lobe and left superior and middle temporal gyri, respectively). The current study explores whether these results can be replicated through a similar preliminary sample of 50 chronic post-stroke participants using the same Western Aphasia Battery (WAB) calculation subtest. We assessed participants on the WAB to derive an aphasia quotient for each individual. Participants were categorized as having no aphasia, mild aphasia, or moderate/severe aphasia. Identical to Baldo & Dronkers, we used the WAB calculation subtest as a measure of arithmetic ability across operation types (i.e., addition, subtraction, multiplication, and division). To assess language comprehension, we isolated the Auditory Verbal Comprehension score from the WAB. We replicated an ANCOVA using the same covariates employed by Baldo & Dronkers (age, education, lesion volume, months post-onset). Our results were in line with the prior findings, demonstrating a main effect of aphasia severity on performance and an interaction effect between aphasia severity and measure, where the difference in calculation versus comprehension scores varied by severity. Next, we employed VLSM using the same threshold parameters and found, similar to the results of Baldo & Dronkers, evidence that the left inferior frontal territory contributes to both arithmetic and language comprehension. In this preliminary sample, voxels within the parietal territory did not meet criteria for inclusion in the VLSM map (n < 15); however, acquisition of the intended full sample should allow for a test of the replicability of the calculation-specific VLSM parietal cluster reported by Baldo & Dronkers. Based upon the results in hand, our findings converge with Baldo & Dronkers to suggest that there are shared neural substrates between language comprehension and simple arithmetic.

Topic Areas: Disorders: Acquired,

## Is there an auditory discrimination defect in dyslexia? A study using time-frequency analysis of mismatch responses of Chinese children

***Poster D45** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Developmental dyslexia is a neurodevelopmental disorder characterized by a notable delay in reading ability. This delay is primarily attributed to a phonological deficit, as suggested by prevailing theories.

Mismatch Negativity (MMN) is a highly sensitive indicator of automatic auditory information processing and can be utilized to identify neural abnormalities in children with dyslexia. However, there is limited research available on dyslexia that investigates the time-frequency information within MMN. Additionally, there is a lack of research specifically focused on dyslexia within Chinese, which is a non-alphabetic language featuring four different tones at the suprasegmental level. The objective of our study is twofold: (1) To determine whether significant differences exist in the time-frequency information processing of MMN between dyslexic children and non-dyslexic children; (2) To explore how the neural representation of auditory features in Chinese-speaking children is influenced by reading-related cognitive abilities, subsequently impacting reading performance. Method: The study involved 22 Chinese children aged 8 to 14, comprising 18 Developmental Dyslexic (DD) children and 6 Non-Dyslexic (ND) children. We assessed their reading-related cognitive abilities. Then the children instructed to ignore the presented sounds through the air tube headsets while watching a silent cartoon. Lexical tone pairs and consonant pairs were played in two separate experiment sessions. The tone pairs session presented /ji1/ as a standard and /ji4/ as a deviant; the consonant pairs presented /ta1/ as a standard and /ba1/ as a deviant. We used MNE to do EEG data processing and run time-frequency analysis to obtain the ITC of MMN. The frequency range was specified as 4–7 Hz (theta range), electrodes of 'Fz' 'F3' 'F4' were chosen, and the time window was 320-390ms. The independent samples t-test was conducted between DD and ND using ITC index as the dependent variable. The correlation between the ITC and reading-related cognitive tests was calculated, and the mediation model was constructed using the PROCESS plugin in SPSS 26.0. Results: The results of the t-test revealed that, in the tone pairs condition, the DD group exhibited significantly higher Inter-Trial Coherence (ITC) compared to the ND group ($t = -2.14$, $p = 0.04$) during standard stimulus trials. Additionally, the ITC index, specifically under the tone pairs condition, exhibited a negative correlation with test scores of Character Recognition, Three-minute Speed Reading, and Phenome Deletion. The findings from the mediation model indicated that ITC, under the tone pairs condition, indirectly influences Three-minute Speed Reading through the mediator Phenome Deletion Task. Furthermore, the direct effect of ITC on Three-minute Speed Reading was found to be insignificant, suggesting that Onset Deletion Task serves as a complete mediator. Conclusion: Our findings revealed an enhanced ITC in the theta frequency band over the MMN time window. These findings shed light on the neurophysiological processes involved in auditory discrimination between children with developmental dyslexia and non-dyslexic children, particularly within the context of a non-alphabetic language. Additionally, our study confirmed the significant impact of phonological perception on phonological awareness, which in turn contributes to children's reading performance.

Topic Areas: Disorders: Developmental, Phonology

## Age-related changes in individuals with and without reading disability: behavioral and fMRI evidence

***Poster D46*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Reading disability (RD) is a common developmental disorder with a prevalence of 10% across languages, however, the etiology has been poorly understood. Developmental studies are important in differentiating persistent deficits, developmental delays and accumulative effects of RD. By using a cross-sectional design, we compared Chinese children and adults with and without RD in the behavior and brain function. In the behavioral Level, we found persistent deficits in phonological awareness and word reading speed, suggesting definitive features of RD. We also found deficits in word reading accuracy only in children but not adults with RD, suggesting a developmental delay. Furthermore, deficits in sentence reading fluency were more evident in adults than children with RD, suggesting that this is an accumulative effect of RD which is more severe with time passing by. In the brain level, we found reduced brain activation in the left inferior frontal gyrus (IFG) only in children with RD than age controls but not in adults with RD, suggesting developmental delay. In contrast, we found reduced brain activation in the left inferior temporal gyrus (ITG) in adults with RD than age controls, and there was a less reduction in children with RD, suggesting that this is an accumulative effect of RD, because the abnormality is greater in adults than children with RD. These findings were replicated in three tasks, namely, an auditory rhyming task, a visual rhyming task, and a visual spelling task. These findings could be explained by greater developmental increase in the left IFG in RD readers than age controls and greater developmental increase in the left ITG in age controls than in RD readers. Further analyses revealed that the left IFG was correlated with word decoding accuracy in children with RD and the left ITG was correlated with sentence reading fluency in adults with RD, suggesting their different functions in reading. Taken together, our results suggest that individuals with RD catch up on phonological reading by involving the left IFG to an appropriate degree, but they can never reach fluent orthographic reading in the left ITG. The current study advances our understanding of the prognosis of RD.

Topic Areas: Disorders: Developmental, Reading

## Neural impact of Skill and Goal-based Training in Adults with Dyslexia: A Randomized Trial

***Poster D47*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Background. Developmental Dyslexia is a lifelong, neurodevelopmental disorder characterized by difficulties in sound processing, inaccurate word recognition and slow reading speed. In addition, there is evidence for reduced brain activation and connectivity in reading-related brain areas in adults with Dyslexia. To date, adult-based reading intervention programs have primarily targeted skill improvement in phonics, morphology, and fluency; however, the behavioural and neural consequences of these skill-based programs remain small-to-moderate. Furthermore, adults have unique contexts like work, education and social lives, which makes it challenging to implement appropriate and feasible interventions. Interventions that go beyond skill-based literacy training to a more holistic, personalized framework are a potential avenue to increase remediation success. In this study, we investigated the neurobiological impact of two intervention programs-a prescriptive, skilled-based training and a personalized, goal-based training- in adults with Dyslexia. Methods. Twenty-one participants with Dyslexia were randomly assigned to one of the training programs: Skill Group (N= 12) and Goal Group (N= 9). Participants completed pre-intervention behavioural (i.e., standardized assessments of reading fluency and decoding and comprehension) and functional near-infrared spectroscopy (fNIRS) (i.e., sound awareness (phoneme deletion task) and comprehension (sentence comprehension)) tasks. Participants then started their respective training programs for eight weeks. In the skill-based training, participants completed training/testing modules on phonology, orthography, morphology and reading fluency. In the Goal-based training, each participant completed the Goal Attainment Scaling measure to identify four literacy-based goals and completed activities to target those goals. After the eight weeks of training, participants completed the same behavioural and fNIRS tasks (with different stimuli). Analysis. The fNIRS data was first assessed for signal quality and then subjected to a standardized preprocessing pipeline (e.g., downsampling, optical density conversion, motion correction, etc.). Next, oxygenated and deoxygenated hemoglobin concentrations for eight brain regions were extracted, including bilateral fusiform gyrus, superior temporal gyrus, medial prefrontal cortex and supramarginal gyrus. A series of 2 (time: pre and post) x 2 (group: skill and goal) mixed measures ANOVA were conducted to identify any significant training effects on the concentration values. Results. Significant improvement in reading fluency, decoding and passage comprehension was found for both intervention groups. During the phoneme deletion task, there was increased brain activity in the left fusiform gyrus (FFG) and right superior temporal gyrus (STG) for the Skill-based group. During the reading comprehension task, decreased brain oxygenation was found in the left medial prefrontal cortex (MPFC) for both training groups. These findings demonstrate that the training was associated with normalizing activity in literacy-based brain areas (left FFG), compensatory activity in right-hemispheric literacy brain areas (right STG and FFG) and disengagement of the default mode network (left MPFC). Conclusion. This study found evidence for normalizing (i.e., significant activation in the typical reading network) and compensatory changes (i.e., significant activation in the regions outside the reading network) in the brain. Moreover, we provided preliminary evidence for the usefulness of goal-based intervention for adults with Dyslexia.

Topic Areas: Disorders: Developmental, Reading

## EEG/MEG resting state activity in dyslexia: a systematic review

***Poster D48*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Developmental dyslexia (DD) is defined as a difficulty in learning to read despite normal intelligence, sensory acuity, and educational opportunities. A weakness in phonological awareness is implicated in DD. In parallel, differences in white matter connections within the language network have been observed in dyslexia. Specifically, the neuronal tracts that connect the left inferior frontal gyrus (IFG) to the posterior areas, the inferior parietal lobule (IPL) and visual word form area (VWFA), are affected, possibly resulting in hypoactivity within the posterior areas of the reading network, and hyperactivity in other brain areas due to compensation. Resting state differences in DD have been observed in research findings, and this systematic review is intended to compile and integrate these findings. We aim to build a comprehensive picture of brain activity in DD during rest using electroencephalography (EEG) and magnetoencephalography (MEG). EEG and MEG were selected due to their good temporal resolution allowing examination of the effects of DD on the frequency bands. Several different analysis methods have been used in the literature, and a systematic review is needed to understand the effect of these different methods and the reliability of findings in dyslexia-related resting state research. This review is currently underway. The 562 research papers found using our search terms were cut down to 25 peer reviewed research papers in a partially blinded two-step eligibility evaluation. The remaining papers are in the process of quality assessment using the AXIS appraisal tool for cross-sectional studies. The data extraction is also currently being carried out and will include the effects of DD on the main frequency bands, affected brain areas, effects on connectivity between these brain areas, and statistical significance. These research papers contain several different analysis methods, and we are currently examining different methods to combine the results into a comparable format. The main categories of methodology are power spectrum analysis, graph theory, and connectivity. The heterogeneous nature of the approaches and lack of parameter estimates reported preclude the possibility for meta-analysis.

Topic Areas: Disorders: Developmental, Reading

## Writing Fluency and Consistency Problems in Chinese Children with Reading Difficulties: A Potential Role for Procedural Memory

***Poster D49*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Reading difficulties (RD) in children frequently coincide with writing issues, suggesting interlinked cognitive processes underlying these skills. However, previous research on writing problems in children with RD has focused on overall handwriting accuracy, and seldom touched upon the online handwriting process. Here we examined handwriting fluency (i.e., pauses during handwriting) and handwriting consistency (i.e., stroke order consistency in writing the same constituents) among Chinese children with RD. Based on the Procedural circuit Deficit Hypothesis (PDH; Ullman et al., 2020), we hypothesized a potential contribution of procedural memory to handwriting difficulties in RD. The PDH suggests that RD may be partially explained by impairments of procedural memory, which is defined as the learning and memory that depend on the basal ganglia and associated circuitry. Forty-four native Cantonese-speaking children (6.42-11.92 years old, mean = 9.10 years ) participated in this study. Twenty-two were diagnosed with RD, while 22 showed typical development (TD). We measured handwriting fluency in terms of the duration of pauses between successive strokes (inter-stroke intervals or ISIs) in a Chinese character copying task (Lau, 2020), utilizing repeated radicals across four blocks to assess children's grasp of radicals as functional writing units in Chinese. Longer ISIs indicated prolonged pauses and represented lower handwriting fluency. Handwriting consistency (how many radicals were repeated in the same stroke order) and repetition benefits (improved fluency or ISI reduction across blocks) were also assessed. Procedural memory was assessed with sequence learning (the difference in reaction time between randomly ordered items and sequenced items) in a Serial Reaction Time task (SRT; Lum et al., 2012), which has been shown to rely on the basal ganglia (Janacsek et al., 2020). Results from a mixed-effects model showed significant radical-level processing (i.e., longer between-radical ISIs than within-radical ISIs) in both groups, but the children with RD exhibited significantly longer between-radical ISIs than the TD children, suggesting less fluent retrieval of radicals or motor planning in the children with RD. Furthermore, the TD children displayed a consistent reduction in ISIs across blocks, an effect that was absent in the children with RD, indicative of diminished repetition benefits in the RD children's handwriting fluency.

Additionally, the children with RD showed significantly lower handwriting consistency than the TD children. While the children with RD showed a non-significant trend towards worse procedural learning than the TD children in the SRT task ($p = 0.07$), we observed a significant three-way interaction between group (RD vs TD), blocks, and procedural learning in a mixed-effects model. Specifically, better procedural learning only predicted greater repetition benefits (ISI reduction across blocks) for writing fluency in the TD children, but not in the children with RD. In conclusion, our preliminary results revealed handwriting fluency and consistency difficulties in Chinese children with RD, and supported PDH by showing a differential role for procedural memory in the writing processes of TD children versus those with RD. The findings have potential translational applications in clinical interventions and educational strategies.

Topic Areas: Disorders: Developmental, Writing and Spelling

## Biomarkers of Developmental Language Disorder and their Relationship with Language Impairment

***Poster D50*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Developmental Language Disorder (DLD) is a heterogenous neurodevelopmental disorder that affects a child's ability to comprehend and produce spoken or written language but cannot be attributed to hearing loss, intellectual disability, or neurological damage. DLD affects around 7-8% of kindergarten-age children in the United States making it more prevalent than other more widely recognized developmental disorders, such as autism spectrum disorders (ASD) and dyslexia (Zablotsky et al., 2019). Children with DLD often suffer from higher levels of depression and social anxiety than typically developing (TD) children and these symptoms tend to persist into adulthood (Botting et al., 2019). Despite the prevalence of DLD and the profound impact it can have on overall well-being, little is understood about the underlying neurobiological mechanisms that contribute to it, as neuroimaging findings are inconsistent regarding the ways in which these factors contribute to language impairment. Nonetheless, there is growing evidence that both structural and functional brain differences exist. Of particular interest to this proposal are functional brain differences that impact language abilities. The few functional magnetic resonance imaging (fMRI) studies of children with DLD have found varying results for between- and within- group comparisons (Evans & Brown, 2016). This variability may have to do with differences in the underlying properties that support brain function (e.g., neurovascular, hemodynamic, etc.). In this ongoing work, we employ metrics of brain health and functionality that include measures of cerebral blood flow (CBF) and intrinsic functional connectivity (iFC) patterns to investigate potential biomarkers of DLD and their relationship to language abilities. To this end, we have piloted the imaging and behavioral testing procedures in both neurotypical adults (n=10) and children (n=2) to ensure feasibility and data quality. Ongoing testing will target 20 monolingual, English-speaking children with DLD and 20 TD children. All participants will be between the ages of 9-11 years (to better account for changing neurological and linguistic milestones) and will be matched at the group level for sex, non-verbal intelligence, and socioeconomic status. All children will be tested on a range of linguistic and non-linguistic assessments and will complete MRI scanning. MRI sequences will include resting-state pseudo-continuous arterial spin labeling (pCASL) to characterize patterns of cerebral blood flow (CBF), resting-state echo planar imaging (EPI) to examine intrinsic functional connectivity (iFC) in language networks, and structural sequences (T1-weighted and T2-weighted). CBF data will be processed using the ASLprep Pipeline to generate CBF values across the whole brain and in language regions of interest (ROIs). iFC data will be processed using the CONN toolbox. An ROI-ROI correlation approach will be used to examine network connectivity in the same language ROIs used for CBF analyses. A linear mixed effects model will be used to examine the relationship between CBF, connectivity indices emerging from the iFC analysis, and language assessment scores to determine if the relationships between CBF, iFC and language skills in children with DLD differ from those observed in TD children. This research will provide a new approach to understanding links between underlying brain function and language in DLD.

Topic Areas: Disorders: Developmental,

## Language in people with cervical dystonia: Evidence of grammatical and specific semantic deficits.

***Poster D51*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Background: Cervical dystonia (CD) is a chronic neurological condition that is characterised by intermittent and/or sustained involuntary contractions of the neck muscles. Although historically considered a motor disorder, CD may present with subtle cognitive impairments. Like many motor disorders, CD is attributed to basal ganglia dysfunction. Basal ganglia dysfunction in other neurological conditions can lead to language impairments in the domains of phonological processing, grammar and syntax, and action semantics; as processing action words recruits the same cortical regions involved in executing the actions these words refer to. Despite this, language in people with CD (pwCD) remains unexplored. Objectives: The current study aimed to explore phonological, grammatical, and semantic language abilities in pwCD compared to neurologically healthy controls. Methods: 19 pwCD and 20 controls completed the Object and Colour subtests of the Rapid Automized Naming Task (RAN), the Test for Reception of Grammar-2 (TROG-2), and a lexical decision task with a masked priming paradigm that compared reaction times to words varying according to two factors- hand relatedness (hand-related, non-hand-related) and word category (verb, noun). Results: Compared to controls, pwCD were less accurate at grammatical comprehension on the TROG-2 ($p<.05$, n2=.15). There were no significant differences between pwCD and controls in phonological retrieval as measured by the RAN. PwCD demonstrated a specific semantic impairment for hand-related words, showing reduced masked priming effects for hand-related verbs and nouns compared to controls ($p<.01$). Priming effects for non-hand words in pwCD were comparable to that of controls ($p=.13$). Conclusion: The present study found significant evidence that pwCD perform worse on measures of grammar and action-related semantics. This provides evidence that the motor system may play an important role in language processing. Language represents a fundamental ability and thus language in pwCD is an important consideration for research and clinical practice.

Topic Areas: Disorders: Developmental,

# Combining MEG with Real-time Measures of Articulation during Speech: The MASK system

***Poster D52*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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MEG recordings of movement-related brain activity provide an ideal method for the study of the cortical control of movement. However, MEG measurements associated with overt speech is limited due to the challenge of tracking speech movements in the MEG environment, particularly for small movements of the tongue which requires non-line-of-sight methods. We have developed an MEG-compatible motion tracking system to monitor brain activity in parallel with ongoing orofacial and speech movements. This technology, dubbed MASK (Magneto-articulography for the Assessment of Speech Kinematics), can be integrated into existing MEG recording systems to acquire 3-dimensional kinematic data simultaneously with neuromagnetic brain activity [1]. This system has been shown to measure speech kinematics comparable to conventional articulography measurement systems [2]. Methods: 10 healthy adults performed a repetitive speech task (10 second trials x 10 repetitions) involving reiterated disyllabic non-words (/ipa/, /api/), non-speech mouth opening-closing, and a simple manual motor task (left and right button press). Speech gestures and non-speech mouth movements were tracked in real time along with brain measures using a 275-channel MEG (CTF Systems, Vancouver) by affixing MASK sensors on the upper and lower lip (bilabial closure) and tongue body (tongue movements associated with vowel formation /a/ versus /i/) in addition to the acoustic speech signal. Results: Source analysis of MEG data showed suppression of beta band (15-30Hz) oscillations during speech localized to regions of the precentral gyrus ventral to the hand motor area activated during button press. Beta suppression during reiterative speech was strongly left lateralized in contrast to non-speech movements which were associated with bilateral beta suppression in lateral motor cortex, similar to that observed during a simple CV repetition task time locked to speech onset [3]. Conclusions: Preliminary results demonstrate the ability to measure time-locked brain responses and speech kinematics during speech tasks using a novel MEG compatible motion-tracking system. Differences in patterns of brain activation between non-speech movements and speech tasks involving articulatory control demonstrate the importance of both task design and the ability to measure complex speech gestures concurrently with functional brain imaging to understand the underlying mechanisms of speech motor control. This technology provides new avenues for both basic research on articulatory control and speech sound disorders. References: [1] Alves, N., Jobst, C., Hotze, F., Ferrari, P., Lalancette, M., Chau, T., van Lieshout, P. & Cheyne, D. (2016). An MEG-compatible electromagnetic-tracking system for monitoring orofacial kinematics. IEEE Trans. Biomed. Eng., 63, 1709–1717. [2] Anastasopoulou, I., van Lieshout, P., Cheyne, D. & Johnson, B. W. (2022), Speech kinematics and coordination measured with an MEG-compatible speech tracking system. Front. Neurology, 13: [3] De Nil L., Isabella S., Jobst C., Kwon S., Mollaei F. & Cheyne D. (2021) Complexity-dependent modulations of beta oscillations for verbal and nonverbal movements. J. Speech Lang. Hear. Res. 64: 2248-2260. Acknowledgements: Supported Australian Research Council (DP170102407) and Natural Sciences and Engineering Research of Canada (CPG-104310) and the Waterloo Foundation, UK.

Topic Areas: Speech Motor Control, Methods

## ERP signals during articulation: should we remove AEP?

***Poster D53*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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In order to study speech planning of multiple syllables/words, it may be necessary to analyse the EEG event-related potentials (ERPs) signal during articulation. However, producing speech involves the overlapping of motor- and auditory/language- related processes. When analysing ERPs during articulation, muscle artefacts but also auditory evoked potentials (AEPs) may mask components related to the encoding of upcoming speech. Muscle artefacts can be removed with appropriate filtering and averaging across trials, or with the use of specific cleaning algorithms. Surprisingly, the processing of AEPs in the study of articulatory production has received, to our knowledge, little to no attention. Thus, the current project focused on distinguishing the signal related to speech planning and programming from the signal related to auditory processing during speaking. In a delayed production task, participants were asked to overtly produce two syllable non-words when a question mark appeared on the screen. On certain trials, no question mark appeared and they had to remain silent. In a second part, they had to listen to the recording of their own productions. In order to keep them focused on the task, they had to report occasional productions from another speaker. While they completed the task, we recorded the EEG signal from 128 channels. Here we report the preliminary results from seven young adults. We will increase our sample size until the meeting. For the analysis, we extracted ERPs aligned to the vocal onset in a time window running from 300 ms pre- to 200 ms post-vocal onset. After subtracting the ERPs associated to the listening signal from the ERPs of the production task, we compared the production average signal as recorded to the production average signal after subtraction. A mictrostate analysis showed that around 100-200 ms following vocal onset, the subtraction permitted to highlight a central positivity that was hidden by the AEP N1 component. The presence of this specific topographic map was accompanied by an increase in the global field power (GFP), indicating that the AEP N1 cancelled the central positivity. The rest of the signal in the time window of interest showed the same topographic maps and similar GFP amplitudes before and after subtraction. This result offers promising perspectives for the analysis of speech production related processes during articulation.

Topic Areas: Speech Motor Control, Methods

## Language dominance is associated with greater speech motor adaptation in unbalanced bilinguals

***Poster D54*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction. In the altered auditory feedback (AAF) paradigm, the speaker learns to adjust their speech motor commands to offset the perceived error in their speech (in reality the altered feedback). This process is termed (speech motor) adaptation. Novel AAF studies in bilinguals suggest that greater second language experience is associated with stronger adaptation responses in that language, and transfer of adaptation into the unperturbed other language (Shiller et al., 2021). However, it is unclear how language dominance and task language mediate adaptation and transfer of adaptation in bilinguals, especially in similar (but not identical) vowels, and across dense and sparse vowel spaces. This experiment assesses adaptation and possible transfer in both an individual's dominant and phonologically similar non-dominant language. Methods. Two groups of English-dominant (n=14) and Spanish dominant (n=14) English/Spanish bilinguals (B2/C1-proficiency in non-dominant language) completed AAF tasks in both languages, >1 week apart. In the baseline phases, speakers produced 30 unperturbed tokens each of the words "head" (English) and "pez" (Spanish). During each Hold phase, speakers produced 120 trials each of "head" or "pez" according to their assigned perturbed language for the session. In each Hold trial, vowel productions were downshifted -130 mels in F1 and upshifted +130 mels in F2 in real time, using Audapter (Cai et al., 2008). Afterwards, in the Transfer phase, participants produced 30 trials of "head" or "pez" in the unperturbed language, thereby switching languages between phases. The last 30 trials of the Hold phase were used for analysis of online adaptation. The 30 Transfer trials were used for analysis of offline transfer of adaptation into the unperturbed language. Adaptation magnitudes were calculated by projecting F1 and F2 change from the baseline in each trial onto the vector of perfect opposition to the perturbation. Results. While producing English words, the English-dominant group showed significantly more adaptation to altered feedback than the Spanish-dominant bilinguals (p=0.039). Conversely, in the Spanish word production task, the Spanish-dominant group showed significantly higher adaptation magnitudes than the English-dominant group (p=0.032). No group significantly outperformed the other when producing words in their dominant language (p=0.44) or in their non-dominant language (p=0.39). When the language of the Transfer phase corresponded with the dominant language of the group, both groups showed adaptation significantly above 0 (English-dominant: p=0.02; Spanish-dominant: p=<0.001) despite showing non-significant or negative adaptation in their non-dominant language in the previous adjacent phase. Conclusions. Language dominance is associated positively with adaptation magnitude. Task language was not significantly associated with adaptation magnitude. It appears to be possible to transfer speech motor learning into the unperturbed dominant language offline following AAF in a non-dominant language, despite non-significant online adaptation. References: Cai, S., Boucek., M, Ghosh, S.S., Guenther, F.H., & Perkell, J.S. (2008). A system for online dynamic perturbation of formant frequencies and results from perturbation of the Mandarin triphthong /iau/. Proceedings of the 8th Intl. Seminar on Speech Production, Strasbourg, France, Dec. 8-12. Shiller, D.M., Bobbit, S. & Lametti, D. R. (2021). Sensorimotor adaptation in bilingual speech. SNL 2021 Virtual Edition, 5-8 October 2021.

Topic Areas: Speech Motor Control, Multilingualism

## Altered EEG Functional Connectivity and Impaired Speech Control in Post-Stroke Aphasia

***Poster D55*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: Synchronization of oscillatory brain activity has been proposed to reflect the underlying neurocomputational processes that are critical for speech production and sensorimotor control. While there is evidence for altered neural or brain connectivity in sensorimotor networks during speech processing and production in individuals with left-hemisphere stroke, the impact of network-level deficits associated with disrupted speech auditory feedback control in post-stroke aphasia has yet to be widely explored. Methods: Electroencephalographic signals were recorded from 40 post-stroke aphasia (17 female; mean age: 61.04 years) and 39 neurologically intact control (29 female; mean age: 61.18 years) participants during speech vowel production and listening tasks under pitch-shifted altered auditory feedback (AAF; delivered at ±100 cents magnitudes) conditions. Using weighted phase-lag index (wPLI), we calculated broadband (1-70 Hz) functional connectivity between electrode pairs covering the frontal, pre- and post-central, and parietal regions. We also investigated associations between connectivity and motor speech compensatory behavior and left-hemisphere lesion profiles. Results: wPLI analysis revealed reduced fronto-central delta- (1-4 Hz) and theta- (4-7 Hz) band and centro-parietal low-beta (13-20 Hz) band connectivity in electrodes covering the left-hemisphere and diminished speech AAF compensation responses in post-stroke aphasia as compared with controls. Lesion mapping analysis demonstrated that stroke-induced damage to multi-modal brain networks within the inferior frontal gyrus, Rolandic operculum, inferior parietal lobule, angular gyrus, and supramarginal gyrus predicted reduced functional neural connectivity within the delta and low-beta bands during both speaking and listening tasks in aphasia. Conclusion: Findings from the current study provide novel insights into network-wide disrupted EEG functional connectivity in participants with post-stroke aphasia associated with atypical modulation of speech compensatory responses under AAF conditions. In addition, our findings also suggest that stroke-induced damage in speech sensorimotor networks predict atypical speech compensation and disrupted low-beta band connectivity, potentially indicative of functional reorganization. These findings motivate future research to further examine the complex interplays between brain connectivity and sensorimotor deficits, thereby, introducing more avenues for interventions of speech disorders in post-stroke aphasia and other neurological conditions.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

## Experimental paradigm for measuring metacognitive awareness of errors in self-produced speech

***Poster D56*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Continuous monitoring of speech auditory feedback is integral to fluent and accurate speech production. Neural control systems compare internal representations of intended speech to actual speech output and, upon mismatch detection, modify speech to compensate for the discrepancy. These control systems are often assumed to function automatically, but for example, when one is learning to pronounce foreign phonemes or trying to compensate for a speech impairment, auditory feedback needs to be consciously evaluated.

Metacognition is the process that enables individuals to evaluate their performance in different tasks; in this case how well one's speech matches the intended target. How individuals differ in their ability to metacognitively assess errors in auditory feedback, and whether this predicts how they adjust their speech in response to these errors, has not been studied. We are developing and testing a psychophysical experimental paradigm to measure an individual's ability to detect and metacognitively assess errors in self-produced speech. We utilize the widely used altered auditory feedback paradigm where speech motor control is studied by perturbing auditory feedback with artificial errors resulting in a perceived mismatch between intended and perceived speech. Our paradigm consists of a two-interval forced-choice (2IFC) task where participants produce sustained vocalizations of the vowel /u/ for 4 s at a time while their voice is fed back to them in real time through headphones. During each vocalization, the pitch (fundamental frequency, F0) of the auditory feedback is shifted upward for 200 ms during one of two intervals (A or B) displayed on a screen in front of the participants. After each vocalization, the participants evaluate whether the pitch-shift was during interval A or B (perceptual discrimination) and, in addition, report how confident they are in their answer (metacognitive judgement). Pitch-shift magnitudes are individually calibrated for each participant to achieve a constant discrimination accuracy, as task performance affects metacognitive performance. All participants take part in two identical test sessions approximately one week apart. Data collection is ongoing with data of 60 healthy adult participants collected so far. We will use signal detection theory to estimate participants' discrimination sensitivity (d′) and metacognitive ability (meta-d′ and Mratio) to detect the pitch-shifts in their auditory feedback. We will examine whether individual differences in discrimination and metacognitive ability predict how participants adjust their vocalization after the pitch-shift. We will look at the latency, magnitude and direction (i.e., opposing/following) of these vocal responses. We will also calculate the test-retest reliability of the paradigm. In future, we will use this paradigm to evaluate differences in perception and metacognition of self-produced speech between healthy adults and people with Parkinson's disease (PD) to gain a better understanding of the speech deficits associated with PD.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

## Sensitivity to auditory feedback and individual variability

***Poster D57*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Monitoring auditory feedback is important for fluent speech production as it enables detection and correction of vocalization errors. Influence of auditory feedback is best illustrated by manipulating it during speech production. A common temporal manipulation technique is delaying auditory feedback (DAF), which disrupts speech fluency, and a common spectral manipulation technique is perturbing the pitch of auditory feedback, which elicits vocal changes in the opposite direction of the perturbation. Interestingly, not everybody is equally sensitive to auditory feedback manipulations, however the reason for this individual variability is unknown. In this study, we aimed to understand whether there is a correlation between sensitivity to temporal versus spectral manipulations of auditory feedback. And whether less sensitive individuals rely less on auditory feedback when an alternative source of sensory feedback (e.g. visual) is available. To address these questions, we collected data from 40 native Dutch speakers (20 females, mean age: 24.5) during both a DAF and a pitch perturbation task. In the DAF task, participants repeated auditorily presented sentences. Auditory feedback was presented either simultaneously or with 200ms delay. In half of the trials visual feedback was presented additionally via a webcam. Voice recordings of the participants were analyzed using linear mixed effect (LME) models to test the effects of four factors (delay, visual feedback, gender and trial structure) on three speech measures (articulation duration, voice intensity and voice pitch). In the pitch perturbation task, participants phonated the vowel /a/ for 4 seconds and pitch of the auditory feedback was shifted by ±100 or ±200 cents for 300ms at a random latency. LME models were used to test the effects of three factors (shift magnitude, shift direction and gender) on three speech measures (compensatory response magnitude, response latency and percentage of opposing responses). We found that DAF significantly prolonged articulation duration and increased both voice pitch and intensity, but participants' speech rate increased as the experiment progressed. In contrary to our expectations, visual feedback did not ameliorate but reinforced the disruptive effects of DAF. For the pitch perturbation task, we only found that larger pitch shift elicited less compensatory responses. We used articulation duration and compensatory response magnitude to measure sensitivity in the DAF and pitch perturbation tasks, respectively. There was a large individual variability in sensitivity to auditory feedback manipulations for both tasks, however there was no correlation between the sensitivity profiles between tasks. Our results demonstrated that an individual can be sensitive to temporal but not necessarily to spectral manipulations of the auditory feedback, or vice versa, suggesting that these features are processed differently. We also showed that, possibly because visual feedback is not naturally available to us during speech production, it is less likely integrated with auditory feedback to aid speech monitoring. Future research can alternatively test whether some individuals rely more on proprioceptive feedback from articulators to overcome the disruptive effects of auditory feedback manipulations. To explain the neural substrates of individual variability, we are currently collecting fMRI and DTI data, which we plan to include in our presentation.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

## The brain's sensitivity to sensory error can be modulated by altering perceived speech variability

***Poster D58*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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When the sensory outcomes of our speech movements don't match our expectations, we learn from the resulting error, changing our subsequent speech behavior. This process, essential in both acquiring spoken language ability and adapting to changing environments, critically relies on error sensitivity, which governs the proportion of learning that results from a given error. Although behavioral and computational evidence suggests error sensitivity can change in response to task demands, neural evidence regarding the flexibility of error sensitivity in the human brain is lacking. In speech production, the sensitivity of the nervous system to auditory errors has been extensively studied by examining the suppression of neural activity related to auditory processing while speaking (speaking-induced suppression, or SIS). Here, we tested whether the nervous system's sensitivity to errors, as measured by SIS, can be modulated by auditory feedback perturbations that alter speakers' perceived variability. Adult speakers (n = 15) underwent MEG recording while producing monosyllabic words and listening to playback of those words. In three separate sessions, participants were exposed to perturbations that either 1) increased perceived variability, shifting all productions away from their mean formant values, 2) decreased perceived variability, shifting all productions towards their mean formant values, or 3) did not change variability (no alteration to feedback). Our results showed that SIS was attenuated when perceived variability was increased, consistent with predictions generated from previous behavioral data and state-space modeling. Conversely, we observed no significant changes in error sensitivity when perceived variability was unaltered or artificially reduced. The current study establishes the validity of behaviorally modulating the nervous system's sensitivity to errors. As sensitivity to sensory errors plays a critical role in sensorimotor adaptation, modifying error sensitivity has the potential to enhance motor learning and rehabilitation in speech and, potentially, more broadly across motor domains.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

## When Jacques isn't Jack: Simultaneous opposite language-specific speech perceptual learning in French-English bilinguals

***Poster D59** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Lexically-guided phonetic recalibration results from exposing a listener to an ambiguous sound embedded in real words that disambiguate the sound. For instance, a sound between /f/ and /s/ replacing /f/ in 'beautiful' will not only be perceived as /f/, after repeated exposure to the sound in various /f/-words the listener will shift his perception even in the absence of disambiguation (Kraljic & Samuel, 2006; Norris et al., 2003). Conversely the same ambiguous sound replacing /s/ in words like 'currency' will induce a recalibration in the opposite direction. Lexical recalibration has been shown to transfer across languages in listeners of Germanic languages like Dutch, German and English (Reinisch et al., 2013). Besides, it is possible to induce opposite recalibrations simultaneously with different talkers or sequentially with the same talker (Luthra et al., 2021; Saltzman & Myers, 2021). Here we investigate whether (1) lexical recalibration transfers across languages in French-English bilinguals and whether (2) simultaneous opposite language-specific recalibrations can be induced in those listeners with stimuli recorded by a unique bilingual talker. Sixty French-English bilinguals (age: 18-40; French AoA=0; English AoA range = 0-12 year-old) from Montreal, Canada, were tested online. They were divided into four groups. In the first phase, Groups 1 and 2 had exposure in English toward /f/ and /s/ respectively, while Groups 3 and 4 had exposure in French toward /f/ and /s/ respectively. In the second phase, participants underwent an exposure in the opposite direction and in the other language than in the first phase. These exposure blocks were interleaved with shorter blocks aimed at maintaining the initial recalibration induced in phase 1. The perceptual shift (i.e., the perceptual boundary between /f/ and /s/) was

assessed in both languages at the end of both phases. We observed that (1) a perceptual shift (i.e., recalibration) occurred in all groups; (2) recalibration in one language fully transferred to the other language in the first phase, and (3) in the second phase simultaneous opposite language-specific recalibration was induced in all groups. This pattern of results suggests that bilingual listeners may have one common phonemic category for sounds that are very similar across languages, but that these representations can be teased apart into two language-specific phoneme categories based on a short exposure. Overall it highlights the malleability of our mental representations of speech sounds and the role language can play in this flexibility. References: Kraljic, T., & Samuel, A. G. (2006). Generalization in perceptual learning for speech. Psychonomic bulletin & review, 13(2), 262-268. Luthra, S., Mechtenberg, H., & Myers, E. B. (2021). Perceptual learning of multiple talkers requires additional exposure. Attention, Perception, and Psychophysics, March, 2217-2228. Norris, D., McQueen, J. M., & Cutler, A. (2003). Perceptual learning in speech. Cognitive Psychology, 47(2), 204-238. https://doi.org/10.1016/S0010-0285(03)00006-9 Reinisch, E., Weber, A., & Mitterer, H. (2013). Listeners retune phoneme categories across languages. Journal of Experimental Psychology: Human Perception and Performance, 39(1), 75-86. https://doi.org/10.1037/a0027979 Saltzman, D., & Myers, E. (2021). Listeners are initially flexible in updating phonetic beliefs over time. Psychonomic Bulletin & Review.

Topic Areas: Speech Perception, Multilingualism

## The Effect of Voice Familiarity on Attention to Speech in a Cocktail Party Scenario

***Poster D60*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Paz Har-shai Yahav[1], Aviya Sharaabi[1], Elana Zion Golumbic[1]; [1]Bar-Ilan University

Processing speech in multi-talker environments is challenging due to the competition for attentional resources. In such scenarios, top-down attention operates to selectively amplify one task-relevant voice (‘target speech’) and suppress irrelevant competing voices. Although attention-based prioritization is primarily task driven, it may also be affected by acoustic and semantic properties of the voices themselves. Here we focus on voice-familiarity, an ecologically important feature of human voices, and ask whether it affects the ability to attend-to or ignore speech in multi-talker situations. We tested two hypotheses: (1) is it easier to selectively-amplify and attend to a familiar voice vs. an unfamiliar one? (2) Do familiar voices that are supposedly outside the focus of attention serve as ‘attention grabbers’, leading to interference? To test this, we measured Magnetoencephalography (MEG) from N=33 volunteers in a dichotic listening paradigm. Participants were presented with two narratives, spoken by different voices, one to each ear. They were instructed to attend to the content from one ear (‘target speech’) and ignore the other (‘non-target speech’). Critically, participants were familiarized with one particular voice during the week prior to the MEG experiment, rendering this voice ‘familiar’ to them. The familiar voice was either designated as the ‘target speech’ or the ‘non-target speech’, allowing us to test the interaction between voice familiarity and attention/task-relevance on the neural response to speech. Using multivariate encoding TRF analysis we estimated the neural responses to target and non-target speech, and we applied source-localization tools to study how attention and voice-familiarity affected the speech tracking response across different brain-regions. We replicated the well-established effect of selective-attention, showing more robust speech tracking response for target speech vs. non-target speech. Interestingly, this attentional effect was modulated by voice familiarity such that neural tracking of both target speech and non-target speech was enhanced when presented in a familiar voice, in a moderately early time window. For target speech this effect was observed in frontal and posterior opercular cortex and insula, and right lateral-temporal and inferior-parietal cortex. For non-target speech this effect was limited to auditory and temporal regions in the hemisphere ipsi-lateral to the non-target speech (contra-lateral to the target-speech), followed by a familiar voice suppression in a later time window. These findings indicate that voice familiarity, and by extension, auditory-semantics, can interact with goal-driven selective attention, and affects both the ability to pay attention to target speech and to ignore non-target speech.

Topic Areas: Speech Perception,

## The Role of Uncertainty in Social Conceptual Combination

***Poster D61*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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When you think about coal, you know its size, shape, and color. Thinking about light coal, it might be different from what you originally imagined. This change results from the conceptual combination of the adjective light with the noun coal. Studies of conceptual combination reveal that our interpretation of combined concepts is influenced not only by our knowledge of these concepts but also by the certainty of that knowledge. For example, if you are asked to give the range of brightness of coal, the range would likely be smaller than if you were asked to provide the range of a shirt; this variation in uncertainty influences how the combined concept is interpreted and the brain systems that are recruited. Nearly all research on conceptual combination to date focuses on concrete concepts and their physical properties, as in the examples above. However, many concepts are abstract. The current project focuses on a subset of abstract concepts, namely social concepts (e.g. lawyers), which can be described by the properties of warmth and competence. People tend to agree on the warmth and competence ratings of these concepts, and these judgements affect behavior as well, as shown in decision making tasks that measure trust and cooperation. This experiment broadly aims to discern whether social conceptual combination is governed by similar principles as is concrete conceptual combination. More specifically, we aim to determine whether the shift in judgments of warmth and competence of combined social concepts (eg. friendly lawyers) is influenced by both the content and uncertainty of the concepts. To do so, we will collect fMRI data while participants play the Dictator Game, in which they decide how much money to share with members of various social categories. We will determine how brain activity is influenced by warmth and competence, which we will measure by asking a different set of participants to estimate the average and range of these properties for each concept. We will also collect familiarity ratings to determine uncertainty. Because there are no prior fMRI studies of social conceptual combination, we are conducting several pilot studies to determine which concepts we will use and the best ways to collect information about their properties. For example, the current pilot project compares different instructions for judgements of the range of warmth and competence. We will use the data to determine which set of instructions has the highest rating agreement among participants.

Topic Areas: Speech Perception,

## Increased electrical brain responses to speech sounds in native vs. non-native listeners in passive but not in active listening condition

***Poster D62*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Piia Astikainen[1], Tiantian Yang[1], Jari L.O. Kurkela[1], Kecheng Chen[2], Youyi Liu[2], Hua Shu[2], Fengyu Cong[1,3], Jarmo A. Hämäläinen[1]; [1]University of Jyväskylä, Jyväskylä, Finland, [2]Beijing Normal University, Beijing, China, [3]Dalian University of Technology, Dalian, China

In previous electrophysiological studies, change detection brain responses have tended to be increased for native vs. non-native speech sounds. However, studies that include both passive and active listening conditions in the same participants are scarce. We compared the event-related potentials (ERPs) of native Finnish and Chinese speakers for changes in vowel's duration and its lexical tone, which are linguistic features in Finnish and Mandarin Chinese, respectively. We examined ERP amplitudes extracted as principal components reflecting change detection (mismatch negativity; MMN and N2b) and attention shift toward changes (P3a and P3b). In the passive listening condition, duration changes elicited increased MMN amplitudes in the Finnish group compared to the Chinese group for both standard and deviant sounds, but no group differences were observed for P3a. In passive listening, tones elicited an increased P3a amplitude in the Chinese for both standard and deviant stimuli, but there were no differences between groups in MMN. No robust group differences were observed when participants actively listened to the same speech sounds. The results suggest an overall increased sensitivity to task-irrelevant native speech sounds, and enhanced brain responses to actively attended foreign speech sounds.

Topic Areas: Speech Perception,

## Auditory brain asymmetry as a specialization for actions and materials

***Poster D63*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Auditory hemispheric asymmetry is currently best explained under the spectrotemporal modulation (STM) framework. Left and right auditory systems show increased sensitivity for temporal and spectral modulations respectively, whether sounds contain speech and music or not. However, for distinct hemispheric sensitivities to develop, the temporal and spectral modulations must be of ecological significance to the individual, an aspect that is not accounted for in the STM framework. Previous work in psychophysics has highlighted two components of sound generation that are ecologically relevant: the action (friction, impact, ...) that impulses some energy, and the material that resonates in response. As actions and materials relate to the temporal dynamic and the spectral structure of a sound respectively, we propose to reframe the distinct hemispheric sensitivity to STMs as a specialization for the processing of actions and materials. First, we analyzed a corpus

of environmental sounds in the STM domain. An independent component analysis revealed that temporal and spectral modulations were the two components explaining most of the variance ($r2 = 0.801$). These modulations are the ones known to drive lateralized brain responses, and their independence suggests that they carry different information, in line with the action/material framework. Then, we synthesized various friction sounds for which action and material content was crossed and balanced, and selectively degraded their temporal or spectral dimensions. In a behavioral experiment (n=20), we show a double dissociation so that discriminating actions rely on temporal modulations only, and spectral modulations rely on spectral modulations only. Finally, we recorded the brain activity of the same 20 participants with functional MRI (3T Prisma Siemens, fast event-related sparse sampling) while they listened to the sounds from Experiment 2. We conducted multivariate pattern analyses (MVPA) with a whole-brain searchlight procedure. Cluster-based permutation tests revealed that actions are encoded in the left auditory cortex ($p = 0.002$) as well as in the left inferior frontal gyrus ($p = 0.006$). In contrast, materials are encoded in the right auditory cortex ($p = 0.036$). We conclude that (1) environmental sounds are composed of an independent mixture of temporal and spectral modulations as expected under the action/material framework, (2) action and material perception rely on temporal and spectral modulations respectively, and (3) action and material are encoded in left and right auditory systems respectively. We propose that action and material are the two ecologically relevant auditory domains that led to the development of distinct hemispheric sensitivities to STMs.

Topic Areas: Speech Perception,

## Speech and music recruit frequency-specific distributed and overlapping cortical networks

***Poster D64** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Noémie te Rietmolen[1,2], Manuel Mercier[1,2,3], Agnés Trebuchon[3], Benjamin Morillon[1,2], Daniele Schön[1,2]; [1]ILCB, [2]INS, [3]APHM

To what extent does speech and music processing rely on domain-specific and domain-general neural networks? Using whole-brain intracranial EEG recordings in 18 epilepsy patients listening to natural, continuous speech or music, we investigated the presence of frequency-specific and network-level brain activity. We combined it with a statistical approach in which a clear distinction is made between shared, preferred, and domain-selective neural responses. We show that the majority of focal and network-level neural activity is shared between speech and music processing. Our data also reveal an absence of anatomical regional selectivity. Instead, domain-selective neural responses are restricted to distributed and frequency-specific coherent oscillations, typical of spectral fingerprints. Our work highlights the importance of considering natural stimuli and brain dynamics in their full complexity to map cognitive and brain functions.

Topic Areas: Speech Perception,

## Electrophysiological evidence for prediction errors during perception of degraded spoken sentences

***Poster D65** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

James Webb[1], Ediz Sohoglu[1]; [1]University of Sussex

Prediction facilitates language comprehension but how are predictions combined with sensory input during perception (de Lange et al., 2018)? While there is accumulating evidence showing that top-down predictions have a strong influence on perception, there are two possible ways this could be instantiated. One possibility is that predictions enhance (or ‘sharpen’) neural representations of speech input. The other possibility is that predictions suppress neural representations of speech input so that only unexpected information (‘prediction errors’) are processed further. Previous evidence suggests that cortical speech representations are best explained by prediction error computations rather than the alternative ‘sharpened signal’ account (Blank and Davis, 2016; Sohoglu and Davis, 2020). In both studies, a two-way interaction between sensory detail and prior knowledge was found, which is uniquely consistent with the prediction error account. This interaction arises because when sensory signals are strongly predicted and signal quality is high, there is little prediction error and diminished neural representations. Whereas when signal quality is low, strong predictions lead to increased prediction errors since the acoustic form of speech mismatches with prior expectations. However, these earlier studies used an artificial listening situation in which isolated spoken words were used, with predictions conveyed by written cues. Therefore, it is unclear whether the results generalise to naturalistic listening situations, in which listeners hear strings of words, and predictions are obtained directly from the speech signal itself. In our experiment, listeners (N=30) heard degraded (16-channel noise-vocoded) sentences in which the last word was strongly or weakly predicted by the previous words in the sentence, based on cloze probability (Peele et al., 2020). We also manipulated the signal quality of the final word (two, four and eight vocoder channels). Importantly, all sentences were plausible and semantically coherent. Behaviourally, listeners’ ratings of final word clarity were higher both when signal quality increased and for strongly predicted words. Using TRF analysis (Crosse et al., 2021) of EEG responses to the final word, we measured how prediction strength and signal quality modulated cortical representations of speech acoustic features (spectral and temporal modulations). We observed a significant interaction between prediction strength and signal quality ($p = .02$) such that neural representations (TRF forward model accuracies) increased with strong predictions but only when signal quality was low. These findings are more consistent with prediction error representations and show that previous findings extend to more naturalistic listening situations. Thus, prediction error computations appear to be a general and central feature of cortical speech processing.

Topic Areas: Speech Perception,

## Effect of auditory and motor rhythms on speech perception

***Poster D66*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Speech perception and speech comprehension are enhanced when speech is preceded or accompanied by a similar rhythmic temporal structure (audio such as a metronome, or motor such as tapping). Although these

phenomena have already been described, the respective contribution of the auditory and motor components has not been fully addressed. In this experiment, participants performed a speech perception task on degraded speech that was preceded by a rhythmic prime that could be auditory, motor or audio-motor. Our results indicate that auditory and audio-motor rhythmic primes facilitate speech perception. While the presence of a purely motor prime (free tapping) does not globally affect speech perception, a facilitation is visible whenever the movement is performed regularly. In order to better explain inter-individual variability, our participants also performed a Spontaneous Speech Synchronization test, allowing to evaluate speech perception-production coupling that resulted to be associated with our speech perception task. These findings are discussed in the framework of the dynamic attending and active sensing theories.

Topic Areas: Speech Perception,

## Naturalistic spoken language comprehension is supported by alpha and beta oscillations

***Poster D67*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Brain oscillations are prevalent in all species and are involved in numerous perceptual operations. α oscillations are thought to facilitate processing through the inhibition of task-irrelevant networks, while β oscillations are linked to the putative reactivation of content representations. Can the proposed functional role of α and β oscillations be generalized from low-level operations to higher-level cognitive processes? Here we address this question focusing on naturalistic spoken language comprehension. Twenty-two (18 female) Dutch native speakers listened to stories in Dutch and French while MEG was recorded. We used dependency parsing to identify three dependency states at each word: the number of (1) newly opened dependencies, (2) dependencies that remained open, and (3) resolved dependencies. We then constructed forward models to predict α and β power from the dependency features. Results showed that dependency features predict α and β power in language-related regions beyond low-level linguistic features. Left temporal, fundamental language regions are involved in language comprehension in α, while frontal and parietal, higher-order language regions, and motor regions are involved in β. Critically, α- and β-band dynamics seem to subserve language comprehension tapping into syntactic structure building and semantic composition by providing low-level mechanistic operations for inhibition and reactivation processes. Because of the temporal similarity of the α-β responses, their potential functional dissociation remains to be elucidated. Overall, this study sheds light on the role of α and β oscillations during naturalistic spoken language comprehension, providing evidence for the generalizability of these dynamics from perceptual to complex linguistic processes.

Topic Areas: Speech Perception,

## The impact of realistic background noises on neural and physiological

## response to speech, in a Virtual-Reality classroom

***Poster D68*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Orel Levy[1], Shirley Hackmon[1], Yair Zvilichovsky[1], Adi Korisky[1], Elana Zion Golumbic[1]; [1]Bar-Ilan University, Ramat Gan, Israel

Speech comprehension in real-life situations can be challenging, due to the omnipresence of irrelevant sounds or background noise. Here we studied how different types of realistic sounds and background noises affects neural processing of speech and ongoing ocular and physiological responses. Using Virtual Reality (VR), we investigated this question in an ecologically-relevant audiovisual context where listening to speech over long periods of time and avoiding distraction is particularly important: The Classroom. In a series of experiments, we measured neural activity (EEG), eye-gaze patterns and galvanic skin response (GSR), while participants listened to a series of mini-lectures in a VR classroom. In Experiment 1, we investigated the impact of hearing continuous or intermittent construction noise in the background of the classroom, and in Experiment 2 we studied the effects of occasional transient sounds such as phone-ringtones and coughs. We also explored whether responses to background events are similar or different in individuals (adults) with ADHD vs. controls. Our findings indicate that the presence of intermittent background noise reduced the accuracy of neural speech tracking and was associated with increased physiological arousal (indexed by GSR) and poorer behavioral performance, but continuous noise did not seem to affect these measures (Experiment 1). For the transient background auditory events (Experiment 2) we observe clear neural and physiological responses, but no tradeoff was observed between responses to these background events and speech-tracking of the teacher's voice. Interestingly, responses to background effects were larger in the ADHD group, but no differences in the speech tracking response were found between groups, further suggesting the lack of consistent tradeoffs between them. Spontaneous eye-gaze patterns and neural alpha-power were not affected by any of the experimental modulations, but were correlated with global GSR metrics of arousal, pointing to potentially important individual differences in the aptitude or sensitivity to processing speech in noisy environments. The novel VR experimental platform introduced here contributes to expanding our understanding of the effects of noise on speech processing to increasingly realistic contexts. Our results suggest that, under realistic audiovisual conditions, there is high fidelity for dealing with noise, and not all types of background events detract from neural processing of target-speech. At the same time, these findings also support previous findings that individuals with ADHD are more sensitive to background events, and that some types of noise are more difficult to ignore than others. While far from exhaustive, this work demonstrates the importance of studying speech-in-noise processing and the effects of potential distractors under increasingly realistic and real-life contexts. It also emphasizes the importance of integrating neural, ocular and physiological metrics, which together offer a more well-rounded description of listeners multifaceted response profile to speech in noisy environments.

Topic Areas: Speech Perception,

## Influence of area V5/MT on the task-dependent modulation of subcortical sensory thalamus during visual-speech recognition

*Poster D69* *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Lisa Jeschke[1], Katharina von Kriegstein[1]; [1]Technische Universität Dresden, Germany

There is evidence that sensory thalamus responses are modulated when humans recognise speech and that this task-dependent modulation is behaviourally relevant. We have previously interpreted these findings within a dynamic predictive coding model of cortico-thalamic interactions. In the context of visual speech recognition, one key prediction of the model is that a reduction in the function of relevant visual cortical regions leads to a reduction in the task-dependent modulation of the lateral geniculate nucleus (LGN, visual thalamus) and in the visual speech recognition performance (lip-reading). Here, we investigated whether the cortical area V5/MT, that is highly sensitive to visual motion and has direct connections to the LGN, might be a source of the task-dependent LGN modulation. In the current study, we carried out offline inhibitory transcranial magnetic stimulation (TMS) over area V5/MT or the vertex as active control region on 25 participants. The TMS was followed by functional MRI. Participants were presented with an identical series of stimuli displaying videos of a muted speaker uttering short syllables and, depending on the task instruction, performed a visual speech recognition task or a facial colour recognition task. We hypothesized that a V5/MT stimulation would lower the task-dependent LGN modulation compared to vertex stimulation. Here, we present first preliminary results. Our findings provide new insights into the neural mechanisms, especially the importance of subcortical structures, which support the perception of human communication signals that will help guide future research in typically developed individuals and populations with communication difficulties.

Topic Areas: Speech Perception,

## Dimensional modulation in continuous speech captures attention

*Poster D70* *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Ashley Symons[1], Fred Dick[2], Adam Tierney[1]; [1]Birkbeck, University of London, [2]University College London

Salient sounds in our environment can capture our attention and potentially distract us from our current goals. Prior work using simple, discrete sounds has shown that changes along multiple acoustic dimensions are linked to higher saliency ratings, increased physiological arousal, and decreased performance in dual-task paradigms. However, many of the socially relevant sounds that we encounter in our environment are continuous and constantly changing in multiple acoustic dimensions over time. For example, natural speech varies continuously along multiple dimensions that convey phonetic and prosodic information. To date, however, we know relatively little about how dynamic changes in natural speech capture attention and their effect on ongoing, goal-directed behavior. Computational models predict that goal-directed behavior will be disrupted following a high degree of spectrotemporal change. We tested this prediction using a synchronized tapping paradigm in which listeners tap to a metronome while ignoring distracting sounds in the background. The degree to which listeners' tapping shifts following the distracting sound changes provides a measure of attentional capture. First, using simple, discrete stimuli, we show that salient changes in loudness and pitch lead to a transient increase in tapping speed between 250 – 750 ms after distracting sound changes. Split-half correlations show reliable individual differences in the magnitude of the tapping shift following sound changes. We then show a similar effect when continuous speech is presented in the background; listeners'

tapping speeds up following salient changes along amplitude, pitch, and spectral dimensions, with the effect most observable between 500 – 1000 ms after the change. These findings show that changes along acoustic dimensions in natural speech can capture attention and disrupt ongoing goal-directed behavior. One potential mechanism underpinning these results is an increase in arousal driven by activity in the locus coeruleus, leading to an expansion of time perception.

Topic Areas: Speech Perception,

## Individual differences in behavioral and neural sensitivity to phonetic contrasts

***Poster D71*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Sara Guediche[1], Rachel Theodore, Hannah Olson, Matt Phillips, Emily Myers; [1]University of Connecticut

Decades of research have pointed to a central role for the superior temporal gyrus in the perception of phonetic category structure. Historical proposals have suggested that the left and right hemispheres may exhibit differential sensitivity to acoustic properties and thus sound category distinctions, with left-hemisphere sensitivity for sounds distinguished primarily by short-duration timing differences (e.g. stop consonants) and right-hemisphere sensitivity for sounds distinguished primarily by longer-duration spectral differences (e.g., vowels). Yet stop consonants and vowels also differ in the degree to which they are perceived categorically; specifically, listeners have been reported to perceive stop sounds more categorically than vowels. This raises the possibility that gradience of perception, rather than the type of contrast itself, could drive differences in hemispheric sensitivity. Individuals also vary in their perception of speech sounds, with some listeners perceiving more gradient distinctions within and between categories while others show a more classic “categorical perception” pattern with diminished sensitivity to contrasts within a category. The current study uses a within-subject design to examine behavioral and neural individual differences in the perception of stimuli that vary along both stop voicing (/g/ vs. /k/) and vowel (/æ/ vs. /ɛ/) dimensions. Pilot experiments were used to select stimuli for four 6-step continua that collectively spanned both dimensions (i.e., /gæ/ - /gɛ/, /kæ - /kɛ/, /gæ/ - /kæ/, /gɛ/ - /kɛ/ resulting in a stimulus matrix consisting of 36 items. Thus far, thirty subjects across different age groups participated in two sessions, separated by 1-3 weeks. At the first session, participants performed a visual analogue scale task (rating stimuli on a scale of 1-6) and a discrimination task (same-different decisions) for each of the 4 continua. They also completed hearing assessments and a battery of cognitive and language assessments. At the second functional magnetic resonance imaging (fMRI) session, participants passively listened to the full matrix of 36 stimuli in the scanner. On 10% of the trials, participants heard a different syllable (catch trial) and were asked to press a button. Of interest, performance on the visual analogue scale and discrimination tasks did not qualitatively differ for stop and vowel continua; however, extensive individual variability in gradient sensitivity across all continua was observed. Further analyses will assess the relationship between individual differences in gradiency for stop and vowel continua and the relationship between behavioral measures and graded vs. categorical neural representations. In addition, the current study will use representational similarity analysis (RSA) to compare whether a theoretical categorical or graded model better predicts the similarity matrix for patterns of brain activity in predefined regions of interest within the superior temporal gyrus, in both the left and right hemisphere. Results will speak to potential left versus right hemisphere differences in sensitivity to the acoustic differences between phonetic contrasts and perceptual gradiency.

Topic Areas: Speech Perception,

## Neural processing of syllabic and phonemic timescales information in spoken language

***Poster D72*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Recent experimental and theoretical advances in neuroscience support the idea that both low and high frequency cortical oscillations play an important role in speech processing. One influential framework proposes that oscillatory activity in the auditory cortex aligns with the temporal structure of the acoustic speech signal in order to optimize sensory processing (Giraud and Poeppel, 2012): Within the theta range, this alignment supports the extraction of discrete syllabic units from a continuous stream of speech information. Higher frequency oscillations in the gamma range (25−40 Hz) parse temporally fine-grained phonological information (phonemic timescale). To date, however, experimental evidence has only established that theta activity in the auditory cortex tracks the syllabic rhythm during speech perception. Neural representations of phoneme level information is seen in high-gamma power measured with electrocorticography methods (Mesgarani et al., 2014) but the temporal properties of this activity, and the degree of phase-locking to the speech signal remains unclear. The present work aims at testing the hypothesis that speech is sampled in parallel at both syllabic and phonemic timescales. To this end, a new behavioural paradigm was developed, in which spoken materials were selected so as to independently manipulate the number of syllables and phonemes present in a set of French sentences. An acoustic analysis exploring a wide variety of acoustic features reveals that amplitude envelope modulations and spectral flux are good acoustic proxies of syllabic and phonemic timescales, respectively. Intracranial neural recordings (sEEG) from ten epileptic patients with electrodes implanted primarily in auditory regions were acquired while patients listened to these sentences. Using cerebro-acoustic coherence analyses (Peelle et al., 2012), we show that theta neural activity (3 to 9 Hz) significantly tracks the speech envelope and allows decoding of syllabic rate. In contrast, low-gamma activity is most coherent with the spectral flux and allows decoding of the rate of phonemic units. These results are most pronounced within the first stages of the auditory cortical hierarchy (bilateral Heschl's Gyri). We also evaluated coupling between the phase of the speech envelope and the amplitude of neural oscillations in the auditory regions. We find that theta-gamma phase-amplitude coupling tracks the syllabic rate. Overall, our results support the hypothesis of parallel sampling of speech at syllabic and phonemic timescales, which occurs at the level of the auditory cortex. However, these timescales operate in synchrony with complementary auditory information, respectively the envelope and the spectral flux. These findings open new avenues for understanding of how the human brain transforms a continuous acoustic speech signal into discrete linguistic representations across linguistic timescales.

Topic Areas: Speech Perception,

## The Role of the Basal Ganglia in Loudness Processing

***Poster D73*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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INTRODUCTION: The basal ganglia are mostly associated with motor processing. Recently, however, the interest in their potential non-motor functions has increased, e.g., in the context of Parkinson's disease (PD), a neurodegenerative disorder primarily affecting the basal ganglia and leading to motor and non-motor impairments. For example, persons with PD both show reduced speech volume [1, 2] and aberrant volume perception of self- and externally generated speech [3, 4], in that comparably low signals (65 to 70 dB) are perceived as louder, and relatively loud signals (75 to 80 dB) as lower than normal [3, 4]. We therefore sought to investigate potential roles of the basal ganglia in the processing of loudness. METHODS: We analyzed the relationship between presented loudness levels of a continuous stimulus combining speech and natural background noises, and the blood-oxygen-level-dependent (BOLD) signal in eight specific basal ganglia regions depicted from the functional Magnetic Resonance Imaging (fMRI) of 63 healthy adults (32 f / 31 m, mean age 43.4 yrs, ranging from 18 to 78 yrs; Erb et al., 2020). A general linear model analysis (GLM) was performed, calculating multiple linear regressions bilaterally for the following eight regions of interest: the putamen, caudate nucleus, nucleus accumbens, internal and external globus pallidus, substantia nigra pars reticulata and pars compacta, and subthalamic nucleus. RESULTS: Positive linear regressions were found in two voxel clusters, one each situated in the right and left putamen, overlapping with a small portion of the adjacent external globus pallidus (sizeR = 303 voxels; pR < .001; ZR = 5.09; sizeL = 386 voxels; pL < .001; ZL = 5.63). Further, negative linear regression patterns were identified in two voxel clusters in the head of the caudate nucleus, one each located in each hemisphere (sizeR = 205 voxels; pR < .004; ZR = 6.00; sizeL = 140 voxels; pL < .006; ZL = 5.90). CONCLUSION: The recruitment of activities in putaminal and external pallidal regions went in parallel with the volume increase of the continuous auditory stimulus. The opposite pattern was found in anterior caudate regions, of which the activity levels scaled with acoustic signal loudness inversely. The data suggest a complex role of the basal ganglia in loudness processing.

Topic Areas: Speech Perception,

## Effects of first language background and musical experience on cue weighting, attention, and dimensional salience in speech and music

***Poster D74*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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What factors determine the importance placed on different sources of evidence during speech and music perception? Attention-to-dimension theories of speech perception suggest that, throughout the lifetime of exposure to their first language (L1), listeners become biased to attend to acoustic dimensions which are

especially informative in that language (Francis et al., 2000; Holt et al., 2018). Musical experience may be another factor shaping listening strategies, since attention to acoustic dimensions is essential to musical training (Patel, 2014). Here we explore how L1 background and musical experience influence neural sound encoding, dimension-selective attention, cue-weighting strategies and dimensional salience in speech and music. 54 native English and 60 Mandarin Chinese speakers (29 musicians in each language group) were assessed on their dimension-selective attention and cue preferences in categorizing linguistic features (phrase boundary, linguistic focus and lexical stress) and musical beats. Cue-weighting strategies were measured with categorization tasks in which participants were presented with speech and music stimuli that varied orthogonally along pitch and duration and categorized them as belonging to the appropriate category (e.g., deciding which word within a short phrase was emphasized). During the behavioural attention and EEG salience tasks, participants listened to sequences of sounds (complex tone or vowel) changing in pitch and duration at two different rates (1 Hz or 0.67 Hz). In the attention task, they paid attention to one dimension while ignoring changes in the other dimension and detected occasional repetitions within the attended stream. In the EEG salience task, the inter-trial phase coherence at the tagged dimension change rate provided a measure of dimensional salience. Moreover, lower-level neural encoding of pitch was assessed using the frequency-following response so that effects of musical training and language background could be assessed at earlier and later stages of the auditory system. Mandarin speakers, compared to native English speakers, showed enhanced attention to and preferential use of pitch across behavioural tasks (up-weighting pitch during prosody and musical beats categorisation and demonstrating superior attention to pitch). However, there was no effect of language background on neural entrainment to acoustic dimensions. One possible explanation of these results is that although tone language speakers benefit from an enhanced ability to direct endogenous attention to pitch when it is task-relevant, they do not experience increased involuntary exogenous capture of attention by pitch. Nevertheless, the frequency-following response to stimulus pitch was enhanced in Mandarin speakers, suggesting that speaking a tone language can boost processing of early pitch encoding, without affecting pitch salience. Comparison of cue weighting strategies between musicians and non-musicians revealed that musical training sharpens tuning to the dimension most relevant to a given categorization task – a pattern of responses suggesting that effects of musical training might depend on L1 background. Our results are consistent with attention-to-dimension theories of cue weighting which claim that listeners redirect their attention toward the most informative cues and those relevant for a given task.

Topic Areas: Speech Perception,

## Disruption patterns of background noise on the neural encoding of speech sounds in newborns

***Poster D75*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Background: Background noise impoverishes speech understanding in people across the life span. This effect can be exacerbated by developmental deficits during the first years of life and can eventually lead to language difficulties. However, the effect of background noise on the neural encoding of speech sounds during the earliest stage of life has not been studied. The present study was set hence to investigate the effects of background noise in the neural encoding of speech sounds in neonates. We analyzed the frequency-following response (FFR), a periodic auditory evoked potential derived from the electroencephalogram that phase-locks to the incoming sounds. Considering that the FFR has been used in speech-in-noise (SIN) studies due to its sound mimicking characteristics, it could emerge as an effective tool to assess this phenomenon in newborns. The present study aims to compare how background noise could modify speech encoding in neonates and adults through the analysis of their FFRs. Methods: Participants were 25 healthy-term neonates (aged <48h after birth) without auditory risk factors, and 25 normal-hearing adults (aged 20-40 years). FFRs were recorded to a 170 ms syllable /da/ with a fundamental frequency (F0) of 113 Hz presented at 65 dB sound pressure level (SPL). The noise condition was created by playing a Spanish six-talker babble noise at -10 dB signal-to-noise ratio (55dB SPL). Several FFR parameters were retrieved from the recordings in time and frequency domains. Results: Results revealed that both newborns and adults exhibited larger spectral amplitude to the speech stimulus in quiet condition than in noise condition, suggesting a better encoding of speech in a quiet environment. Conclusion: This study constitutes the first step towards understanding the development of SIN encoding from the very first moment of life. Speech-in-noise encoding in newborns showed a different pattern than adult one perhaps due to their auditory system only being exposed to low-frequency sounds during gestation.

Topic Areas: Speech Perception,

## Microstructural underpinnings of top-down signals in cortical speech tracking

***Poster D76*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Low-frequency oscillatory activity in the auditory cortex synchronizes to rhythmic patterns in the envelope of the acoustic input (Lakatos et al., 2005). Speech is quasi-rhythmic and neural activity in auditory cortex follows rhythmic features in the speech envelope, with prominent tracking occurring in the theta frequency range (4-8 Hz) for syllables rates and in the delta frequency range (0.5-4 Hz) for prosodic rhythm (Ahissar et al. 2001; Gross et al., 2013). Previous studies have investigated how speech tracking is modulated by interactions with oscillatory activity in other brain areas, revealing that the synchronisation of low-frequency oscillations and speech envelope is under the influence of top-down control from (pre-) motor and orbito-frontal areas (Park et al., 2015; Keitel et al., 2017). Here we aim to investigate the microstructural foundations of top-down

control in speech comprehension by relating MRI-based estimates of local cortical myelination, (as a proxy of local cell density) to the strength of speech tracking across subjects. We hypothesise that higher myelination in areas linked to top-down control of speech tracking indicates stronger top-down signals and thus predicts stronger speech tracking in earlier auditory areas. We acquired MEG data from 45 healthy participants who listened passively to continuous speech from a short story (Das Schwimmteam, Miranda July, 11 min 23 sec). For each participant we also acquired high-resolution (0.8 mm isotropic) quantitative MRI maps using a multi-parameter map protocol (Weiskopf et al., 2013) on a 3T Connectome scanner. The hMRI toolbox in SPM was used to generate quantitative R1, R2* and MT maps (https://github.com/hMRI-group/hMRI-toolbox). Longitudinal relaxation (R1) values were sampled at 50% cortical depth, as R1 has been demonstrated to be a marker for cortical myelination. Speech tracking was assessed at the sensor-level by calculating the cerebro-acoustic coherence between the speech envelope and pre-processed brain signals converted to BIDS format, spanning a frequency range from 0.4 to 20 Hz. Consistent with previous findings, cluster-based permutation statistics in sensor space revealed significant speech tracking in the delta and theta frequency ranges, predominately at fronto-temporal and temporal sensors, respectively. We found that theta frequency band speech tracking during story listening was significantly correlated with cortical R1 values at bilateral early and associative auditory cortex, left inferior parietal cortex (IPC) and right hippocampus. Delta band sensor coherence correlated negatively with cortical R1 values in bilateral cingulate motor area, left inferior frontal cortex, including Broca area, as well as anterior cingulate areas. We suggest that the positive correlations at inferior parietal cortex for the theta band speech tracking may reflect the role of IPC in providing semantic constraints during language comprehension (Seghier et al., 2013), while the negative correlations at inferior frontal regions, bilateral cingulate motor and anterior cingulate areas may be related to motor predictions in speech perception (Morillon and Baillet, 2017). The unexpected direction of these negative correlations can potentially be explained by the lower cell density at mid cortical layers in cortical areas associated with top-down signals (Goulas et al., 2018).

Topic Areas: Speech Perception,

## The interaction between talker variability and selective attention along the auditory pathway

***Poster D77*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Speech processing is less efficient when listeners process speech from variable mixed talkers compared to one consistent talker. Recent behavioral work provides evidence that talker variability is detrimental to speech processing because talker discontinuity evokes involuntary stimulus-driven attentional reorientation to a new auditory object (i.e., talker). However, little is known about the cognitive and neural mechanisms of automatic, stimulus-driven attentional reorientation in the context of speech communication. In this in-progress research, we are using talker variability as a tool to examine how stimulus-driven attentional disruption impact neural encoding of speech at different stages in the auditory processing pathway. Furthermore, we are examining whether the impact of talker variability depends on the goal-directed attention when recognizing speech in the presence of unattended competing speech. Using electroencephalography (EEG) and functional

MRI, we are investigating whether the impact of talker discontinuity arises during the early encoding of speech in the auditory brainstem and/or in the higher-order domain-general vs. auditory-specific cortical regions. In a pilot EEG experiment, we recorded n=7 participants' auditory brainstem responses during passive listening of a target speech syllable (English /da/), randomly intermixed with two non-target syllables (/di/ and /du/). We contrasted the frequency-following responses (FFRs) to the target syllable in contexts where listeners heard either a single talker vs. four mixed talkers, and tested whether this differed for speech in quiet vs. unintelligible babble noise. We hypothesize that talker variability would disrupt neural encoding of speech, and the effect of talker variability would be greater in the presence of background noise. Our preliminary results indicate a trend towards higher neural tracking of the target syllable's fundamental frequency (F0) and second harmonic component (H2) in a single vs. mixed talker context; however, the FFR strengths across talker or noise contexts do not reach statistical significance. With fMRI, we are examining how talker variability affect cortical activity in auditory areas and the ventral attention network in the brain. We are using sparse-sampling fMRI while participants perform an auditory word-matching task, in which words are heard in single- vs. mixed-talker context, with or without competing speech in the background. By separately localizing the stimulus-driven ventral attentional network, we aim to determine whether listeners' attentional focus is reoriented whenever they encounter talker switches in the mixed-talker context. We hypothesize that if mixed-talker speech leads to attentional disruption in a stimulus-driven manner, mixed-talker speech will lead to greater engagement of the bilateral auditory cortices and auditory-based ventral attentional networks. Alternatively, if mixed-talker speech only increases computational demands of configuring acoustic-phonetic mappings, we expect to observe the effect of talker variability only within auditory areas. From this project, we aim to delineate how stimulus-driven attention processes during speech processing operate at different levels of neural computation.

Topic Areas: Speech Perception,

## Does speech adaptation generalize across adverse listening conditions?

***Poster D78*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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[Rationale] Human speech perception exhibits remarkable adaptability in challenging conditions such as speech-in-noise or nonnative accents. Previous research has shed light on the neural basis of the flexibility and adaptive plasticity (Chandrasekaran et al., 2015; Guediche et al., 2014; Adank, 2020). Yet, a crucial question remains unanswered—Is there a shared mechanism that supports adaptive speech perception across different adverse conditions? Nonnative-accent adaptation has been considered exposure-specific: adaptation to speech-in-noise does not transfer to adaptation to systematic shifts of pronunciations common in nonnative accents (Xie et al., 2018). However, studies have also identified individual difference variables (e.g., receptive vocabulary size) that predict adaptation to multiple adverse listening conditions (McLaughlin et al., 2018). This may suggest that there is a common source of resilience to different types of challenging listening conditions. The present study provides a direct test of whether exposure to nonnative-accented speech improves subsequent recognition of speech-in-noise and vice versa. [Task Design and Predictions] Building upon previous work (Clarke Garrett, 2004; Xie et al., 2018), we employ a cross-modal matching task to assess speech recognition abilities. 120 participants (planned) judge whether a visual target (e.g., tents) matches the final word of an auditory sentence (e.g., “He pointed at the cents”). After task familiarization, participants are randomly assigned to one of three exposure conditions (Control, Noise, Accent, n = 40 each) presented over three blocks, followed by two test blocks (Noise and Accent, with order randomized across participants). Finally, a baseline block is administered to account for individual differences in response speed. Changes in baseline-corrected response times (RT) and error rates served as measures of adaptation. Data analyses use generalized mixed-effects regression models to distinguish between two competing hypotheses. If speech adaptation is exposure-specific, then listeners in the Noise and Accent conditions will exhibit better performance only for the corresponding type of speech during the test, compared to Control listeners. In contrast, if adaptation transfers across exposure conditions, listeners in either Noise or Accent conditions will outperform Controls in both test conditions. [Plans for Follow-up Studies] If results support exposure-specific adaptation, it would suggest that different mechanisms are engaged depending on the specific type of variability. In such a case, we will further delve into the source of such specificity by evaluating the effects of prior experiences (e.g., environmental exposure to Spanish-accented English) on accent adaptation. If the specific acoustic-phonetic properties of novel speech input are important for adaptation, then long-term experiences with a given condition may affect adaptation to that condition (e.g., Spanish-accent) without influencing another (e.g., Mandarin-accent). Alternatively, if transfer is observed, it would raise new questions about the cognitive, attentional, and neural mechanisms recruited for all adverse listening conditions. In such a scenario, we plan to conduct follow-up experiments involving populations with diverse attentional and cognitive abilities (e.g., young vs. older adults). In summary, the results of the current study will provide critical insights into individual differences in the ability to cope with challenging listening conditions.

Topic Areas: Speech Perception,

## Individual differences in the impact of semantic ambiguity on speech-in-noise perception

***Poster D79** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The cognitive demands imposed by a speech-listening situation can vary dramatically and include both perceptual demands such as the presence of masking background noise, and linguistic demands, such as homophony, which is ubiquitous in English. Whereas speech in noise requires the listener to disambiguate phonological form (e.g., distinguish /kæt/[cat] from /kæp/[cap]) homophony provides a clear form (e.g., /bɑːk/[bark]) but listeners must select the appropriate meaning. Although listeners can use meaningful context to select the appropriate word form (for masked sentences) or word meaning (for sentences with homophones), brain imaging data from our lab revealed that the brain networks recruited to understand acoustically degraded sentences and sentences containing homophones were largely disjoint, overlapping only in the cingulo-opercular network. Furthermore, when the two challenges were combined, intelligibility of masked sentences without homophones was substantially higher than that of identically masked sentences with homophones, even when intelligibility overall was high. The reduction in intelligibility for sentences with,

compared to without, homophones varied dramatically across participants and may be related to individual differences in cognitive ability. Given how common homophony is in everyday speech and the size of the effect, this phenomenon probably has substantial real-world impact on speech understanding. In the current study, we further investigate how these two challenges (homophony in sentences, and background noise) interact. We examine the intelligibility of sentences with and without homophones, masked with different levels of multi-talker babble (a more naturalistic masker compared to the signal-correlated noise masker used in our previous work). We also take measures of matrix reasoning (related to fluid intelligence) and working memory (reading span, n-back) to examine whether these relate to individual differences in the degree to which homophony reduces intelligibility of sentences. In an online study, 121 participants transcribed 112 sentences, one at a time, half containing homophones ("high-ambiguity") and half without ("low-ambiguity"). Sentences were masked with 12-talker babble, at +2 dB, +4 dB, and +6dB signal-to-noise ratio (SNR), and were also presented clearly (no masker). In a second session, participants completed the cognitive tests. Word-report performance decreased as masking increased. High-ambiguity sentences were less intelligible than low-ambiguity sentences at all SNRs. The difference in intelligibility between low and high-ambiguity sentences increased as SNR decreased. Individual variability in this difference also increased as SNR decreased: some individuals appear to be less affected than others by semantic ambiguity when background noise is also present. We will investigate individual variability in the combined effects of semantic ambiguity and noise on intelligibility by relating scores on the cognitive tasks to the difference in word-report accuracy between low and high-ambiguity sentences. Higher scores on all tasks should lead to higher intelligibility, regardless of the presence of ambiguity. We also predict that fluid intelligence, indexed by matrix reasoning, will help to mitigate the effects of both noise and ambiguity on intelligibility, such that those who score higher will be less affected by background noise and will show less of an effect of ambiguity as the noise level increases.

Topic Areas: Speech Perception,

## Brain Network Connectivity and Behavioral Improvements After Intensive Aphasia Treatment

***Poster D80*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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INTRODUCTION: Neuroimaging studies indicate that aphasia is associated with large-scale reorganization of brain network functional connectivity (FC), as measured with resting-state fMRI (rsfMRI), and that connectivity changes can partially explain different behavioral symptoms in and across various patient groups. Despite these observations, the specific networks involved in aphasia recovery following intensive treatment remain relatively obscure. Here, we use rsfMRI to examine the role of FC in determining aphasia recovery following intensive therapy in stroke patients. METHODS: We studied 19 aphasia patients with left hemispheric lesions who completed an intensive comprehensive aphasia program (ICAP), which included treatment for 6 hours/day, 5 days/week, for 4 weeks (120 hours total). All participants completed pre- and post-treatment rsfMRI scanning and behavioral testing, including the Western Aphasia Battery Revised (WAB-R). The WAB-R comprises a number of subscores (e.g., Fluency and Repetition), as well as overall quotients, i.e., Aphasia, Language and Cognitive Quotients (AQ, LQ, CQ). Behavioral score improvements were assessed using a paired t-test. The Brain Connectivity Toolbox was used to compute a variety of graph measures, including local and modular changes, before and after treatment. A multiple regression model was used to identify the relationship between behavioral subscores and the AQ. Within- and between-network FC was assessed with a paired t-test. Finally, changes in behavior were correlated with FC changes. RESULTS: Overall, patients showed significant improvement across several behavioral subscores following treatment, including Fluency ($p<0.01$), Sequential Commands ($p<0.01$), Repetition ($p<0.001$), Information Content, Object naming and Responsive Speech (last 3; $p<0.05$). Additionally, AQ ($p<0.001$) and LQ ($p<0.001$) showed significant improvement. Multiple regression indicated that Fluency, Sequential Commands, Repetition and Object Naming improvements best predicted those of AQ. These subscore improvements were also found to significantly positively correlate with brain FC changes involving salience, attention, top-down control and default mode networks (DMN). In particular, Object Naming was positively correlated with decreased auditory-salience network FC ($r=0.6$, $p<0.01$), and increased DMN-dorsal attention network FC ($r=0.65$, $p<0.01$). AQ improvement was significantly positively correlated with reduced FC between the salience and the auditory-language network ($r=0.6$, $p<0.01$). More generally, FC involving salience and attention networks changed significantly across the intervention, independent of the correlations with these specific behavioral measures. FC within the salience and ventral attention network (VAN) increased significantly, as did salience-VAN FC, and salience-task control network FC (all $p<0.05$). Dorsal attention network (DAN)-visual and DAN-auditory network FC also decreased significantly ($P<0.05$). Graph measures did not show significant changes across the intervention. CONCLUSIONS: These results suggest that salience and attention network FC plays a key role in determining the behavioral improvements of aphasia patients participating in an ICAP. Importantly, externally-focused attention is an essential factor for the successful completion of several WAB-R tasks, many of which involve command following. It therefore follows that salience and attention networks would be significant to the recovery of language functions requiring this faculty. More studies are needed to further describe the relationship between aphasia recovery and brain network connectivity changes, however.

Topic Areas: Speech-Language Treatment,

## ERP evidence for object label understanding in family dogs

***Poster D81** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The extent to which non-human animals are capable of understanding communication about the external entities in their environment has received considerable attention in comparative research. Dogs have been extensively selected for their abilities to communicate with humans and nowadays, more than ever, they live immersed in the human socio-linguistic environment. Therefore, they provide a unique case to study referentiality in a non-human animal. Whereas their ability to understand referential communication has been widely tested using pointing and gazing, whether this understanding extends from human nonverbal to verbal communication is controversial. fMRI studies provide emerging evidence for lexical processing in dogs, at least for praise words. Yet, recent behavioural studies indicate that typical family dogs perform at chance level when tested on their ability to match object labels to their referents, even after extensive training, and that only a handful of dogs are capable of acquiring a large vocabulary of object labels. However, human and animal studies indicate that using only performance measures may be insensitive to capture implicit knowledge effects, thus neuroscientific measures could be more adequate to demonstrate dogs' passive understanding of object labels. Here we used electroencephalography (EEG) to measure dogs' event-related responses (ERPs) in a violation of expectation paradigm, by presenting them matching or mismatching objects after hearing presumably known object labels. Stimuli were personalized for each dog (N=19). We found a significant difference in dogs' brain responses between the match and the mismatch conditions, characterized by a temporal dynamics comparable to the human semantic N400 effect, which is widely regarded to be an index of semantic processing. Our results provide the first neural evidence that even dogs whose name-to-object matching behaviour remains at chance may understand that words can refer to specific objects.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies, Meaning: Lexical Semantics

## Bat Brains as a Window into the Neurobiology of Spoken Language

***Poster D82*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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In order to learn and produce spoken language, we must be able to accurately perceive strings of sounds, store and retrieve them from memory, and reproduce them while monitoring our output at the same time. Whilst spoken language is uniquely human, a small group of animals, called vocal learners, does possess the skillset outlined above; they are able to learn to produce novel vocalizations. Interestingly, whilst some evolutionarily distant animals, such as bats, are vocal learners, strong evidence for this capability has not been found in most other mammals including our most closely-related relatives, non-human primates. A powerful way to understand how learning to produce new sounds is encoded in our brains and our DNA is to compare the brains of different vocal learners and vocal non-learners to see if certain similarities and differences can be found. Of particular interest is the bat Phyllostomus discolor, as it is a vocal learning mammal in which the neurogenetic, molecular, and neurobiological intricacies of vocal learning can be investigated to an extent that is not possible in humans. These investigations could lead us to a better understanding of how mammalian brains can facilitate vocal learning and give us insight into the biology and evolution of spoken language. In the current study, as one of the initial steps in this line of inquiry in P. discolor, we aimed to get a basic understanding of the structure and connectivity of the P. discolor brain to facilitate future comparative investigations into vocal learning. We used two complementary approaches: neuroimaging, to map the macroscale connectivity of the P. discolor brain, and neurogenetic mapping, to identify vocal learning-related regions in the P. discolor brain. To map the macroscale connectivity, we performed diffusion tensor imaging (DTI) and polarized light imaging (PLI). We are reconstructing the major white matter pathways of the P.

discolor brain to create a white matter atlas. We are also mapping the connectivity of two cortical regions involved in social communication in P. discolor, the auditory and frontal cortex, via probabilistic tractography as previous research suggests increased and altered connectivity of such areas in vocal learners. To identify novel vocal-learning related regions in the P. discolor brain, we looked at the expression of a set of genes that show a unique pattern of expression in vocal motor brain regions in humans and songbirds. We hypothesize that these genes could guide us to vocal learning areas of interest in the P. discolor brain. Using immunohistochemistry, immunofluorescence, and in situ hybridization, we mapped the expression of 7 potential marker genes. This neurogenetic mapping revealed that these vocal-motor area marker genes are not dispersed uniformly across the P. discolor cortex, but are enriched and reduced in specific layers and cortical areas, highlighting candidate regions of homology that can be investigated further. Finally, we discuss how this study increased our knowledge of the structure of the P. discolor brain and how this can eventually help us better understand the neurobiology of vocal learning in all mammals, including humans.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies, Speech Motor Control

## fMRI evidence for phonetic detail-insensitive word processing in dogs

***Poster D83*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Understanding words requires several processing steps, from the acoustic analysis of a series of sounds to accessing word meaning. While the capacity for certain prelexical processing steps from auditory stimuli, such as speech sound discrimination, is common among animals, evidence for the recognition of sequences of sounds and the understanding of their meaning is scarce in non-humans. Nevertheless, recent reports on dogs’ lexical processing capacities suggested that even non-primate mammals may process higher-level information and advances in dog neuroimaging revealed remarkable similarities in how dog and human brains process speech. However, it is debated whether dogs have similar abilities to humans in accessing the phonetic details of words during lexical processing. While a behavioural study has suggested that dogs may attribute a meaning-changing role to a single speech sound in a word, an electroencephalography (EEG) experiment has found no evidence for that. It is also an open question whether the previously identified brain areas involved in lexical processing are sensitive to the phonetic details of words. The aim of the present study was to investigate phonetic sensitivity during lexical processing in the canine brain. Twenty awake, unrestrained dogs were presented with (1) instruction words (WORD), (2) phonetically similar (SIM, differing in only the first vowel) and (3) dissimilar nonsense words (NONW) during the experiment, while the elicited brain activity was measured using functional magnetic resonance imaging (fMRI). The animals were all trained previously to lie motionless in the scanner throughout the test using positive reinforcement. We found that certain auditory cortical brain areas previously found to be involved in the lexical processing of praise words (mid and caudal ectosylvian gyrus) responded stronger to instruction words than to dissimilar nonwords. However, the activity elicited by instruction words and phonetically similar nonwords did not differ in these regions. Furthermore, in a whole-brain analysis comparing the WORD and SIM conditions with the NONW

condition we also revealed a significant cluster outside the auditory cortex, extending to the mid cingulate gyrus, which in humans is associated with cognitive control and decision making during social interactions. These findings suggest the presence of lexical representations in dogs' near-primary and secondary auditory cortex not only for praise but also for instruction words, and reveal that these representations lack phonetic detail, corroborating recent electrophysiological evidence. Finally, the increased activity in an executive region to these instruction-for-action words may reflect that dogs could not only recognize speech sound sequences but also access word meanings.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies, Speech Perception

## Neural entrainment in dogs suggests human-analogue specialization in speech sound-category processing

***Poster D84*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Human speech processing appears to depend on assigning different roles to consonants and vowels, with the former sound-category supporting the identification of word boundaries, while vowels provide information on grammar. To date few cross-species comparisons exist, but suggest that humans are uniquely constrained and inflexible in how consonants and vowels are utilized when novel speech input is processed. Dogs which have expanded into the manmade niche since more than 14000 years ago are known to occasionally learn words without explicit training, but it has not been examined if they are uniquely adapted to the perceptual properties of human language, which would include the special roles that consonants and vowels play in providing language with structure. We set out to test how dogs respond to artificial speech while their EEG is measured. Our goal was to observe how the segmentation of continuous sound-streams into words and syllables is affected by assigning different roles (across conditions) to consonants and vowels in providing affordances for structure. Three different speech-streams (one per condition) of 7 minute duration were constructed by concatenating nonsense artificial words, 750 ms long, from three syllables of 250 ms each. In the consonant condition, information about word boundaries was encoded in the consonant patterns, while in the vowel condition word boundaries were defined by vowel patterns. An additional control condition consisted of random syllables which did not form recurrent words. We present data from dogs which attended one condition each, analysing these results in a between-subject design. Using inter-trial coherence (ITC), an established EEG correlate of statistical learning and speech-stream segmentation, we show that in dogs entrainment to the recurrence frequency of syllables (4 Hz) and words (1.3 Hz) is higher when word-identities are defined by consonants as opposed to vowels. In the control condition ITC values were likewise low for 1.3 Hz, but for 4 Hz higher than in the vowel condition. The results suggest that dogs may possess a similar to humans specialization in how sound-categories are utilized when speech is processed. Work with other animals, although sparse, suggests that dogs' perception of speech-like sounds is affected by their proximity to humans. Syllable entrainment was uniquely suppressed during the vowel condition compared to both the consonant and control conditions. Considering that the conditions differed on the level of word structure, this syllable-level effect may suggest a top-down modulation of speech-stream processing, i.e. that regularities detected on the word-level are used to modulate how syllable-level processing progresses. The findings invite the question if this humanlike processing of vowels and consonants is a phylogenetic or ontogenetic adjustment to an environment dominated by the use of human speech.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies, Speech Perception

## Chimpanzees show the capacity to communicate about combined daily life events

***Poster D85*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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A universal of human language is its versatility in communicating combined information about everyday events. Versatility is achieved through using a diversity of information combination and modification mechanisms. Versatile combinatorial systems of communication can be selected for if (a) several vocal units are flexibly combined into numerous and long vocal sequences and (b) vocal sequences convey information about numerous and diverse daily life events. If (a) and (b) are in place, then we expect to find (c) a diversity of information combinatorial and modification mechanisms. Versatile combinatorial systems combining (a), (b) and (c) have not yet been found in non-human animals. Chimpanzees are a candidate for such a system since they fulfil (a). Here, we test the potential for (b) and (c) in chimpanzees. We analyzed 9391 vocal utterances across the repertoire of 98 wild chimpanzees, Tai Forest, Ivory Coast, and the events occurring during emission. In support of (b), chimpanzees used vocal sequences across a range of daily life events and twice as often during combined than single events. We also found a positive correlation between the diversity of utterances and the diversity of events. In support of (c), when focusing on two-unit utterances (bigrams) and the events during which the bigrams were uttered, we found patterns consistent with several information modification mechanisms found in other animal species: new information creation, combination of information, single call information affixation and ordering effects. Previously, usually only one such mechanism has been found per species. Our results show the potential for chimpanzee utterances to convey combined information about numerous daily life events. This capacity is likely achieved by utilizing a diversity of information modification mechanisms. Whilst we did not assess the construction of meaning through hierarchical ordering, a requirement of syntax, the chimpanzee vocal system may demonstrate a step from which generalized combinatoriality could have evolved.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies, Syntax and Combinatorial Semantics

## Electrophysiological evidence for conspecific voice sensitivity in non-human mammals

***Poster D86*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The neural processing of various vocal stimuli is a prominent focus in human studies, yet only a handful of studies investigated non-human species in this context. Despite the great potential of comparative studies, our understanding is far from complete regarding similarities and differences across species in various voice processing mechanisms. Here, we aimed to investigate the neural responses to conspecific, heterospecific and environmental vocal stimuli in two domesticated mammalian species, the pig (Sus scrofa domesticus) and the dog (Canis familiaris). Based on prior human studies and given that intra-species communication relies on the ability of individuals to differentiate between conspecific vocalizations and other auditory stimuli, we hypothesized, that (1) the distinctive neural processing of conspecific vocalization may be generally found in mammalian species. Additionally, considering dogs' selective breeding for collaboration with humans, along with dogs' and humans' lifelong close relationship, we hypothesized that (2) these may have led to neural specializations in dogs for processing the human voice. Non-invasive, awake electroencephalography (EEG) was applied to identify potential intra- and inter-species differences in sound processing; subjects listened to human, dog, pig, and environmental sounds while event related potentials (ERPs) were registered. We found that both species exhibited distinct ERPs for processing conspecific vocalizations vs. heterospecific (dogs: 0.318-0.478, pigs: 0.122-0.414 ms after stimulus onset) and environmental sounds (dogs: 0.308-0.496 ms, pigs: 0.074-0.530 ms after stimulus onset). However, based on our results, neither species showed a difference in ERPs when processing human versus other heterospecific vocal stimuli. Our findings corroborate earlier human research, indicating that the processing of conspecific sounds is distinct from that of heterospecific and environmental sounds in both dogs and pigs. Furthermore, to our knowledge, this is the first ever electrophysiological evidence for conspecific voice sensitivity in non-human mammals. In addition, our results indicate that dogs' domestication history did not lead to neural specializations for processing human vocalizations.

Topic Areas: Animal Communication and Comparative/Evolutionary Studies,

## Cortical tracking of continuous speech in young children with typical language development (TLD) and Developmental Language Disorder (DLD)

***Poster D87*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Although multiple adult studies have demonstrated that cortical tracking of the speech envelope (or 'entrainment') is key for spoken language comprehension, little is known about how this mechanism develops in young children (i.e. between the ages of 3-6 years). For example, in adults, envelope tracking correlates with speech perception performance and is modulated by prior language knowledge and attention. However, it is unclear whether the same occurs in children or if atypical entrainment patterns play a role in language

disorders, as has been reported in dyslexia or autism spectrum disorder. Thus, we asked whether cortical envelope tracking would vary between young children and adults and between children with different language skills. This study aimed to investigate cortical responses to continuous speech in children with typical language development (TLD) and Developmental Language Disorder (DLD) and compare them to those observed in adults. We recorded EEG during unattended listening of continuous speech (18 short stories, average total time 12.5 minutes) in two groups of Spanish-speaking children (age 4.7 to 5.7 years, Mage=5.05, SD=0.48, no age differences): a group with previous DLD diagnosis (n=17), a TLD group (n=12), and a group of neurotypical adults (n=17, Mage=33.4, SD=4.3). Individual Multivariate Temporal Response Functions (mTRFs) were estimated to predict the speech broadband envelope (2-32 Hz) from the cortical responses (EEG) using backward linear modelling (Crosse et al., 2016). Permutation-based analysis confirmed above-chance performance of the mTRF decoders in all our groups of participants, with significantly higher Pearson's correlation coefficient (r) for models estimated from actual speech-EEG data pairs than from randomly matched ones (TLD, Z= -2.667, p=.008; DLD, Z= -3.636, p<.001; Adults, Z=-3.621, p<.001). At the individual level, statistically significant neural tracking was detected in 67.7% of the TLD children, 76.5% of the DLD children and 88.3% of the adults, with correlation coefficients above the 95th percentile compared to a null distribution of r values. However, we found no between-group differences in the r magnitudes [F(2,46)=1.49, p=.237], with similar strength of the neural tracking observed in the TLD (M=0.11, SD=0.04), DLD (M= 0.12 SD=0.05) and adult group (M=0.14, SD=0.33), although with a small effect size ($\eta p^2$=.065), and low power (30%). At the functional level, these findings suggest that (i) adult-like, unattended tracking of the speech acoustic envelope is already in place during early childhood, (ii) children with DLD show no deficits in cortical speech envelope processing, and (ii) neural entrainment to speech in unattended conditions is similar between groups with different language abilities. Therefore, it is unclear whether language effects modulate envelope tracking in children under these experimental conditions and at this age range. As a next step, we will further analyse potential sources of within-individual variability (e.g. differences in baseline EEG levels or amounts of data) and neural tracking of speech lexical features. Crosse, M. J., Di Liberto, G. M., Bednar, A., & Lalor, E. C. (2016). The Multivariate Temporal Response Function (mTRF) Toolbox: A MATLAB Toolbox for Relating Neural Signals to Continuous Stimuli. Frontiers in human neuroscience, 10, 604. https://doi.org/10.3389/fnhum.2016.00604

Topic Areas: Language Development/Acquisition, Disorders: Developmental

## Intra-individual variation in sensory processing as a predictor of individual differences in language acquisition

***Poster D88*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Theories regarding the mechanisms underlying individual differences in language abilities have proposed various factors as contributors to language learning difficulties. For example, the generalized slowing hypothesis suggests that domain-general slowness of processing hinders language acquisition (Kail, 1994). Empirical studies have provided some support for these theories, but none of them alone is sufficient in explaining the individual differences. We propose that observations used to support the generalized slowing hypothesis and other theories actually reflect intra-individual variation (IIV) in sensory processing. As a preliminary test of our hypothesis, we examined the relationship between language abilities and IIV in two visuomotor tasks measuring response times (RT) in children aged 7 to 10 (n = 77). We observed that higher language abilities, measured by standardized tests, were associated with lower RT variation, measured by individual RT standard deviations. Additionally, as RT distributions are typically right-skewed, we sought to investigate whether the degree of this skewness as a form of IIV would be associated with language abilities. To this end, we fitted exponentially modified Gaussian distributions to individual participants' RT data, and modelled the parameters reflecting distribution shape as a function of language abilities. We found that lower dispersion and right skew were both associated with stronger language abilities. In our presentation, we relate our proposed hypothesis to other theories explaining the individual differences in language development. We suggest that many findings that support other theories could actually reflect a mechanism of domain-general variation in sensory processing during language acquisition. We posit that increased IIV (inconsistency of sensory processing) hampers updating the neural representations of language, requiring more repetitions for the child to learn patterns in their environment. IIV in RTs has been linked to variation in visual ERP latencies, suggesting that it might be caused by varying sensory processing (Ribeiro et al., 2016). The generalized slowing hypothesis has found support in studies showing longer RTs in children with weaker language abilities. However, as many of these studies solely rely on mean RT estimates, the potential differences between participants in the spread or shape of the distribution might have been overlooked. Our next step is to test our hypothesis using infant data on saccadic RT distributions (in a task measuring attention disengagement from faces to distractors) as a predictor of later language abilities. If our hypothesis holds, we would expect deviations in saccadic RTs at 8 months to predict language abilities at five years. This data is collected and to be analyzed, and preliminary results from this study will be presented. References: Kail, R. (1994). A Method for Studying the Generalized Slowing Hypothesis in Children With Specific Language Impairment. Journal of Speech, Language, and Hearing Research, 37(2), 418–421. https://doi.org/10.1044/jshr.3702.418 Ribeiro, M. J., Paiva, J. S., & Castelo-Branco, M. (2016). Spontaneous Fluctuations in Sensory Processing Predict Within-Subject Reaction Time Variability. Frontiers in Human Neuroscience, 10. https://doi.org/10.3389/fnhum.2016.00200

Topic Areas: Language Development/Acquisition, Disorders: Developmental

## The effect of emotional facial expressions on second language emotional vocabulary acquisition: an fMRI study

***Poster D89*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Expressing and understanding emotions in a second language (L2) is challenging for language learners (Dewaele, 2008). Facial expressions are essential nonverbal cues for emotion perception alongside emotional vocabulary. Embodied cognition theory highlights the significance of bodily experiences in cognitive activities (Lakoff et al., 1999; Gallese, 2005), thus sheds lights on the potential benefits of facial expressions in language learning. However, facilitative effects of observing facial expressions on L2 emotional language learning and its neural mechanisms remain unknown. Thus, to provide neural evidence for this theory in the context of second language acquisition, this study investigates whether vocabulary acquisition is enhanced by engaging emotion- and bodily sensation-related brain areas when emotional facial expressions are incorporated into L2 emotional vocabulary learning. Participants 40 healthy right-handed native Japanese speakers with no knowledge of Mandarin Chinese will participate in a Chinese vocabulary learning experiment. Materials 72 Chinese phrases (i.e., 24 negative, 24 positive, and 24 neutral phrases) were selected as the training materials, based on ratings of emotional arousal, valence, and imageability obtained from 20 native Chinese speakers. The 72 target words were divided into two sets for two training conditions: emotional-face exposure learning and neutral-face exposure learning. The phrases in the sets were equally distributed in a counterbalanced way considering frequency, number of syllables, emotional valence, arousal, and imageability. Emotional and neutral-face videos were created by native Chinese actors/actresses, uttering each word with a neutral or corresponding emotional facial expression. Participants will learn half of the stimuli in each condition. Training Procedure and Memory Assessment Over three days, participants will watch videos with audio and written stimuli in Chinese pronunciation, accompanied by Japanese translations. Each stimulus will be presented 12 times per training day. On the fourth day, participants will complete a lexical decision task, while their brain activity is scanned using MRI. Reaction time and accuracy rates will be recorded. Memory performance will be assessed through translation tests from Japanese to Chinese and Chinese to Japanese two weeks and one month after the MRI scanning. Data collection is currently underway. Data Analysis and Expected Results Repeated measures ANOVA will be conducted on both behavioral and functional data, considering two factors: Training (emotional vs. neutral-face exposure) and Time (two vs. four weeks after scanning). Behaviorally, we expect that emotional-face exposure learning will result in superior memory performance during translation tests compared to neutral-face exposure learning. Functionally, emotional-face exposure learning is anticipated to elicit stronger activation in emotion- and bodily sensation-related brain areas than neutral-face exposure learning. These findings would suggest that emotional facial expressions could benefit L2 vocabulary learning by engaging larger brain networks associated with emotion- and bodily sensation-related areas. By investigating the impact of emotional facial expressions on L2 emotional vocabulary acquisition, this study contributes to the understanding of embodied cognition in language learning. The findings may have implications for language education and pedagogy, emphasizing the integration of bodily experiences and emotional engagement to enhance vocabulary acquisition in an L2.

Topic Areas: Language Development/Acquisition, Multisensory or Sensorimotor Integration

## The development of audiovisual speech binding in 6- to 10-year-old children and the role of selective attention

***Poster D90*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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In natural communication, we not only hear our social partners but also see their articulatory gestures from their talking faces (visual speech). Adults are known to benefit from this multimodality to enhance speech perception, notably in adverse situations (e.g., noisy environment, non-native languages). While children strongly rely on these audiovisual (AV) speech cues during the acquisition of their native language, the benefit of AV speech remains smaller than in adults. One mandatory step to benefit from this multimodality is AV binding. Children must select and match precise visuo-spatial configurations of lip movements with speech sounds. This matching process takes place in narrow temporal windows, since in running speech, these configurations quickly change over time. Binding speech sounds and articulatory gestures into a coherent percept relies on a combination of top-down knowledge of spatial configurations of speech articulators associated with speech sounds and temporal synchrony processing skills. In children, AV binding improves until teenagerhood, which could be due a maturation of one or both aforementioned subskills and probably their interaction with attention. The goal of this study was to examine the role of these factors in the developmental trajectory of audiovisual speech binding in 6- to 10-year-old children (N total = 131: N 6-7 yo: 50; N 7-8 yo: 40; N 8-9 yo: 37). To this aim, we examined the spatial and temporal components of the AV binding process by using an audio-only vs. AV word identification in noise (AV-noise) and AV temporal synchrony judgement (AV-synch). The additional role of selective attention on these components was evaluated by using a standardized selective attention subset of the WISC V. In the AV-noise task, we compared children’s word identification performances when words were uttered against background noise in either audio-only or AV speech context. We found that the AV gain score (derived from the comparison of the performance obtained in the two speech contexts) was sensitive to the interaction between age and selective attention [$F(2,131)= 3.69$, $p = 0.03$], which indicates that the level of AV gain increases with the level of selective attention only in the oldest group [8-9 yo: $F(1,37) = 4.94$, $p = 0.03$] (Figure Xa). In the AV-synch task (Figure Xb), we compared children’s asynchrony judgement of lips movements and speech sounds at five levels of temporal delay (SOA): 0; 165; 333; 500; 666 ms (speech sounds always preceded lips movements in the asynchrony conditions). Asynchrony judgement performances improved with age and SOA [$X^2(6) = 15.9$, $p = .014$], but it was not affected by selective attention. Interestingly, performances on both AV tasks were positively correlated (Figure Xc), suggesting that both components of AV binding process may also share a common mechanism ($p = .008$). These results on a large pool of young children provided a mechanistic account of the developmental trajectory of audiovisual binding, and the respective roles of age and attention in this central process of speech processing.

Topic Areas: Language Development/Acquisition, Multisensory or Sensorimotor Integration

## Infant neural adaptation to native versus foreign audio-visual speech perception

***Poster D91** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Despite the immature cortical infrastructure newborn infants already show a preference for speech-like stimuli (Werker & Gervain, 2012). Throughout the first postnatal year, linguistic input helps the brain with significant structural and functional reorganization (Werker & Hensch, 2015). The increase in power of neural oscillations in faster frequency ranges, such as the gamma band appearing around 6 months, is an example of functional reorganization (Pivik et al., 2019). Higher gamma power has been associated with native language processing both in adults and infants in the auditory modality (Ortiz-Mantilla et al., 2013; Peña & Melloni, 2012). However, adult studies have shown visual speech can travel to temporal cortices even before auditory input arrives to cause a phase reset and induce oscillatory patterns necessary for audio-visual speech integration (Zhou et al., 2020). It is therefore likely that beyond native language auditory input, visual cues are also modulating oscillatory responses to speech. In fact, 4-month-old infants can discriminate among languages based on visual facial information, further highlighting the multimodal nature of speech input (Weikum et al., 2007). Adult studies have shown gamma oscillations are reflective of multisensory integration (Karthik et al., 2021), suggesting multisensory input in infants might boost an oscillatory pattern that further helps with the acquisition of native language. Thus, we hypothesized young infants will show a gamma band response to native audio-visual language phonemic contrasts in frontotemporal cortices indicative of both native language processing and multisensory integration. In this project, we designed an audio-visual oddball paradigm to test 6 to 8-month-old Spanish and/or Catalan native infants' neural responses to native and foreign phonemic contrasts. For the pilot, we tested 11 infants (6 female) with an average age of 7.25 months from Barcelona, Spain. For the experimental procedure, the standard stimuli consisted of the Catalan/Spanish native contrast /da/ and the deviant stimuli consisted of the English contrast /tha/. The infants watched a total of 288 trials (1.75s each, 72 deviant), adding up to a total time of 10 min. To measure brain responses, we used a 128-sensor HydroCel Geodesic Sensor EEG Net and impedances were kept below 100 kΩ where possible. Data pre-processing was carried out using the APICE pipeline (Fló et al., 2022) and manually inspected to remove any remaining artefacts using EEGLAB software. Evoked response potential (ERP) analysis was carried out using EEGLAB software and time-frequency analysis was carried out using Fieldtrip. As expected, pilot ERP results in central electrodes showed a stronger response to deviant relative to standard stimuli. However, the increase in signal potential commenced after mouth movement onset rather than after auditory onset. Time-frequency analysis in left frontotemporal electrodes showed higher gamma power to native phonemic contrast relative to non-native phonemic contrast. A complex pattern of higher gamma power was observed around the onset of mouth movement onset. Although preliminary, we speculate the increase in signal potential and higher gamma power observed when the mouth movement starts might be related to the phase reset in auditory cortices triggered by preceding visual cues observed in adults.

Topic Areas: Language Development/Acquisition, Multisensory or Sensorimotor Integration

## Neuro-behavioural correlates of audio-visual speech perception at different speech intelligibility levels in infants and toddlers

***Poster D92*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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When auditory speech is degraded during face-to-face communication, more resources are needed for comprehension. As intelligibility decreases, a wider neural network involving premotor and prefrontal cortex activates in adults, children and infants. When intelligibility decreases, adults increase their attention to the speaker’s mouth to reconstruct the degraded auditory speech signal. In infants, attention to the mouth depends on their language acquisition stage. During their first half year of life, infants look more at the speaker’s eyes than at the mouth. From 6 to 12 months, during the perceptual attunement stage, when native speech perception abilities undergo a significant increase, infants look more at the mouth than at the eyes, regardless of speech intelligibility. After 12 months, infants gradually start to selectively look to the mouth when intelligibility decreases. After 2.5 years, attention to the mouth becomes more stable and is deployed only if needed. Recently, 6-month-olds’ tendency to look at a speakers’ mouth has been related to their neural activity in the prefrontal and inferior-frontal gyrus, in response to audio-visually presented vowels (Altvater-Mackensen & Grossmann, 2016, 2018). These results reflect a behavioural and neural correspondence on the use of resources to perceive speech. However, it is unclear whether this relation holds across different points in development, and whether it is modulated by speech intelligibility. To address this gap, we are conducting a study that includes two groups of children acquiring Basque. One group includes 8-10-month-old infants, the age corresponding to perceptual attunement, and the other includes 27-30-month-old toddlers, the age corresponding to significant lexical development. Infants are presented with 18 videos of audio-visual speech in Basque (15-20 seconds each; separated by a 3-6 second attention getter). The visual modality remains non-degraded across all videos while the auditory signal is presented as clear audio, degraded (vocoded) audio and silent audio (6 trials each). Infants’ gaze to the speaker’s mouth is measured using an Eye-Tracker (Eyelink 1000). Concurrently, neural activity is measured in prefrontal, premotor, temporal and occipital brain areas using fNIRS (NIRX systems), a neuro-imaging technique based on optical signals which capture the oxygen changes in the blood driven by neuro-vascular coupling. Data collection is in progress and will continue until 20 participants in each age group contribute analysable eye tracking and fNIRS data. Behaviourally, toddlers are expected to increase their attention to the speaker’s mouth when speech intelligibility decreases, whereas infants are expected to look at the mouth regardless of the speech intelligibility level. Neurally, toddlers are expected to show increasing neural activity (indexed as amplitude of the hemodynamic response) in prefrontal, premotor and visual brain areas as intelligibility decreases, while infants are expected to maintain their neural activity constant across conditions. Neuro-behaviourally, the looks to the mouth are expected to positively correlate with neural activity in the prefrontal cortex, premotor and visual areas (Altvater-Mackensen & Grossmann, 2016, 2018). These results will inform the current behavioural evidence and expand the knowledge on neural mechanisms behind attentional patterns during speech processing at different stages of language acquisition.

Topic Areas: Language Development/Acquisition, Multisensory or Sensorimotor Integration

## Integrity of Ventral White Matter Tract Predicts Mean Length of Utterance at 5 years of age in The FinnBrain Birth Cohort Study

***Poster D93*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Background: In this proposed poster, we will present a study we conducted to examine if variance in young children's functional language use can be linked to integrity of their dorsal and ventral language streams proposed by the dual-stream model of speech processing in the brain. Evidence from studies relating gray matter structures in cortical language related areas to language difficulties (Mayes et al., 2015) have yielded inconsistent results. Based on Hickok and Poeppel's (2007) dual-stream model, dorsal and ventral white matter tracts connecting these cortical language areas are important in speech processing. Given, that Fractional anisotropy (FA), a measure of the white matter integrity, increases during childhood brain development and that the increase is associated with white matter maturation e.g., increased tract myelination (Reynolds et al., 2019), we hypothesized that higher FA of these language-related white matter tracts would be associated with better language skills. Method: The participants of this study were Finnish speaking children from the FinnBrain Birth Cohort Study. All children (N = 105) participated in language and brain imaging study visit at 5 years of age. Language skills were measured using Mean length of utterance (MLU), which was calculated from conversational speech sample recorded during free play. Regions of interest (ROI) were left and right Inferior fronto-occipital fasciculus (IFOF), Inferior longitudinal fasciculus (ILF) and Uncinate fasciculus representing ventral tract as well as Superior longitudinal fasciculus (SLF), a part of dorsal tract (obtained from FSL's autoptx). Sex, handedness, age, socioeconomic status and parent's age were considered as control variables. Multiple linear stepwise regression analyses with backward selection were conducted to explain variance in MLU with the FA values. Results: The results indicated that MLU was associated with left ILF FA. Higher FA of the left ILF was associated with shorter MLU. On the right hemisphere, none of the FA ROIs were significant correlates of MLU. However, predicting MLU, FA of right IFOF as well as interaction of right Uncinate fasciculus FA and ambidextrousness approached significance. Also, handedness and sex were significant predictors of MLU. Conclusion: The results of the study strengthen the evidence that integrity of ventral language white matter tracts is associated with individual differences in functional language abilities already at age 5. However, the direction of the relationship, higher FA predicting lower MLU, was opposite from what was expected. One explanation for this is that development of white matter integrity of different streams and language abilities is not linear. This calls for more longitudinal research relating developmental changes in the white matter integrity of ventral and dorsal streams to language development.
Reference: Hickok, G. & Poeppel, D. (2007). The cortical organization of speech processing. Nature Reviews Neuroscience, 8(5), 393–402. https://doi.org/10.1038/nrn2113. Mayes, A.K., Reilly, S. & Morgan, A.T. (2015). Neural correlates of childhood language disorder: a systematic review. Neural correlates of childhood language disorder, 57(8), 706–717, https://doi.org/10.1111/dmcn.12714. Reynolds, J.E., Grohs, M.N., Dewey, D. & Lebel, C. (2019). Global and regional white matter development in early childhood. NeuroImage, 196, 49–58,

https://doi.org/10.1016/j.neuroimage.2019.04.004.

Topic Areas: Language Development/Acquisition,

## Impact of inhibitory control demands on subsequent processing and judgment of semantically weakly related L2-L1 word pairs: an ERP study

***Poster D94** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Radel et al. (2015) reported a behavioral hyperpriming effect for semantically weakly related word pairs in the first language (L1) when inhibitory control demands were high on a preceding conflict task. At the same time, research has shown that language switching requires inhibitory control not only in language production, but also in language comprehension (Bosma & Pablos, 2020). Inspired by these findings, we investigated in an event-related potential (ERP) experiment whether processing of semantically weakly related word pairs in a cross-language (L2-L1) situation is modulated by inhibitory control demands in a prior task. Following Radel et al. (2015), we employed a Simon task in two sessions (2,000 trials in each session) in a within-subject design. The High demands session included 50% incongruent trials, and the Low demands session, 10% of incongruent trials.The Simon task was followed by a semantic relatedness task, in which participants evaluated strongly related (SR), weakly related (WR), and unrelated (UR) word pairs. A delayed response procedure was used, with a response trigger presented 1,000 ms post target. Twenty-six Polish proficient learners of English participated in the study. Behavioral analysis revealed a larger congruency effect in the Simon task in the Low demands than in the High demands session. Importantly, semantic relatedness judgments were modulated by inhibitory control demands in the prior Simon task; reaction times for WR pairs were numerically shorter than for UR pairs after the Low demands Simon task, but were significantly slower than for UR pairs after the High demands Simon task. ERP results showed that the N400 amplitudes for the WR pairs were smaller than those for the UR pairs after the Low demands task, whereas after the High demands task they did not differ. Overall, the results did not show a hyperpriming effect that was observed in the behavioral study by Radel et al. (2015). The reaction times to WR pairs were actually longer than to UR pairs when inhibitory control demands in the preceding task were high. Also, the ERP results showed that the N400 amplitudes for the WR pairs converged with those for the UR pairs following the high demands Simon task. This effect might mean that when participants performed a demanding cognitive control task, they became better at inhibiting the responses (as confirmed by the modulation of the Simon congruency effect) when the number of incongruent trials was large, and this increase in inhibition later impacted both semantic processing and semantic judgments of weak semantic relations. Alternatively, the effect may be due to language switching in cross-language (L2-L1) word pairs, so that high inhibition demands in the conflict task resulted in stronger inhibition in the semantic relatedness task for WR pairs, thereby eliminating the facilitatory effect.

Topic Areas: Control, Selection, and Executive Processes, Multilingualism

# Bilingual language experience and neural recruitment during verbal and non-verbal cognitive control

***Poster D95*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Shanna Kousaie[1]; [1]University of Ottawa

It has been hypothesized that bilinguals benefit from superior cognitive/executive control abilities compared to monolinguals due to the constant management of their two languages. While behavioural evidence is inconsistent, neuroimaging findings generally support this hypothesis. However, there is a lack of research that examines what and how specific language experiences influence cognitive control and its neural correlates, and whether these effects are the same for verbal and non-verbal tasks. The current investigation aims to compare the influence of different bilingual language experiences (e.g., age of second language acquisition, attained proficiency, language usage patterns) on neural recruitment during the performance of verbal and non-verbal cognitive control tasks. Young adult bilinguals (data collection is ongoing; currently n=15) completed a colour-word Stroop task and an arrows Simon task in the functional magnetic resonance imaging (fMRI) scanner. For the Stroop task, participants identified the colour of the font of control (i.e., non-words printed in colour), congruent (i.e., colour words printed in the matching colour), and incongruent (i.e., colour words printed in a different colour) stimuli. For the Simon task participants used lateralized response keys to identify the direction of arrows either presented in the centre of the screen (i.e., control trials), on the same side of the screen as the correct response (i.e., congruent trials) or on the opposite side of the screen (i.e., incongruent trials), or to identify the opposite direction of centrally presented arrows (i.e., reverse condition). In addition, comprehensive language experience measures were collected, including both self-report and objective measures. Preliminary analyses show canonical behavioural effects (i.e., increases in response time and decreases in accuracy for incongruent and reverse trials compared to control and congruent trials), confirming that the tasks were effectively tapping into cognitive control processes. There were no significant correlations between language experience factors (i.e., age of second language acquisition, relative self-reported language proficiency, relative language usage, and self-reported code-switching frequency) and behavioural effects; although there was a trend suggesting that the more frequently individuals code-switch, the larger their inhibition effect in the Simon task. In terms of the fMRI results, for each task the brain regions that showed greater recruitment for the conflict condition (i.e., congruent and incongruent trials) compared to control trials were identified. Largely overlapping brain regions were observed across the two tasks, including bilateral frontal and inferior parietal regions. Neural activation was extracted from these brain regions for each participant and related to language experience factors. Relative language usage predicted the increase in neural recruitment for conflict compared to control trials in the left inferior frontal gyrus during Simon task performance; no other significant relationships were found, although some trends were observed. The preliminary results suggest that different language experiences are associated with differential effects on verbal and nonverbal cognitive control tasks. Data collection is ongoing and additional language experience variables (e.g., objective measures of proficiency and language entropy) will be explored in the larger sample to identify the contributions of a wide range of language experience factors on verbal and non-verbal cognitive control tasks.

Topic Areas: Control, Selection, and Executive Processes, Multilingualism

## Flexible and dynamic prioritisation of sounds and action plans within auditory working memory

***Poster D96*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Items and actions within visual working memory can be flexibly and dynamically prioritised to guide adaptive behaviour. However, less is known about the selection of sounds and action plans within auditory working memory, a process which may be essential for language processing and speech production. In the present study, we adapted a visuomotor working memory task to the auditory domain to test the dynamic prioritisation of sound representations and action plans within auditory working memory. At the beginning of each trial, participants (n = 24, healthy, aged 18-35) encoded the pitch of two vowels (played separately to the left and to the right ear). Each vowel was linked to a response (left or right button press) according to whether its pitch was high or low, respectively. Following encoding, a visual cue (vowel identity) prompted participants to prioritise one of the vowels and its corresponding action plan (left or right button press). If the delay between the visual cue and the pitch report probe was short (2 s; 50% of trials), participants reported the pitch of the cued vowel by pressing the corresponding button (80% validity). However, if the delay after the cue was sufficiently long (4 s; 50% of trials), participants were instructed to “switch” to the other vowel representation and action plan, thus reporting its pitch by pressing the other button (80% validity). At the end of both short and long trials, participants reported the pitch of the prioritised vowel by pressing the left or right button repeatedly thus circling through a set of sequentially played pure tones until they found the tone matching the pitch of the selected vowel. In this study, the prioritisation of auditory representations and action plans was prompted by two different signals: an external, visual cue and the internal monitoring of the passage of time. Additionally, sound location and required response hand were orthogonally manipulated, enabling us to track sound and action prioritisation independently. We revealed that the flexible prioritisation of sounds and action plans within auditory working memory resulted in significant behavioural benefits. Participants were faster and better at reporting the prioritised vowels in trials where selection was prompted by an external cue and in trials in which prioritisation was guided by the internal monitoring of time. From this, we conclude that sound and action representations within auditory working memory can be flexibly and dynamically prioritised. Such flexible prioritisation of relevant sounds and motor plans within auditory working memory at specific times may be a fundamental process for language processing and speech production.

Topic Areas: Control, Selection, and Executive Processes, Multisensory or Sensorimotor Integration

## The P600 during sentence reading predicts behavioral and neural markers of recognition memory

***Poster D97*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Friederike Contier[1], Milena Rabovsky[1]; [1]University of Potsdam, Germany

The P600 event-related potential component is elicited by a wide range of anomalies and ambiguities during sentence comprehension and remains important for neurocognitive models of language comprehension (e.g., Li & Ettinger, 2023, Cogn.). On the neurobiological level, it has recently been proposed that the P600, similar to the earlier domain-general P3, signals phasic norepinephrine release from the locus coeruleus to salient stimuli that need selective attention and behavioral adaptation (e.g., Sassenhagen & Bornkessel-Schlesewsky, 2015, Cortex). Transient norepinephrine activity has also been linked to explicit memory formation, since it concurrently innervates limbic structures that are crucial for long-term learning (Sara, 2009, Nat. Rev. Neurosci.). Thus, if the P600 during sentence comprehension indeed reflects phasic norepinephrine release from the locus coeruleus, its amplitude should be predictive of explicit memory formation. Here, we tested this prediction using a sentence reading and subsequent word recognition task. In the encoding phase, 36 participants read sentences word by word including a critical target noun that was either semantically deviant, morphosyntactically violated (incorrect article), or correct and semantically fitting. As expected, morphosyntactic violations elicited a large parietal P600, while the positivity on semantic deviants was additionally left-frontally distributed. In the subsequent word recognition task, participants judged whether a particular word (seen target vs new unseen word) appeared in a sentence during the encoding phase or not (Y/N). Behaviorally, seen targets that had appeared as a semantic violation during encoding were recognized better, but those that had appeared within morphosyntactic violations were recognized worse than correct control targets. In addition, correctly identified seen targets generally elicited a more pronounced old/new recollection ERP effect (positivity at 500-800 ms over frontal and left-parietal areas) than unseen words. Crucially, the P600 amplitude during encoding was related to these recognition effects in the subsequent memory task on a trial-by-trial basis: Recognition accuracy was better for violated words that had previously elicited a larger P600. However, this was only the case for semantically deviant words, but not morphosyntactic violations. Moreover, the amplitude of the old/new recollection ERP effect during recognition was positively related to the amplitude of the P600 during encoding. This relationship of ERPs between encoding and recognition was present for both semantic deviants and morphosyntactic violations. In sum, we find that the P600 predicts later recognition memory both on the behavioral and neural level. Such explicit memory effects further link the component to the LC/NE system, suggesting a more domain-general nature of the component. The link between the P600 and later recognition indicates that the neurocognitive processes that deal with salient and anomalous aspects in the linguistic input in the moment will also be involved in keeping this event available for later recognition. Lastly, the stronger behavioral memory effect for semantic deviants and the P600-memory effect elicited by them could be due to differences in the formed memory representation: Semantic mismatches might form a memory trace for the nouns themselves (which was tested in our recognition task) whereas morphosyntactic violations possibly elicit a memory trace specific to the article-noun mismatch instead.

Topic Areas: Control, Selection, and Executive Processes, Reading

## Attentional networks contributions during phonological and semantic

## judgments revealed by hemispheric lateralization

***Poster D98*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Functional lateralization in the left hemisphere for language and in the right hemisphere for attention has been extensively studied, but less frequently in the context of verbal tasks. It is important to identify attentional activations during language tasks in order to accurately differentiate language regions from other contributing factors, as attentional involvement can significantly affect the success of language operations. Attention is generally organized into two distinct anatomofunctional networks: a dorsal frontoparietal network (FPN) responsible for voluntary attentional orienting, and a ventral frontotemporal network (FTN) involved in automatic attentional orienting based on external stimuli (Corbetta and Shulman, 2002). A previous study reported that reading activations overlap with right hemisphere attentional regions, suggesting differential engagement of these two networks depending on the type of reading (lexical or sublexical; Ekstrand et al., 2019). In our study, we targeted regions of interest (ROIs) involved in these attentional networks, as identified in an independent functional run, and assessed their activation and lateralization profiles during a phonological and semantic judgment task. In addition to identifying attentional regions based on their lateralization profiles, we aimed to determine if the two networks were differentially engaged depending on the type of language processing. Using slow event-related fMRI, we selected a subset of 125 individuals from the Bil&Gin database (Mazoyer et al., 2016) who exhibited typical left-lateralized language organization (Labache et al., 2020). They first completed a rhyming task (PHONO) where they judged whether visually presented pseudowords had the same ending sound. In the second task (SEM), they identified whether both written words on the screen referred to man-made objects. Our analyses focused on the BOLD signal and lateralization indices in the frontoparietal (FPN) and frontotemporal (FTN) networks identified in the same participants based on task-induced right-lateralized activations and their intrinsic connectivity (Labache et al., 2023). The results revealed significant activation of almost all ROIs in these attentional networks during the language tasks, without showing qualitatively different network involvement based on the task. Generally, PHONO elicited greater and more lateralized activations than SEM in both networks. We observed right lateralizations in certain regions (anterior prefrontal and inferior parietal regions) of the FPN associated with the frontoparietal control system, as well as in regions of the FTN (anterior insula and cingulate cortex) related to the salience network. The lateralizations observed in the FPN were accompanied by contralateral recruitment of the ROIs, indicating inter-hemispheric cooperation or concurrent activity. The rightward lateralizations of the TFN exhibited similar profiles. In contrast, specific regions of the TFN (F3t, STS3, STS4) corresponding to core language areas in the left hemisphere showed left lateralization due to the suppression of homotopic activity in the right hemisphere. This study demonstrated that despite engaging in tasks involving phonological or semantic processing, attentional executive regions that remain right-lateralized can be identified. These regions may play a crucial role in individuals' ability to efficiently engage in and monitor the language processes required by the task. Furthermore, different inter-hemispheric dynamics were observed, with interhemispheric inhibition emerging as a characteristic of language-specific processes.

Topic Areas: Control, Selection, and Executive Processes, Reading

# The impact of domain-general cognitive load on language processing in the aging brain

***Poster D99** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Healthy aging is accompanied by a myriad of cognitive changes. Due to the largely intact system of semantic memory in healthy aging, language processing is typically not associated with strong age-related decline. However, changes have been reported on the word, sentence, and discourse level when processing becomes cognitively demanding (Kemper & Anagnopoulos, 1989; Obler & Pekkala, 2008; Peelle, 2019). A central question is to what extent domain-specific cognitive resources remain available in aging when concurrent executive demands increase. To this end, the current study explores the impact of a dual-task paradigm on language comprehension in healthy young and older adults. Data collection for this project is currently ongoing and results will be presented at the conference. So far, 32 healthy older adults (mean age = 71.4, SD = 6.4, range 61-85 years, mean MMSE = 28.2 points) have participated in the project and we are currently testing healthy young adults (planned n = 30, age range 18-40 years). Participants complete one experimental session of a self-paced reading paradigm followed by a short neuropsychological assessment. The reading paradigm consists of tasks blocks where participants read short newspaper articles (n = 6, average length of 300 words) and answer comprehension questions at the end of each text. Self-paced reading is either performed in isolation (two task blocks) or paired with a competing n-back task which uses a 1-back and 2-back design on the words' font color (two task blocks each). Moreover, to assess executive functions in isolation, participants also perform two task blocks for each n-back level based on the color of rectangles. Thus, participants complete a total of ten task blocks during the experimental session. Afterwards, general verbal intelligence is assessed via the German version of the spot-the-word test. Further, in older adults, the MMSE is assessed to exclude possible cognitive impairments. Performance is measured via word-level reading speed and accuracy on text comprehension questions and the n-back task. Linear mixed models will be used to analyze the effect of the dual-task design on reading speed and accuracy and a possible interaction with age group. While we expect that both age groups are affected by the enhanced cognitive demand of the dual-task design as evident by slower reading times and reduced accuracy, older adults might show a stronger decline already at the 1-back level compared with young adults. Furthermore, we plan to assess the effect of the dual-task design on word predictability. To this end, surprisal scores will be used at four distinct time scales. An interaction of cognitive load and surprisal rates on reading times and accuracy as well as a possible moderation by age group will be analyzed using mixed models. Overall, our findings will reveal the impact of increasing cognitive load on domain-specific resources during language comprehension in the aging brain. Moreover, our results will demonstrate how language predictions are modulated by increasing cognitive demands in healthy young and older adults.

Topic Areas: Control, Selection, and Executive Processes, Speech Perception

## Theta-gamma phase-amplitude coupling as a neural signal of events in language

***Poster D100*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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[Introduction] What do we represent in our minds when we process events in language? Altmann and Ekves (2019) proposed that events comprise objects and their histories (i.e. in the sentence “the chef chopped the mango”, we simultaneously represent the intact and chopped mango). There is fMRI evidence of competition between these object-states in the left ventrolateral prefrontal cortex (Hindy et al. 2012; Solomon et al. 2015). However, little is known about the dynamics of these representations and how they are maintained simultaneously in the brain. Here we propose a neural code for event representation: theta-gamma phase-amplitude coupling (henceforth PAC). PAC is a neural signal which is hypothesized to sequentially encode multiple items in working memory (Lisman 2005); the strength of theta-gamma coupling increases with working memory load (Heusser et al 2016, Rajji et al 2017, Bahramisharif et al 2018). Recently, Reinhart and Nguyen (2019) demonstrated greater working memory accompanied by stronger theta-gamma PAC at left temporal electrodes. PAC is thus a strong candidate mechanism for how the brain represents distinct object states separated in time. This study presents PAC analyses of data from two existing experiments on events in language (analysis of the second experiment was used to validate the results of the first). We hypothesized that PAC would increase in the substantial change condition (e.g. “the chef chopped the mango”; corresponding to more distinct object-states) but not the minimal change condition (e.g. “the chef weighed the mango”). [Methods] In both experiments (1: N=45; 2: N=31), participants read sentences on a screen word-by-word (ISI: 600ms) while having their EEG data recorded. Stimuli consisted of 2 sentences each – in the first sentence, an object underwent either substantial or minimal state change, and in the second sentence, it was referenced again (e.g. “The woman will bite the plum. And then, she will squeeze the plum.”). EEG was recorded using 256-channel EGI HydroCel Geodesic Sensor Nets at a sampling rate of 1000 Hz. Raw data was bandpass filtered at 1-80 Hz then downsampled to 250 Hz. 7.2-second (12-word) epochs were extracted from a left temporal electrode (T7) following the onset of each trial. PAC at this channel was then quantified by a Driven Auto-Regressive (DAR) model (Dupré la Tour et al 2017) and z-scored using 200 surrogates. [Results] Contrary to our hypothesis, theta-gamma PAC was present in the minimal change condition but not the substantial change one. In experiment 1, there was significant theta-gamma PAC (6 Hz and 35-40 Hz; $p < 0.001$) in the minimal change but not substantial change condition. These findings were replicated visually in experiment 2, albeit at a higher range of gamma frequencies (45-55 Hz). [Summary] Theta-gamma PAC is a promising candidate for event processing in language in the brain. We propose that in events with minimal change, individual object-states are less diagnostic of the event, hence we are less able to rely on them to represent it. More working memory is needed to maintain distinct representations of an object in time, which manifests as increased PAC.

Topic Areas: Control, Selection, and Executive Processes, Syntax and Combinatorial Semantics

# Upper theta-band power indexes noun-phrase interference during sentence comprehension

***Poster D101*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Prior studies have assumed that activity in a frequency band reflects a single cognitive mechanism, unless separated by temporal or spatial dynamics. However, here we find two functionally and spectrally distinct responses within theta band (3-7Hz) in two large scale studies examining the neural oscillatory dynamics of sentence processing. Participants silently read sentences in rapid-serial visual presentation (SOA = 550; ISI = 150) while EEG was recorded and responded to simple Yes/No comprehension questions after one-third of all sentences. EEG data was epoched at the sentence level for pre-processing, including removing low-frequency (0.001Hz) drift, eye-blink, and high amplitude artifacts for each participant. Power in the theta band was derived by squaring the absolute value of complex wavelet coefficients (6-cycle Morlet wavelets 64 frequencies, octave spaced 2-8Hz). For each participant, lower (3-4.5Hz) and upper (4.5-7Hz) theta power was calculated by finding the local maxima within each range and averaging power around the peak within a mid-frontal group of electrodes. Independently for each theta range, repeated paired t-tests were conducted across time with false-discovery rate correction for multiple comparisons to evaluate differences between conditions. In Study 1 (N = 195) participants read sentences containing center-embedded relative clauses, semantic and syntactic anomalies, and well-formed control sentences. First, in response to object-relative (difficult) compared to subject-relative (easy) sentences we find an increase in upper theta activity at the main verb. The presence of two subject noun phrases (NP) in the object relative clause sentence creates interference when the comprehender encounters, and must assign a subject to, the main verb, reflected in this upper theta band increase. Secondly, in response to semantic anomalies compared to controls we saw an increase in upper theta band power. This effect was not present for syntactic anomalies; however a lower theta band increase was found here, indicating a specificity for the upper theta band reflecting the interference between a well-formed predicted NP and the anomalous noun. In Study 2 (N=192), participants read sentences containing prepositional phrases that either did or did not match the subject NP in number. There was an increase in upper theta band power for prepositional phrases that matched the subject in number, and thus interfered with the subject NP, at the main verb phrase compared to sentences that contained a mismatching prepositional phrase. Furthermore, when examining numerically anomalous verb phrases, we saw an increase in lower theta band power, mirroring the syntactic anomaly effect found above. In sum, two distinct peaks of theta band activity arose consistently across two groups of participants completing different comprehension tasks indicating that there is likely not only one cognitive process operating in the range. The current results demonstrate that upper theta band activity reflects the processing demand present when NP interference occurs during comprehension, a finding consistent with work generally linking theta band activity to cognitive control processes. Further work can determine the functional significance of activity in the lower theta band, however it appears to be linked to syntactic error processing, not interference between semantically distinct noun phrases.

Topic Areas: Control, Selection, and Executive Processes, Syntax and Combinatorial Semantics

## Auditory attention: the influence of tonic arousal at the behavioral and physiological levels

***Poster D102*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The control of attention requires a good balance between voluntary and involuntary attention. Distraction by unexpected auditory events often occurs in daily life and can be important to adapt to environmental situations. Although it has been shown that unexpected salient sounds impair task-performance, an increasing number of studies demonstrated that unexpected stimuli can be beneficial for the performance. Current theories attribute this beneficial effect to a transient increase in the arousal level, under the control of the Locus Coeruleus – Norepinephrine (LC-NE) system. Animal studies suggest that tonic and phasic activity of the LC-NE system are linked, with an intermediate level of tonic arousal accompanied by high phasic bursts and optimal performance. The objective of the study was to investigate the impact of tonic arousal on voluntary and involuntary attention and on phasic arousal at behavioral and physiological levels in Human. We modulated the tonic arousal by using calm and exciting music extracts. We recorded electroencephalography, pupil dilation, skin conductance and heart rate in 16 healthy young adults performing the Competitive Attention Task. At the behavioral level, an increase in tonic arousal appears to be associated with an increase in voluntary orienting of attention. At the physiological levels, results suggest that skin conductance is sensitive to the tonic arousal level; while pupil dilation is more sensitive to phasic modulations. Event-Related Potentials to the target sounds were found reduced under low tonic arousal level. Event-Related Potential to the distractor sounds were also modulated by the tonic arousal level, showing a complex interaction between the arousing content of the distractor, the level of tonic arousal, and the level of attention preparation. In summary, these results show that tonic arousal can modulate the processing of both task-relevant and task-irrelevant sounds.

Topic Areas: Control, Selection, and Executive Processes,

## The Architecture of Auditory Statistical Learning in the Brain: A Dynamical Functional Connectivity Study

***Poster D104*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Will Decker[1], Julie M. Schneider[1], Christopher Cox[1]; [1]Louisiana State University

Statistical learning (SL) is a neurocognitive mechanism used to identify patterns of statistical regularity embedded within the environment (Conway, 2020). SL is not a discrete process—it occurs continuously over time (Conway, 2020). In particular, SL supports the identification of boundaries across the temporal domain via tracking of transitional probabilities (TP) within patterns of input (Cairns et al., 1997; Saffran et al., 1996;1999), like word boundaries in spoken language. In this regard, foundational observations from Saffran

et al. (1996;1999) demonstrated that infants were able to identify words embedded within a continuous stream of auditory stimuli, elucidating SL's role in learning language. From this, investigations into the cognitive mechanisms supporting SL of language arose: a dual model was constructed in which domain-general (i.e., cognitive computations occurring during SL are shared across domains/modalities) and domain-specific mechanisms (i.e., cognitive computations occurring during SL are distinct across domains/modalities) work in tandem to facilitate perceptual and executive functioning—in turn supporting SL (Conway, 2020; Frost et al., 2015). To further subserve this understanding of SL and language, explorations into the neural basis of SL demonstrated that domain-general regions, like the superior temporal gyrus (STG) and the inferior temporal gyrus (IFG; Karuza et al., 2013), as well as domain/modality-specific neural regions are activated during processing of patterns embedded within auditory input (Schneider, et al., preprint; Thothathiri & Rattinger, 2015). While informative, these findings limit their categorization of learning to modular when, rather, it is facilitated by distributed networks and connections across the brain (e.g., López-Barroso et al., 2015). To understand how the brain processes statistical patterns at a distributed level, functional connectivity (FC) analyses can be used to determine the interactions of brain regions underpinning cognitive functioning. Little research has utilized FC to examine auditory SL as it unfolds over time. This sparse literature has demonstrated activation of domain-general regions involved in executive functioning, such as working memory and attention (Sengupta et al., 2019). However, the lack of domain/modality-specific regions involved in SL is contrary to theoretical accounts of SL (see Conway et al., 2020), and may be attributed to the fact that previous FC analyses did not account for changes across time. Therefore, the current project aims to uncover the functional architecture of SL as it unfolds over time—making use of functional magnetic resonance imaging (fMRI) and dynamical FC analyses. Adult participants will complete a baseline resting state (RS) FC scan followed by a task-based auditory SL FC scan, similar to Schneider et al., (2020). They will be tested on accuracy during a 4AFC post-test. We hypothesize that the stimulus onset will probe connections in perceptual regions involved in auditory SL (STG, IFG) and an increase in stimulus duration will reduce these connections while simultaneously increasing connections in top-down, executive regions. We further hypothesize that characteristics in FC will be related to participants' accuracy on the post-test. These findings would provide a characterization of the neural mechanisms supporting SL over time, a novel finding that would bolster theoretical accounts of SL.

Topic Areas: Control, Selection, and Executive Processes,

## A Systematic Scoping Review of Research on Alexia with Agraphia: Implications for Neural Models of Reading and Writing

***Poster D105*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Venugopal Balasuramanian[1], Jayashree Balaraman[2], Ava Amano[3], Sarah Zimmer[4], Kaitlyn Weber[5], Christina Barnes[6]; [1]Seton Hall University, [2]Communication Neuroscience & Aphasia Research Lab

In 1890, Joseph-Jules Dejerine reported on the co-occurrence of alexia with agraphia (AWA), with relative sparing of other language functions, in a case with left angular gyrus (AG) lesion (Henderson,2010). Dejerine hypothesized that the AG lesion might have caused the loss of optical images of letters, and this loss was the underlying mechanism of AWA. He was aware that AWA could occur in association with aphasia syndromes.

Such possibilities suggested that the interface between reading and writing rests on complex neural networks consisting of components that are spatially distributed. Unearthing numerous lesion sites associated with AWA, hopefully, will offer some clues regarding the neural underpinnings of reading-writing interface. For example, earlier neurological account of AWA in conduction aphasia, with arcuate fasciculus lesion, was based on the reasoning that both reading and writing impairments resulted from defective phonology (Goodglass, 1992). Cognitive neuropsychological (CN) models of reading and writing/spelling have, mostly, dealt with alexia and agraphia separately. When AWA occurred in a case, research studies tend to focus on either alexia or agraphia but not both (Nolan & Carmazza, 1982, 1983). Coltheart observed that some degree of writing impairments was always present in deep dyslexia (Coltheart, 1980). Hence, the frequency of occurrence of AWA must be higher than reported in the literature. Moreover, the neural bases of the interface between reading and writing have not been consistently focused on in recent research, with occasional exceptions (Baldo et al, 2018). The objectives of the current scoping review were as follows: to find the total number of published case reports of AWA in English language, to map the extent of lesion in each case, and to identify the neural- and cognitive-model oriented accounting of each case of AWA. The results of the current study will be discussed in the context of the contemporary neural models of reading and writing ( Method. A systematic scoping review of literature was undertaken. Only case reports with information, as mentioned earlier, were included. Results. An interim report of this review process is as follows: So far, 14 case reports in English reporting AWA were located (for example, Day et al, 1987., DeMarco et al, 2018., Kawahata et al, 1988., Kawamura et al, 1987., Kim et al, 2015., Kirshner & Webb, 1982). Lesion sites associated with AWA cases, for example, included these: 1) left angular gyrus (AG), 2) left supramarginal and AG, 3) Demyelination of the temporo-parietal region,4) Left temporo-parieto-occipital lesion, 5)right temporo-occipital hemorrhage, 6) lesion in the territory of the right superior cerebellar artery, 7) atrophy in the leftparieto-occipital regions, 8) left temporal lobe tumor, 9)Left middle and inferior occipital gyrus lesion.... Discussion We discuss how some of the the contemporary neural models of reading and writing (Baldo et al, 2018., Purcell, et al 2011., Planton et al, 2013., Roeltgen & Heilman, 1985., Roux et al, 2013., Scarone, et al, 2009) explain AWA cases reported in this study.

Topic Areas: History of the Neurobiology of Language, Disorders: Acquired

## What does the spontaneous speech synchronization task measure?

***Poster D106*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

J. Devin McAuley[1], Bailey Rann[1], Frank Dolecki[1], Toni Smith[1], Soo-Eun Chang[2], Emily Garnett[2]; [1]Michigan State University, [2]University of Michigan

Assaneo and colleagues have developed a spontaneous speech synchronization (SSS) task that consists of participants whispering the syllable ‘tah’ while monitoring a series of synthesized syllables (Assaneo et al., 2019). For this task, some participants appear to spontaneously synchronize produced syllables with the timing of heard syllables, while others appear to produce syllable timings that are unaffected by the heard syllable rhythm, resulting in a bimodal distribution of phase-locking values (PLVs) between the amplitude envelopes of the produced and perceived syllable sequences. Two central claims about the SSS task are that it (1) distinguishes between individuals who, without conscious awareness, spontaneously synchronize their speech with a to-be-attended syllable stream from those who do not and (2) reflects a robust individual difference predictive of behavioral and neuroanatomical characteristics of speech and language processing. With respect to Claim 1, although the SSS task is framed as a syllable perception task where participants are not instructed to synchronize produced with heard speech, it is still possible that speech synchronization is conscious rather than unconscious. To test this possibility, forty-six participants, 18 – 43 years of age, completed the SSS task twice during separate visits followed by the administration of a modified version of the Perceived Awareness of Research Hypothesis (PARH) survey. The two key questions were a 'yes/no' response to the statement 'I tried to synchronize' and a 1 - strongly disagree to 7 - strongly agree rating of the statement 'I tried to say tah in time with the sounds.' Consistent with Assaneo and colleagues, there was a bimodal distribution of PLVs distinguishing 'high' synchronizers from 'low' synchronizers and PLVs showed high test-retest reliability, $r(44) = 0.78$, $p < 0.001$. Contrary to the claim that the SSS task measures unconscious synchronization, however, 60.9% of participants indicated that they tried to synchronize their produced speech with heard speech and PLVs were substantially greater for participants who indicated they tried to synchronize ($M = 0.54$, $SD = 0.07$) compared to those who did not ($M = 0.28$, $SD = 0.06$), $p = 0.015$. Moreover, when we used binary logistic regression to predict binary classification of 'high' and 'low' synchronizers based on only the two key questions overall classification accuracy was 76.1% (corresponding to a d' score of 1.42). In sum, the distinction between 'high' and 'low' synchronizers in the SSS task does not appear to emerge spontaneously without any listener intent to synchronize, but rather the bimodal distribution of PLVs on the SSS task reflects whether or not participants consciously try to synchronize their produced speech with heard speech.

Topic Areas: Methods, Multisensory or Sensorimotor Integration

## Prediction errors modulate brain responses during multisensory feedback learning in adults

***Poster D108*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Nina Raduner[1,2,3,4,5], Carmen Providoli[1,5], Sarah Di Pietro[1,4,5], Saurabh Bedi[5,6], Ella Casimiro[5,6], Nico Ehrhardt[1,2,3,4,5], Sina Gubler[1], Iliana I. Karipidis[1,4], Maya Schneebeli[1], Michael Von Rhein[3,5], Nora M. Raschle[2,4,5], Christian Ruff[4,5,6*], Silvia Brem[1,4,5*]; [1]Department of Child and Adolescent Psychiatry and Psychotherapy, University Hospital of Psychiatry, University of Zurich, [2]Jacobs Center for Productive Youth Development, University of Zurich, [3]University Children's Hospital Zurich and University of Zurich, [4]Neuroscience Center Zurich (ZNZ), [5]URPP Adaptive Brain Circuits in Development and Learning, University of Zurich, [6]Department of Neuroeconomics, University Zurich, [7]*equal contribution

Living in a multisensory world requires individuals to learn how to integrate information from different sensory modalities. Multimodal integration optimizes behaviour by improving processing speed and memory performance, making it particularly relevant for language function (Barutchu et al., 2011; Denervaud et al., 2020; Dionne-Dostie et al., 2015). From a brain perspective, learning and processing of multisensory information depend on an extended cortico-striato-thalamic network (Van Den Brink et al., 2014). In this study, we aimed to characterize the dynamics of multisensory learning across sensory modalities in the brain. Our objective was to establish a potential framework to advance our understanding of multisensory learning and processing during development and in clinical populations with developmental language or reading impairments. 25 healthy adults (mean age = 25.81 years, SD = 2.756, 20 female) conducted four runs of a multisensory feedback learning task during fMRI recordings. In two audio-visual (AV) and two visuo-tactile (TV) runs participants learned associations between three pairs of symbols and environmental sounds or vibrations, respectively. 50% of the AV or TV pairs were correct pairings, the others incorrect. We analysed stimulus and feedback processing for AV and TV runs. We than applied a Rescorla-Wagner model (Rescorla & Wagner, 1972) to derive trial-wise prediction error (PE) values, in addition to reaction times (RT) and accuracies (ACC). Linear mixed models were used to analyse the behavioural data. PE was entered as parametric modulator of BOLD activation on feedback onset to explore learning in more detail. The behavioural data showed that participants learned the correct pairings. Mean RT and ACC improved from the first to the last third within runs (ps<.001). Furthermore, learning AV pairings was less difficult than learning TV pairings (ACC AV > TV runs; p=.046). The fMRI analyses of AV or TV runs showed activations during stimulus processing in visual and auditory or tactile sensory processing regions including frontal, occipital, temporal and parietal cortex (pFWEc<.05, pCDT<.05 (FWE)). The PE modulated BOLD activation during feedback processing in the precentral gyrus, the left hippocampus, putamen, and amygdala (pFWEc<.05, pCDT<.001 (unc.)). We show that audio-visual and visuo-tactile stimulation yielded the expected activation during stimulus processing in sensory regions in this associative learning task. Furthermore, the modulation of activation by PE in the network comprising the precentral cortex, temporal cortex, and putamen may reflect the brain's dynamic adjustments and adaptations in motor planning, sensory integration, and reward processing based on feedback. In summary, our task may provide a framework for studying developmental trajectories of children with and without language impairments, advancing our understanding of the behavioural and brain dynamics of multisensory learning.

Topic Areas: Multisensory or Sensorimotor Integration, Computational Approaches

## Sex differences in low-level multisensory integration in developmental dyslexia

***Poster D109*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Agnieszka Glica[1], Katarzyna Wasilewska[1], Bartosz Kossowski[2], Jarosław Żygierewicz[3], Katarzyna Jednoróg[1]; [1]Laboratory of Language Neurobiology, Nencki Institute of Experimental Biology, Polish Academy of Sciences, [2]Laboratory of Brain Imaging, Nencki Institute of Experimental Biology, Polish Academy of Science, [3]Faculty of Physics, University of Warsaw

Background Reading acquisition involves the integration of auditory and visual stimuli. Thus, low-level audiovisual multisensory integration might contribute to disrupted reading in developmental dyslexia. Although dyslexia is more frequently diagnosed in males, previous studies examining multisensory integration did not evaluate potential sex differences nor tested its neural correlates. Methods We investigated multisensory integration using simple detection of stimuli in unisensory (white flash in the visual-alone and 1000 Hz tone in the auditory-alone condition) compared to the multisensory condition (simultaneous presentation of visual and auditory stimuli) while continuous EEG was recorded in 88 adolescents (44 with dyslexia and 44 controls, with an equal number of males and females). To assess the behavioral effect of multisensory integration, the race model inequality was applied. At the neural level, early components of event-related potentials related to sensory processing (i.e., P1, N1, N2) were evaluated in response to the multisensory compared to the sum of unisensory conditions. Results We found that only males with dyslexia showed a deficit in multisensory integration of simple non-linguistic stimuli at the behavioral level, and this deficit was related to lower reading speed. At the neural level, both females and males with dyslexia presented smaller differences in response to multisensory compared to unisensory conditions in the N1 and N2 components than the control group. Additionally, the neural indices of multisensory integration were differently related to reading skills in females and males. Conclusions Our study indicates that deficits of multisensory integration seem to be more severe in males than females with dyslexia. This provides important insights into sex-modulated cognitive processes that might confer vulnerability to reading difficulties.

Topic Areas: Multisensory or Sensorimotor Integration, Disorders: Developmental

## A comparison of different methods for new word learning and the underlying neural representations

***Poster D110*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Shuai Wang[1], Sophie Restoy[1], Julien Sein[2], Bruno Nazarian[2], Jean-luc Anton[2], Anne-Sophie Dubarry[3], Clément François[1], Felipe Pegado[4], Franck Lamberton[5], Chotiga Pattamadilok[1]; [1]Aix Marseille Univ, CNRS, LPL, Aix-en-Provence, France, [2]Aix Marseille Univ, CNRS, Centre IRM-INT@CERIMED, Institut des Neurosciences de la Timone – UMR 7289, Marseille, France, [3]Aix Marseille Univ, CNRS, LNC, Marseille, France, [4]Université Paris Cité, LaPsyDÉ, CNRS, F-75005 Paris, France, [5]CERMEP – Imagerie du vivant, MRI Department and CNRS UMS3453 , Lyon , France

Audio-visual association is fundamental in language acquisition. Early on, infants perceive speech with speakers' articulatory gestures (Aud-Artic learning) and later, when they learn to read, speech is associated with orthography (Aud-Ort learning). Our previous behavioral study suggests that new words which were learned through different methods might be consolidated and stored in the mental lexicon differently (Pattamadilok et al., 2021), with multimodal learning methods leading to higher learning efficiency than unimodal. This difference in learning efficiency could be due to the nature of the underlying representations built up through the different learning methods. The present study combines a learning paradigm and fMRI to 1) determine whether new words which were learned through different methods evoke the same or different brain activity, and 2) investigate which learning method leads to the brain activity that is most similar to known words. METHODS: 25 native French speakers were recruited. Participants were asked to learn three sets of 15 novel words associated with 15 unknown objects through three different methods, i.e., Audio, Aud-Ort and Aud-Artic, in a within-subject design. The fMRI acquisition was conducted in two sessions: Immediately after the learning phase and ~24hrs later. In each session, participants performed an auditory lexical decision (ALD) task on five types of spoken input: pseudowords, known words and new words learned through each of the three methods. FMRIPrep and AFNI were used for processing MRI data. Linear-mixed models were applied for the group analysis using the 'lme4' package in R. Both ROI-based and whole-brain analyses were conducted. Three ROIs were selected for three modality-specific processing, i.e., left-STG for speech processing, left-vOT for orthographic processing, left-SMA for articulatory gestures processing. For each ROI, several linear-mixed models were created by considering Stimulus Type, Session and their interaction as fixed factors, learning performance, accuracy and/or RT of the ALD task as covariate(s), participants and/or their response specificity and sensitivity as random factor(s). According to AIC and BIC, the optimal model was BOLD = Stimulus Type * Session + Participant. This model was then applied to the whole-brain analysis. SUMMARY: As expected, preliminary analyses showed no significant Stimulus Type effect in the left-STG ($p > 0.13$), indicating that the area was involved in speech processing regardless of learning methods. Both left-vOT and left-SMA showed a significant Stimulus Type effect ($ps < 2e-5$). The post-hoc tests revealed that, in left-vOT, Aud-Ort new words evoked higher activation than known words ($p < 0.038$). In left-SMA, all types of new words evoked higher activation than known words ($ps < 0.031$) while pseudowords evoked higher activation than known words and Audio new words ($ps < 0.034$). Although the ROI-based analysis did not show any consolidation effect, the whole-brain analysis revealed a stronger activation in session 2 for Aud-Artic learning in right Fusiform and middle Occipital (FDR $q < 0.05$). In short, learning modality seems to have an impact on how spoken words are encoded in the different areas in the language network even when the input was presented in auditory.

Topic Areas: Multisensory or Sensorimotor Integration, Speech Perception

## (How well) do you see what she's saying? Inter-individual variability and correlates of the audiovisual speech benefit in behaviour and MEG

***Poster D111*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Jacqueline von Seth[1], Máté Aller[1], Matt Davis[1]; [1]University of Cambridge

It is well-established that seeing the face of a speaker can substantially enhance speech perception, especially in noisy environments. However, this audiovisual benefit is highly variable across individuals and measurement indices (Grant & Seitz, 1998; Tye-Murray et al., 2016). Previous studies have demonstrated neural tracking of acoustic features during silent lip-reading (Suess et al., 2022) and probed differences in speech tracking between unisensory and audiovisual conditions (Aller et al., 2022). Yet, inter-individual differences in neural speech tracking for audiovisual speech and its behavioural relevance remains poorly understood. Here we present a planned study designed to explicitly compare enhanced audiovisual benefit using temporal response functions (TRF) based on targeted recruitment of exceptional speechreaders and trial-level measures of intelligibility. We also present re-analyses of existing MEG data (N=14) and discuss preliminary results of an ongoing, large-scale behavioural study designed to a) quantify the distribution of the audiovisual benefit for acoustically degraded speech in the general, healthy population, b) probe cognitive correlates of an enhanced benefit and c) validate our intelligibility-matched audiovisual benefit measure. Rather than comparing changes in intelligibility due to added visual speech, we measure the relative intelligibility of matched audiovisual (AV) and auditory-only (AO) speech. In our behavioural study, participants report words-in-sentences, words in isolation and complete a forced-choice phoneme identification task in AO, AV and visual-only (VO) conditions. Acoustic clarity is manipulated using a noise-vocoding procedure to create two levels of degradation matched to achieve approximately 50% accuracy in both AO and AV conditions, based on the mixing proportion of unintelligible 1-channel and intelligible 16-channel vocoded speech (Zoefel et al., 2020). We assess the test-retest reliability of our audiovisual benefit measure across experimental sessions, its distribution and correlations between benefit measures at different levels of linguistic structure (phonemes, words, sentences). We also test predictors of enhanced audiovisual benefit, including level-specific measures of lipreading ability (VO), domain-general cognitive and linguistic skills (non-verbal and verbal IQ) as well as speech-in-noise perception thresholds and hearing experience using linear mixed-effects modelling (LME). The results of our behavioural study will inform the recruitment strategy for our planned MEG study powered to explicitly compare neural indices of audiovisual benefit in low and high benefit groups using TRF modelling of visual, acoustic and linguistic features. Among the list of planned analyses are: a) neural encoding of facial motion estimated using partial canonical correlation analysis (CCA) of facial landmark timecourses (Pederson et al., 2022) during silent lipreading and b) neural indices of audiovisual integration, comparing encoding of acoustic and linguistic features in intelligibility-matched AO and AV conditions, at the MEG sensor- and source-level. These will be illustrated in a re-analysis of our existing MEG dataset, alongside a discussion of predictions for the planned study. Group-level comparisons of individuals with higher and lower audiovisual benefit will allow us to elucidate neural responses relevant to behaviour and improve our understanding of inter-individual variability in the audiovisual benefit for speech.

Topic Areas: Multisensory or Sensorimotor Integration, Speech Perception

## Attention drives visual processing and audiovisual integration during multimodal communication

***Poster D113*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Noor Seijdel[1], Jan-Mathijs Schoffelen[2], Peter Hagoort[1,2], Linda Drijvers[1,2]; [1]Max Planck Institute for Psycholinguistics, [2]Donders Institute for Brain, Cognition and Behaviour

During communication in real-life settings, our brain needs to integrate auditory and visual information, and at the same time actively focus on the relevant sources of information, while ignoring interference from irrelevant events. The interaction between integration and attention processes remains poorly understood. Here, we use rapid invisible frequency tagging (RIFT) and magnetoencephalography (MEG) to investigate how attention affects auditory and visual information processing and integration, during multimodal communication. We presented human participants (male and female) with videos of an actress uttering action verbs (auditory; tagged at 58 Hz) accompanied by two movie clips of hand gestures on both sides of fixation (attended stimulus tagged at 65 Hz; unattended stimulus tagged at 63 Hz). Integration difficulty was manipulated by a lower-order auditory factor (clear/degraded speech) and a higher-order visual semantic factor (matching/mismatching gesture). We observed an enhanced neural response to the attended visual information during degraded speech compared to clear speech. For the unattended information, the neural response to mismatching gestures was enhanced compared to matching gestures. Furthermore, signal power at the intermodulation frequencies of the frequency tags, indexing non-linear signal interactions, was enhanced in left frontotemporal and frontal regions. Focusing on LIFG, this enhancement was specific for the attended information, for those trials that benefitted from integration with a matching gesture. Higher power at this intermodulation frequency was related to faster reaction times. Together, our results suggest that attention modulates the strength and speed of audiovisual processing and interaction, depending on the

congruence and quality of the sensory input.

Topic Areas: Multisensory or Sensorimotor Integration, Speech Perception

## Is face perception necessary for audio-visual speech integration?

***Poster D114*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Enrico Varano[1], Alexis Hervais-Adelman[1]; [1]UZH

Understanding spoken language is substantially facilitated by seeing the speaker's face, a particularly salient effect when speech intelligibility is compromised. Factors such as degraded auditory signals, background noise, older age, and hearing impairment often necessitate a greater reliance on this audiovisual (AV) comprehension. The neural mechanisms underlying this phenomenon are thought to involve multi-stage feedback between the visual and auditory processing pathways but, despite ongoing research, a gap remains in our understanding of the precise neural pathways that contribute to successful AV integration. This sandbox series study aims to elucidate the relationship between the effects of orofacial articulatory and temporal signals in audiovisual degraded speech comprehension. Evidence from the literature and our previous findings suggest that facial context significantly impacts speech comprehension. Specifically, cartoon mouths based on facial landmarks were found to improve speech comprehension only if presented within the context of a cartoon face. This implies that recognizing dynamic visual signals as belonging to a speaker's face is crucial for audiovisual integration. Our proposed research entails a systematic exploration of the feature space indexed by three parameters. Firstly, following several conflicting results in the literature regarding the viability of simple, speech envelope-driven visual features for the improvement of speech-in-noise comprehension, the AV comprehension gain due to a cartoon face with 5 different drivers of mouth movements will be assessed. Secondly, the putative role of face-sensitive neural circuitry in mediating audiovisual integration will be addressed by repeating previously defined conditions with diffeomorphed versions of each cartoon type. Such controls contain the local motion cues but lack dynamic configural information of faces. Lastly, to differentiate between effects driven by separable and non-separable speech degradation, this matrix sentence behavioural experiment will be repeated with both a noise masker and with noise vocoded speech. This research is anticipated to enhance our understanding of sensory integration mechanisms, which has potential implications for clinical interventions and our understanding of the evolution of language perception. Further, it is expected that these results will clarify conflicting evidence regarding the influence of acoustic energy visualisations on AV gain. If a difference in comprehension gain between original and diffeomorphed videos were to be found, the authors plan to investigate the putative integration-gating role of loci such as the fusiform face area (FFA), superior temporal sulcus (STS) and anterior cingulate cortex (ACC) in a follow-up M/EEG study.

Topic Areas: Multisensory or Sensorimotor Integration, Speech Perception

## Functional and structural connectivity underlying silent visual speech perception

***Poster D115*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Relevant visual information is available in speakers' faces during face-to-face interactions that improve speech intelligibility. Visual speech processing requires to process faces that are conveying linguistic information by the mean of speech effector movements. Additionally, visual and auditory speech perception often co-occur during face-to-face conversations. The perception of faces is known to elicit brain activity in the fusiform face area (FFA), with preferential responsiveness in the right hemisphere. In contrast, a region of the fusiform gyrus called the visual word form area (VWFA) preferentially responds to written words and letters in the left hemisphere, suggesting a specialization for the visual processing of linguistic symbols. Recently, a third visual pathway (TVP) was identified in both human and non-human primate's right hemisphere that is proposed to support social perception, and particularly the visual processing of biological motion such as dynamic faces. The TVP projects on the lateral surface on the brain from V1 to the anterior temporal lobe via the superior temporal sulcus, a region known for its role in the integration of multimodal information. The aim of the current study is to describe the neural circuitry underlying visual speech perception, to explore the possible recruitment of the TVP for multimodal integration of speech and to disentangle the contribution of both hemisphere in this process. We designed a lip-reading task in which participants were presented shown video clips of silently spoken words and had to identify the target word among three written words distractors presented subsequently, which differed in their visemic distance from the target. We demonstrated that participants discriminated target words above chance and that error rate significantly decreased with increasing visemic distance from target words. We then acquired functional (task and resting-state) and diffusion MRI data from 24 healthy participants. Functional connectivity analyses of the task are being performed to contrast the brain activity elicited by the perception of faces silently articulating words versus faces producing backward speech or static faces. Resting-state functional connectivity as well as tractography analyses will be performed and correlated with the performance on the behavioral lip-reading task.

Topic Areas: Multisensory or Sensorimotor Integration, Speech Perception

## Beyond central vision: Unique peripheral word and face processing abilities in deaf signers

***Poster D116** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Zed Sevcikova Sehyr[1], Sofia E. Ortega[1], Katherine J. Midgley[1], Phillip J. Holcomb[1]; [1]San Diego State University

Words are most efficiently processed in central vision although readers also utilize information in the parafovea to preprocess upcoming words during reading. Congenitally deaf people proficient in sign language have consistently shown larger reading spans than hearing readers (Belanger et al., 2012), reflecting an efficiency in allocating attention and integrating information presented simultaneously across the visual field during signing. This study examined the ability of readers to process words in the periphery using an ERP repetition priming paradigm. The primes were presented in the central vision and were fixated, followed by target stimuli in the periphery (left or right). Eccentric targets were not fixated and participants who consistently made saccades to the targets were excluded. Participants made same-different judgments by pressing a response button while we recorded EEGs from 29 scalp electrodes. The handedness of responses was counterbalanced across participants. We additionally included faces and car stimuli in separate blocks to assess whether enhanced visual processing capacity in deaf readers is specific to words or generalizes to non-orthographic objects. We focused on priming effects on the N400 component which we predicted should be sensitive to any lexico-semantic processing of peripherally located targets. The study included 38 adults, comprising 19 deaf American Sign Language signers and 19 hearing English speakers. Results revealed semantic priming effects as indexed by the N400 component for words, with unrelated word pairs generating more negative-going ERPs between 300-450ms than repeated pairs. However, this effect was more pronounced and consistent across participants in the deaf group, suggesting an increased ability to extract and integrate meaning from spatially and temporally distinct word stimuli. Secondly, unrelated face pairs also elicited a more negative-going deflection between 300-450ms than repeated face pairs in both groups, indicating similar peripheral processing benefits to faces. Notably, the face priming effect lasted longer in the deaf group, perhaps due to the signers' linguistic experience with facial expressions. Further, both groups showed priming effects for words and faces earlier when eccentric stimuli were presented to the right and left visual fields respectively, supporting the expected left hemisphere dominance for words and right hemisphere dominance for faces. Finally, deaf and hearing participants exhibited similar time course and distribution of N400 repetition effects to cars. Accuracy and reaction times were collected for all stimulus types and aligned with these patterns. Overall, deaf readers showed enhanced, perhaps more resilient lexico-semantic processing of words in the periphery across the two visual hemifields, while hearing readers may do so inconsistently. Although these results are promising, more work is needed to explore the exact mechanisms involved. The study furthers our understanding of the neurobiological basis of language and visual processing in readers with atypical sensory-perceptual experiences.

Topic Areas: Reading, Signed Language and Gesture

## Involvement of first-order thalamic nuclei in human language systems: Functional and structural correlates

***Poster D117*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The cerebral cortex has been regarded as the key player in higher cognitive functions, including language. The subcortical structures, such as the thalamus, have been thought to have subordinate or negligible involvement in these functions. Despite lesion and functional neuroimaging evidence of thalamic involvement in language, the field of neurobiology of language is still debating the notion that the thalamus plays any role in language at all. Previously, the thalamus was understood as a simple transponder, relaying information in cortico-cortical and cortico-subcortical systems. These views have been extensively challenged over the last years. For example, the first-order relay thalamic nuclei, traditionally viewed as mere gateways to the cerebral cortex, are suggested to play a more integrative role in higher functions. Nevertheless, the role of the sensorimotor thalamic nuclei and their interactions with the cerebral cortex in language processing remains largely unknown. Different language systems heavily rely on distinct types of sensorimotor information (e.g., visual input for reading, auditory input for speech comprehension, and motor articulation for speech production), and it is expected that the involvement of the lateral geniculate nucleus (LGN), medial geniculate nucleus (MGN), and ventral lateral nucleus (VLN) may vary across these language systems. Here, we present the results from a large multimodal MRI study aimed at investigating the involvement of sensorimotor thalamic nuclei (LGN, MGN, VLN) in reading, speech comprehension and speech production. The analytical approach included an examination of the functional activation of these nuclei, and their functional and structural connectivity with cortical and cerebellar regions of the language network. To this end, 40 participants underwent MRI scanning and performed tasks associated with language comprehension and production processes. Along with linguistic stimuli, non-linguistic stimuli, such as scrambled visual pixels, scrambled speech sounds, and unintelligible sound production, were included as control conditions. Outside of the MRI, participants completed comprehensive behavioral testing to further examine functional and structural brain-behavior associations. Our results demonstrated greater engagement of the LGN, MGN, and VLN in both linguistic and non-linguistic tasks across the corresponding sensory modalities, compared to baseline. Furthermore, the functional activation of each task was specific to the examined first-order thalamic nuclei (e.g., LGN activation during reading but not during speech comprehension or speech production). Importantly, we observed stronger activation in language comprehension tasks for linguistic stimuli compared to non-linguistic stimuli. For instance, the LGN exhibited higher activation when reading real words than when viewing scrambled pixels. Additionally, task-related functional connectivity within visual, auditory and motor thalamocortical networks was associated with the respective language systems. Finally, statistically significant associations between functional, structural and behavioral data within each language system were observed in multiple regression models. In sum, our findings indicate a segregation in the implication of different human thalamic sensorimotor nuclei and their thalamocortical interactions in the main human language systems, indicating that their functional and structural properties significantly contribute to explain language behavior.

Topic Areas: Reading, Speech Perception

## Voices in my head: activation of auditory cortex during silent reading

***Poster D118*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Reading requires visual word representations to be mapped to both sound and meaning and is an essential life skill that promotes both personal well-being and professional success. However, while dyslexia is the most common learning disability worldwide, its associated pathophysiology remains unclear, and current management strategies consist primarily of behavioral therapy. As such, a better understanding of the neural mechanisms supporting reading would provide important insights into the pathology underlying its disruption and facilitate the development of improved treatment methods. Here, we investigated the role of auditory cortex in silent reading and compared these findings to regions recruited during listening. Data were obtained from 63 patients who underwent invasive electrophysiology (electrodes=8,082). Recordings were acquired during two matched cued-naming tasks using auditory and written descriptions displayed as single words in rapid serial visual presentation. Importantly, the last word in each prompt across both paradigms was crucial

to bind semantic concepts. We analyzed broadband gamma activity (BGA; 65-115Hz) to index cognitive engagement of local cortical substrates. Additionally, group-level BGA was estimated using a surface-based mixed effects multilevel analysis. For each written word, visual cortex activity was followed by activation of lateral occipito-temporal cortex and the intraparietal sulcus. Subsequently, activation was seen in the posterior superior temporal gyrus (pSTG; 20.4% BGA, 238ms) and the posterior middle temporal gyrus (pMTG; 29.3% BGA, 266ms), and these regions were also active during listening (pSTG: 128.3% BGA, 161ms; pMTG: 41.3% BGA, 206ms). Activation of pMTG was greatest for the last word for both tasks, which implicates its role in lexical-semantic processing and sentence comprehension. In contrast, activation of pSTG was consistent across each word in the description and preceded pMTG activity, which supports its involvement in orthographic processing. Furthermore, activity from depth electrodes placed along STG in a subset of 37 patients showed a consistent posterior-to-anterior gradient during both listening and silent reading. Electrodes within more anterior regions, including Heschl’s gyrus and the transverse temporal sulcus, showed a sustained activation consistent with entrainment during listening and were quiescent during silent reading. However, electrodes within more posterior regions, including the planum temporale, showed onset-specific, transient activation during listening as well as activation for each word in the description during silent reading. This distinct activity profile further implicates pSTG (primarily the planum temporale) in orthographic decoding and suggests that it may play a critical role in orthographic-to-phonological processing. Altogether, these results contribute a deeper understanding of the spatiotemporal dynamics associated with orthographic processing and the specific functional roles of critical neural substrates. Ultimately, we believe that this work would provide important insights to optimize the design of neural prosthetics for the treatment of reading-related disorders.

Topic Areas: Reading, Speech Perception

## Greater reliance on sentence context during naturalistic listening predicts larger reading gains over two years

***Poster D119** in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Individuals with decoding-based reading disability (also known as dyslexia) often exhibit deficits in phonological processing (Shaywitz, 1996), including deficits in speech sound processing (Schulte-Körne & Bruder, 2010; Vellutino et al., 2004) and in low-level auditory processing more generally (Giraud & Ramus, 2013; Lehongre et al., 2011). Many children with reading disability also have higher-level language difficulties (Adlof & Hogan, 2018), including using auditory sentence contexts to generate predictions about upcoming words (Sabisch et al., 2006; see Hestvik et al., 2022 for evidence in children with DLD). Here, we used naturalistic stimuli (audiobooks) and assessed how well each individual’s EEG “tracked” content as it accrued during story comprehension across multiple linguistic levels, as indexed by linguistic surprisal and entropy derived from a sentence context model. Then, we asked whether this content-tracking measure was related to contemporaneous and/or future reading ability. METHOD: Participants (n=28) were students with reading disability attending schools specializing in remediating language- and reading-based disabilities (at study enrollment, mean age=10.3 years, SD=1.6 years, range=7.5–13.2 years). To measure word reading ability, participants were administered the TOWRE Sight Word Efficiency subtest, a timed test of word decoding ($\mu=100$; sample M=84, SD=11, range=66–117). This test was administered 4-5 times at 6-month intervals; gains were measured as average change in score per year. At the first timepoint, participants also listened to audiobook excerpts for 12 minutes while their EEG was recorded. A sentence (lexical 5-gram) context model was used to quantify word surprisal, cohort entropy, and phoneme entropy for all words and phonemes in the excerpts, based on the four preceding words and the partial current word. Then, time-lagged regression analyses were used to measure how much each participant's EEG covaried with this time series of linguistic probabilities, while controlling for acoustic predictors, sublexical context, and lexical context (see Brodbeck et al., 2022 for more details). RESULTS: Participants who relied more on sentence context to generate and evaluate predictions about upcoming words and phonemes during the listening task showed significantly greater gains in reading scores over the next 1.5 to 2 years ($\Delta r2=16\%$, $p=.027$), controlling for initial reading scores and age. Descriptively, this effect was driven by a centroparietal negativity to phonemes in more contextually surprising words from 200 to 350 ms – consistent with an N400 effect (auditory N400 onset begins around 200 ms; e.g., Heilbron et al., 2022) – which was more pronounced in participants who made larger gains. In contrast, reliance on sentence context was not related to contemporaneous reading ability ($\Delta r2 < 1\%$, $p=.75$). CONCLUSIONS: The present study provides further evidence that neural responses to continuous speech can index individual differences in predictive processing (cf. Gillis et al., 2023; Keshavarzi et al., 2022), while also showing that these differences can identify listeners who are on the verge of making substantial reading gains which are not reflected in current reading scores. Speculatively, leveraging sentence contexts to generate predictions about upcoming speech in real-time may allow a listener to derive more benefit from linguistic input, enabling faster progress in reading-related skills.

Topic Areas: Reading, Speech Perception

## An EEG investigation into early syntactic processing: A rapid parallel visual presentation study of agreement and WH-dependencies in English

***Poster D120*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The majority of research and theorizing in language processing assumes that language is understood word-by-word. However, during naturalistic reading, readers make use of information from multiple words in parallel (Schotter, Angele, & Rayner, 2011; Snell & Grainger, 2019). Findings from the rapid parallel visual presentation paradigm (RPVP), where multi-word sentential stimuli are briefly presented, demonstrate that sentence recall is more accurate when the stimuli are semantically congruent (Asano & Yokosawa, 2011) and syntactically well-formed (Snell & Grainger, 2017). This is evidence for some early, form-based syntactic processing. These processes are reflected in EEG recordings; Wen, Snell & Grainger (2019) found greater negative amplitude for scrambled stimuli compared to grammatical stimuli ~300ms . We build upon this work, asking: what kinds of syntactic features is this brain response sensitive to? [METHODS] N = 12 English speakers participated in two adaptations of the Snell & Grainger (2017) paradigm, in which short sentences were displayed briefly, followed by a memory probe. In the first task, stimuli were 48 sets of 5-word, grammatical sentences, ungrammatical sentences with a subject-verb number agreement error, ungrammatical scrambled sentences, and consonant strings matched in length to the sentential stimuli. In the second task, stimuli were 64 sets of 5-word sentences. We manipulated whether the subject was a wh-expression (±WH-Subject), and whether the object was a wh-expression (±WH-Object). EEG signals were recorded with a 64-channel BrainVision actiCHamp+ system, with FCz as on-line reference. [RESULTS] For both tasks, sensor space spatio-temporal cluster-based permutation tests were conducted in 'N400' (200–500ms) and 'P600' (500–800ms) time windows, plus an additional exploratory analysis in the entire time window (0–800ms). For the first task, we identified a cluster 380–693 ms, showing a difference among the 4 conditions over left lateral sensors ($p < 0.01$). Qualitatively, the consonant string waveform diverges negatively from the waveforms of the linguistic conditions. Subsequent pairwise spatio-temporal cluster-based permutation tests between grammatical stimuli and the three other conditions identified an effect of consonant strings, 200–500ms, distributed over posterior midline sensors ($p < 0.01$). For the second task, we identified a cluster 258–335ms, showing greater positivity for NP subjects over WH subjects, irrespective of the form of the object, over left lateral and left posterior sensors ($p < 0.03$). [CONCLUSION] While grammatical vs ungrammatical EEG differences do not yet emerge in the first task---even though they would be expected---the results of the first task do suggest that linguistically plausible stimuli are processed differently from linguistically content-less consonant strings. With respect to the second task, interrogatives with NP subjects require 'do'-insertion, regardless of the object's form– 'Did she pet this dog?', 'Which dog did she pet?' vs 'Who pet this dog?', 'Who pet which dog?. Thus, the early divergence in EEG signals may reflect sensitivity to this superficial cue to syntactic structure. When data collection is complete, we will use the digitized sensor positions coregistered with the freesurfer average ('fsaverage') template brain to compute the inverse solution using the sLORETA method to identify the source space correlates of any significant sensor-space clusters.

Topic Areas: Reading, Syntax and Combinatorial Semantics

## The Functional Connectivity Underpinning Reading and Writing Abilities in Chinese-English Bilingual Children

***Poster D121*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Abstract: The universality and specificity of the neural basis underlying literacy skills in the first (L1) and second (L2) language, as well as the assimilation-accommodation hypothesis for L2 processing remains a hot question in the field of neurolinguistics. Previous studies have shown that L1 and L2 shared similar resting-state functional connectivity (RSFC) in Chinese-English adults' reading abilities. However, whether early bilingual children may recruit different neural mechanisms for L1 and L2 reading remains unclear. In addition, reading and writing are both developed based on written language, while RSFC neural mechanism for young Chinese-English bilingual children's writing skills is also unknown. Sixty-three Chinese-English bilingual children from primary schools, who started learning to read both Chinese and English at approximately 6 years old were recruited for fMRI scanning and behavioral assessment. A battery of tests was administered to

measure the participants' reading and writing abilities in Chinese and English, as well as reading and writing-related cognitive abilities (phonological awareness, visual-motor integration, and visual-spatial skills) and non-verbal intelligence. RSFC analysis was performed based on twelve regions of interest, from meta-analyses which focused on children's reading networks regardless of the language types and Chinese typical reading networks. Our conjunction analysis found that both Chinese and English reading skills were positively correlated with RSFC among the phonological processing regions (e.g., L.STG to L.IFGop, L.Putamen), between phonological and visual regions (e.g., L.Insula-L.Calcarine). Furthermore, some common RSFCs for L1 and L2 reading were positively correlated with visual-motor integration and phonological awareness. Our contrast analysis found that Chinese reading was uniquely supported by RSFC of R.IOG-L.SMG, which was positively correlated with visual-spatial processing and visual-motor integration. However, no unique RSFC for English reading was found. With regards to writing, the common RSFCs supported Chinese and English writing were between phonological and visual regions (e.g., L.Insula-R.Lingual), between central and peripheral processes of handwriting and visual regions (e.g., L.medial FrG-L.Calcarine), orthographic representation regions (L.FG-R.MFG). Our contrast analysis found that Chinese writing was uniquely supported by RSFC of phonological processing and motor execution involved in handwriting (e.g., L.STG-L.IPL). In contrast, English writing was uniquely supported by RSFC of L.IOG-R.MTG, which was positively correlated with English phonological awareness. Taken together, our results suggest that universal neural mechanisms existed for reading and writing across languages in Chinese-English bilingual children at the critical phase of literacy skills development. Furthermore, children could form unique neural recruits only for Chinese reading but not English reading, which may indicate assimilation or less proficiency in L2 reading. Whereas writing across different writing systems both recruits unique neural resources, which may indicate accommodation. Additionally, it highlights the vital role of meta-linguistic and general cognitive skills supporting reading- and writing-correlated RSFC across language. Key words: Chinese-English bilingual children, RSFC, reading skill, writing skill, cognitive skills

Topic Areas: Reading, Writing and Spelling

## Perturbing the Pathway: The Impact of Lollipops and Lidocaine on Supramarginal Gyrus Activity During Reading Tasks

***Poster D122*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Introduction: The universal print-to-speech framework describes a tight coupling between auditory (i.e., superior temporal gyrus) and somatosensory (i.e., supramarginal gyrus) feedback systems during various reading tasks. And, while much evidence has outlined the consequences of auditory perturbations on subsequent reading performance, comparatively little work has examined the impacts of somatosensory perturbations on reading. Surprisingly, recent work from our lab showed that somatosensory perturbations (i.e., lollipops and/or lidocaine in the mouth) facilitated reading performance in typical readers. However, the neural consequences of these perturbations remain unknown. The current study investigates the effects of mouth perturbations on the activity of the supramarginal gyrus, the brain region understood to play an important role in the somatosensory feedback system. Specifically, we examine whether lidocaine, known for numbing sensory receptors, suppresses activity, while large lollipops enhance activity in the supramarginal gyrus during reading tasks. This research will act to further our understanding of a universal print-to-speech framework. Methods: Participants proficient in English completed two reading tasks: an Orthographic Lexical Decision Task (OLDT; “does the letter string spell a real word, yes or no?”) and a Phonological Lexical Decision Task (PLDT; “does the letter string sound like a real word, yes or no?”) under three conditions: no perturbation, a lollipop perturbation (i.e., a large lollipop held in the mouth), and a lidocaine perturbation (i.e., a topical lidocaine solution swished in the mouth). Functional Near-Infrared Spectroscopy (fNIRS) was used to measure cortical hemodynamic responses during each task. Results: Behavioural data indicated enhancements in reading performance for both perturbation conditions compared to the control condition. Additionally, there was a marked increase in brain activity within the supramarginal gyrus during the lollipop condition compared to control and lidocaine conditions. Conversely, the lidocaine condition exhibited decreased brain activity compared to control and lollipop conditions. Conclusion: Our findings demonstrate that the lollipop perturbation increased supramarginal gyrus activity, while the lidocaine perturbation decreased activity. These results support our hypothesis that somatosensory perturbations in the mouth modulate the activity of the supramarginal gyrus during reading tasks and shed light on the neural underpinnings involved in the print-to-speech framework.

Topic Areas: Reading,

## A parvocellular-magnocellular functional gradient in human visual cortex

***Poster D123*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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The magnocellular and parvocellular systems are major visual recognition pathways, with distinct histological and physiological properties. Despite their critical role, there is limited evidence on the specific contributions these visual pathways make to visual recognition in general and to word reading in particular. Using a multimodal functional MRI approach and individual-subject analyses, here we investigate the involvement of visual cortex regions in the recognition of magnocellular- and parvocellular-biased words and images. The study sample consisted of 34 participants (19 females and 15 males, mean age 25.37 ± 4.41 years). Fourteen of them (8 females and 6 males, mean age 25.10 ± 4.58 years) also participated in an identical second session 7–10 days later (i.e., retest session), to examine data reproducibility. Our results reveal a functional gradient in the activation profile of both left and right visual cortex: posterior regions were more strongly recruited for processing parvocellular-biased, while anterior regions were more involved in processing magnocellular-biased stimuli. Furthermore, functional connectivity analyses show clustering in the strength of functional coupling among visual cortex regions as a function of the distance between regions, with greater coupling within and less coupling across posterior and anterior regions. Finally, we found minimal differences in lateralization for word and image recognition in these visual cortical regions. These results were replicated in a retest session with a subset of participants. Our findings underscore a functional division of labor in the visual cortex as a function determined by a parvocellular or magnocellular bias in properties of the stimuli and further reveal that in this context the visual cortex is not particularly biased towards words or images. These findings will be discussed in line with current neurobiology of language theoretical accounts and potential implications of these pathways in typical and atypical reading.

Topic Areas: Reading,

## Atypical Electroencephalographic Language Lateralization in Temporal Lobe Epilepsy as revealed by fast periodic visual stimulation

***Poster D124*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Language functions are left lateralized in the majority of the healthy population. However, this dominance of the left hemisphere is not systematic and presents inter-individual variability, underlining the importance of developing non-invasive sensitive, objective and reliable measures at the individual level. This is especially relevant in patients with drug-resistant left temporal lobe epilepsy (LTLE) who may present atypical language lateralization and frequent language disorders. The assessment of this atypical representation is crucial to understand and prevent cognitive language disorders in TLE patients who are candidates for cortical surgery. Unfortunately, there are methodological and practical limitations in using neuroimaging techniques and linguistic tasks to determine language lateralization, particularly in this population. Here we used a fast periodic visual stimulation approach coupled with high-density (64 channels) electroencephalogram (FPVS-EEG) providing objective and sensitive measurement of language lateralization across three visual word stimulation paradigms. LTLE patients (N=18) and matched healthy adults (18) were presented with 1) written words embedded periodically in rapidly presented variable nonwords and pseudoletters (Lochy et al., 2015), 2) words of the same semantic category (i.e., animals) embedded in words of another category (i.e., cities) (Volfart et al., 2021) and 3) celebrity names embedded in unknown names (unpublished). All three paradigms were administered in total in only 15 minutes, with rapid objective identification and quantification of lexico-semantic markers in the EEG frequency-domain (e.g., Rossion et al., 2020). While category-selective periodic neural responses over the occipito-temporal cortex were all left lateralized in healthy controls, we report atypical lateralization at the group level in LTLE, characterized by shifted lateralization (i.e., to the right occipito-temporal) and/or bilateral lateralization in the three paradigms. Although this atypical lateralization is consistent with previous studies, different patterns are found across individual patients, showing that this atypical language representation is not systematic. Further analysis is needed to understand the sources of these inter-individual variabilities (e.g., duration of disease, handedness). Atypical hemispheric lateralization of lexico-semantic language processes in LTLE can be rapidly measured with FPVS-EEG, offering promising

results for non-invasive characterization of the hemispheric functional organization of language in drug-resistant epileptic patients.

Topic Areas: Reading,

## An EEG functional localizer for identifying visual word form responses in sensor and source space

***Poster D125*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Substantial attention has been paid to the left fusiform gyrus' role in processing visual word form information (Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin 1999; Dehaene & Cohen 2011), and its role in initial stages of morphological processing (Solomyak & Marantz 2011). The functional 'visual word form area' (VWFA) has been studied predominantly in fMRI and MEG, due to their accurate spatial resolution. However, coregistered fMRI-EEG studies on word recognition show that left fusiform activity correlates with the N1 peak in EEG recordings (Cohen, Dehaene, Naccache, Lehéricy, Dehaene-Lambertz, Hénaff, Michel 2000; Pleisch, Karipidis, Brem, Röthlisberger, Roth, Brandeis,Walitza, Brem 2019), and EEG source reconstruction techniques localize N1 responses to bilateral occipitotemporal regions (Brem, Halder, Bucher, Summers, Brandeis 2009; Maurer, Brem, Bucher, Brandeis 2005). Here, we present a replication of an 'abridged' functional localizer, first demonstrated in MEG by Gwilliams, Lewis, & Marantz (2018). We show that this quick (~5 min) experimental paradigm can identify word-specific brain responses in both sensor and source space, which can then serve as a functional ROI. [METHODS] N = 12 English speakers participated in a passive reading task. Stimuli were 50, 4-letter words printed in a sans serif font, and 50, 4 non-linguistic symbols. Both stimuli were embedded in two levels of noise. Luminance, horizontal width, and pixel density of the stimuli were controlled ($p > 0.05$). EEG signals were recorded with a 64-channel BrainVision actiCHamp+ system, with FCz as on-line reference. Electrode positions were digitized using BrainVision CapTrak system. Stimuli were presented for 60ms, with a 200ms ISI. The study took approximately 5 minutes. [RESULTS] Spatio-temporal cluster-based permutation tests were conducted on sensor space data, from 0–300ms. Sensors were re-referenced off-line to average reference. We identified a cluster 125–168ms, showing greater positive activity for words over symbols, irrespective of noise, over left posterior sensors ($p=0.02$). Another cluster showed more positive activity for low noise conditions over high noise stimuli, irrespective of language status, over midline posterior sensors ($p<0.01$). Sensor positions were coregistered with 'fsaverage' template brain, and inverse solutions were computed using sLORETA. Spatio-temporal cluster-based permutation tests were conducted in source space over bilateral occipitotemporal regions, taken from Gwilliams et al. (2018). A marginal cluster showing greater activity for words over symbols was observed in inferior and anterior left temporal lobe, 140–168ms ($p=0.06$). Expanding the search space to include all left temporal lobe, we found a significant cluster 138–168ms in left anterior middle and superior temporal regions, showing greater activity for words over symbols ($p=0.02$). Expanding the search space to the entire brain, a cluster was identified in left posterior fusiform gyrus, 137–168ms ($p=0.09$), showing greater activation for words over symbols. [CONCLUSION] Understanding the brain's response to written words requires a fast, easy-to-use functional localizer. We demonstrate that the 'abridged' functional localizer paradigm used by Gwilliams et al. (2018) in MEG works in EEG. However, our results localize to a more anterior and lateral portions of left temporal lobe than previous studies.

Topic Areas: Writing and Spelling, Methods

## Enhanced handwriting proficiency in Latin-Arabic biscriptuals: an effect of fine motor skills or executive functions?

***Poster D126*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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“Biscriptuality” is the ability to write in two scripts. Most biscriptuals are trained to write in both scripts at an early age. Compared to monoscriptual training, biscriptual training imposes stronger constraints on motor and executive functions. Such constraints could have long-term consequences on the neural circuits driving graphomotor behavior. In this context, Latin-Arabic biscriptuality is a relevant case, because Latin and Arabic alphabets involve opposite writing orientations and rotation directions. In a recent study (Alhaddad et al., 2023), we showed that Latin-Arabic biscriptuals display better graphomotor performance than Latin monoscriptuals in a loop tracing task, raising the possibility that biscriptuality is advantageous for handwriting. Two mechanisms could lead to the biscriptual advantage in this graphomotor task. Due to their extensive training and adaptation to the two scripts, biscriptuals could display either more efficient manual motor control or more efficient domain general executive control than monoscriptuals. The aim of the present study was to replicate the effect of biscriptuality on graphomotor coordination, to test whether this effect extends to a handwriting task in French and Arabic, and to disentangle the potential contributions of fine motor skills and executive functions. We measured graphomotor coordination dynamics in the loop tracing task and handwriting proficiency through standardized handwriting assessment scales in both French and Arabic in 33 Latin monoscriptual and 33 Latin-Arabic biscriptual participants. We also measured the participants’ fine motor skills (Purdue Pegboard, spatial tapping task) and executive functions (working memory, inhibition and flexibility). Preliminary results confirm that biscriptuals perform better than monoscriptuals in the loop tracing task. They further show that this biscriptual advantage extends to handwriting. Biscriptuals displayed more proficient fine motor skills than monoscriptuals, but the two groups did not significantly differ in their executive control. Fine motor skills also predicted several of the indexes of graphomotor coordination and of handwriting in both groups, while executive functioning did not. In sum, the biscriptual advantage in handwriting is mediated by enhanced motor control rather than enhanced executive functions.

Topic Areas: Writing and Spelling, Multilingualism

## Constructed languages are processed by the same brain mechanisms as natural languages

***Poster D127*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

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Many domains share similarities with language and have been argued to draw on the same or overlapping neural mechanisms: for example, like language, math and logical reasoning require manipulation of symbolic representations; like language, music is highly structured; and like language, gestures are a critical communication channel. Despite these similarities, these and many other information systems do not engage the brain mechanisms that support language comprehension (e.g., Fedorenko et al., 2011; Monti et al., 2012; Ivanova et al., 2020; Chen et al., 2023). In the present study, we examined a new domain, previously untested: constructed languages, or conlangs, like Esperanto or Klingon. Do we use our language-processing mechanisms to understand conlangs? Or does conlang processing instead draw on the system that supports our processing of math, logic, and computer languages: the Multiple Demand system (e.g., Duncan, 2010; Monti et al., 2012; Ivanova et al., 2020; Amalric & Dehaene, 20xxNeuroimage)? We tested 38 proficient speakers of conlangs: Esperanto (n=19), Klingon (n=10), Na'vi (n=8), High Valyrian (n=3), and Dothraki (n=3; five participants were proficient in 2 conlangs). While in an fMRI scanner, participants performed a language localizer task (Fedorenko et al., 2010) in their native language (English for most participants) and a critical conlang comprehension task, where they listened to conlang sentences vs. to acoustically degraded version of those sentences (e.g., Malik-Moraleda, Ayyash et al., 2022). Additionally, each participant completed a Multiple Demand network localizer based on a spatial working memory task (e.g., Fedorenko et al., 2013; Shashidara et al., 2019). Using individual-subject fMRI analyses, we identified language functional regions of interest (fROIs) in each participant using their native-language localizer, and then examined the responses to the conlang task conditions. We found that both frontal and temporal language fROIs respond robustly to conlang comprehension, evidenced by a large and significant conlang>degraded effect. The magnitude of response to conlang sentence condition is similar to the magnitude of response to the participant's native language, and a Dice coefficient analysis on the individual-level whole-brain maps revealed strong overlap between the language localizer contrast in the native language vs. in the conlang. In contrast, the Multiple Demand network fROIs showed little to no response during conlang comprehension. The results hold across all five conlangs, which can be construed as five independent replications. To summarize: Constructed languages like natural languages, can express a wide range of meanings related to the external and internal worlds. On the other hand, conlangs differ in critical ways: they were created much more recently, often for different (sometimes esoteric), purposes, and are not shaped by learning and processing pressures, at least not to the same degree (e.g., Okrent, 2010; Goodall, 2022). In spite of these differences all five conlangs recruit the same brain mechanisms as those that support comprehension of natural languages, which suggests that the language network is robust to variation along these dimensions.

Topic Areas: Writing and Spelling, Multisensory or Sensorimotor Integration

## Cerebro-cerebellar pathways contribute to written language production

***Poster D128*** *in Poster Session D, Wednesday, October 25, 4:45 - 6:30 pm CEST, Espace Vieux-Port*

Romi Sagi[1], Sivan Jossinger[1,5], J.S.H. Taylor[2], Kyriaki Neophytou[3], Brenda Rapp[3], Kathleen Rastle[4], Michal Ben-Shachar[1]; [1]Bar-Ilan University, [2]University College London, [3]Johns Hopkins University, [4]The Royal Holloway,

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Producing language is a highly complex human skill involving a distributed network of brain regions. Written language production constitutes a part of our everyday communication, but the neural pathways that support it are relatively understudied. The current study examines the pathways associated with language production in its written form. For spoken language production, studies have demonstrated the involvement of bilateral cerebro-cerebellar pathways and of the bilateral frontal aslant tract (FAT), which connects the inferior frontal gyrus (IFG) with the supplementary motor area (SMA) (Jossinger et al., 2023). The cerebellum, IFG, and SMA have also been implicated in a few fMRI and lesion studies of writing (Purcell et al, 2011; Planton et al., 2013; Paul et al., 2022). However, the pathways connecting these regions are yet to be studied in the context of written language production. Here, we aim to assess the contribution of the cerebro-cerebellar pathways and the FAT to spelling performance. 73 English-speaking neurotypical adults (mean age: 21y±2.7, 57 females) underwent a typed spelling-to-dictation task, to assess their written spelling accuracy. To avoid a ceiling effect, stimuli consisted of long, low-frequency words, with one-to-many phoneme to grapheme mappings. Imaging data were acquired on a 3T Siemens scanner, using a diffusion-weighted, single-shot EPI sequence (64 diffusion directions at b=1000 and 1 volume at b=0 s/mm^2, voxel size: ~2*2*2mm^3). Two pipelines were used to preprocess diffusion MRI data: (1) constrained spherical deconvolution modeling coupled with probabilistic tractography, and (2) tensor modeling coupled with deterministic tractography. The bilateral cerebro-cerebellar pathways and FAT were identified in individual participants using automated tools. Fractional anisotropy (FA) values were calculated along each tract, and Spearman's correlations were calculated between spelling accuracy scores and FA. Spelling accuracy scores were widely distributed across individuals, ranging between 7% to 97% correctly spelled items. We found a significant correlation between spelling accuracy scores and FA in the left cerebro-cerebellar pathway, such that higher FA values were associated with higher spelling accuracy scores. This finding was consistent across both preprocessing methods. Specifically, we detected a significant correlation with spelling accuracy in a large portion of the left cerebro-cerebellar tract (pipeline 1, $N=65$, $r=.38$, $p<.05$, family-wise error corrected). Similarly, spelling accuracy was correlated with the mean tract-FA of the left cerebro-cerebellar tract (pipeline 2, $N=73$, $r=.26$, $p<.05$, uncorrected). No significant correlations were found between spelling accuracy scores and FA in the bilateral FAT, nor in the right cerebro-cerebellar pathway. The current findings demonstrate, for the first time, the involvement of cerebro-cerebellar connections in spelling processes. According to a dominant view, the cerebellum encodes internal models, corresponding to neural representations of the external world (Wolpert, 1998). By interacting with the cerebral cortex through cerebral-cerebellar loops, cerebellar internal models can be utilized to simulate mental representations, such as the orthographic and phonological representations essential for accurate spelling. Future studies will further isolate the specific components of the spelling process mediated by the cerebro-cerebellar pathways.

Topic Areas: Writing and Spelling,


# Poster Session E

## Dissecting the relationship between speech and dance in humans: from brain pathways to clinical therapy

***Poster E1*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Constantina Theofanopoulou[1,2], Erich D. Jarvis[1,3]; [1]Rockefeller University, [2]New York University, [3]Howard Hughes Medical Institute

Evidence from different levels of analysis points to intriguing commonalities between vocal learning, a core feature of human speech, and beat synchronization, a core feature of human dance. Recent findings go beyond the fact that both behaviors rely on rhythmic motor control and on a tight auditory to motor integration. For example, parrots, who are complex vocal learners, like humans, were shown to be able to entrain their body movements to a musical beat (i.e., dance) in a spontaneous and sporadic way, something that led to the hypothesis that the ability to move in time with an auditory beat originated in the neural circuitry for complex vocal learning (Keehn et al. 2019; Patel et al. 2009). Further, developmental studies in human children showed that the development of the ability for a sustained beat perception and synchronization predicts the development for phonological production ability until late childhood (Nave, Snyder, and Hannon 2023). In this talk, we aim to shed light on this hypothesis by introducing our projects and preliminary findings, in a series of studies in humans, ranging from behavioral neuroscience, and genetics, to clinical applications. First, we will discuss our past and current efforts to compare the speech and dance brain pathways, starting from our methodology (Theofanopoulou et al. 2023) to run mobile electroencephalography in 5 dancers while dancing simultaneously, and a comparison between the oscillatory patterns we identified during speech production vs. dance movement production. We will also introduce our methodology to assess brain activity, via functional Magnetic Resonance Imaging (fMRI), while speaking vs. while dancing, with the latter taking place while the participants' heads are fixed in the scanner. Second, we will talk about how these fMRI MNI coordinates from speech and dance brain areas will inform our brain dissections of 6 frozen human brains with the objective to profile gene expression in speech vs. dance brain regions, via single nucleus RNA-sequencing, and of our current methodology and progress to reconstruct these human brain sections in a 3D space, a necessary step before gene expression profiling. Third, we will present how this hypothesis led us to test the effect of dance in the speech profile and brain activity (via fMRI) of patients with Parkinson's Disease

(PD) diagnosed with speech deficits (i.e., dysarthria). In this context, we will present our preliminary findings showing that 8 months of dance training in PD patients, without undergoing any speech therapy, led to significant activation changes in brain regions that have been shown to be involved in speech production (e.g., Dichter et al. 2018), e.g., in the dorsal Laryngeal Motor Cortex. We will further present our ongoing efforts to test whether by activating the dance brain pathways (through dancing) we can stimulate activity in the speech brain pathways, and, hence, drive improvement in speech deficits in PD. Independently of the evolutionary hypothesis that links vocal learning and beat synchronization, our lecture will unravel a comparison between the neurobiology, genetics and clinical applications of two complex sensorimotor behaviors that serve human communication.

Topic Areas: Language Production, Speech Motor Control

## Neuromotor control of reiterated speech in adults, typically developing children and children with Childhood Apraxia of Speech (CAS)

***Poster E2*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Ioanna Anastasopoulou[1], Kirrie Ballard, Peter Wilson, Douglas Cheyne, Pascal Van Lieshout; [1]Macquarie University,School of Psychological Sciences, Sydney, New South Wales, Australia, [2]University of Sydney, [3]Australian Catholic University, [4]University of Toronto,Department of Speech-Language Pathology, Toronto, Ontario, Canada, [5]Hospital for Sick Children Research Institute, Toronto, Ontario, Canada

Introduction. Neuroimaging protocols for mapping of expressive speech centres employ several standard speech tasks including object naming, rhyming, and covert word production (Agarwal et al., 2019). These tasks reliably elicit activation of distributed speech centres in prefrontal, precentral and cingulate motor cortices and are widely used for presurgical mapping and in research studies of language production. In the present study we used an alternative speech protocol employing reiterated productions of simple disyllabic nonwords (Anastasopoulou et al., 2022). Here we show that this task elicits highly focal activations of speech motor control areas centred on the precentral gyrus and adjacent portions of the middle frontal gyrus. Methods:Participants. 11 healthy adults (mean 35.5 years, range 19-64), 19 typically developing children (TD) (mean age 11.0 years, range 7-14) and 7 children with CAS (mean age 8.5 years, range 6-12). Assessments. All children were tested for nonverbal IQ, hearing, speech, expressive, receptive language and oral- motor development, fine and gross motor skills, and handedness. Neuroimaging. KIT/Yokogawa 160 channel MEG, whole cortex, axial first order gradiometers. Acoustic and speech movement recordings. A MEG-compatible tracking system (Alves et al., 2016) used tracking coils placed at mid-sagittal positions on the lips, tongue body, and jaw. Time-aligned speech acoustics were recorded in an auxiliary channel of the MEG setup at the same sample rate as the MEG recordings. Stimuli. (1) Reiterated productions of disyllabic sequences V1CV2 /ipa/ and /api/ at normal and faster rates. Each participant repeated all tasks for ten trials, with each trial lasting approximately 10 seconds. (2) Self-paced manual button press with right index finger at a rate of about 1 per 2 seconds for 300 sec (about 150 trials). Analyses. For each speech production task, the continuously recorded MEG signals were segmented into 15-second epochs, consisting of -10 to +5 seconds with respect to the speech trial onset. Button press trials were segmented into 1.5 second epochs consisting of -0.5 to 1.0 seconds with respect to the button press. Source analyses were performed with SAM beamformer (pseudo-t;

Jobst et al., 2018). Group statistics were performed with permutation tests ($p < 0.05$). Results. (1) Speech clusters were located immediately ventral to hand motor cortex identified with the button press task. (2) Speech clusters were left lateralized in adults, bilateral in TDs, and right lateralized in CAS. (3) Speech was associated with beta band desynchronisation in adults and TDs but not in children with CAS, who showed theta band synchronisation during speech. Conclusions. The functional relevance of the middle region of the precentral gyrus to expressive speech motor control has been highlighted in several recent reviews of lesion, electrocorticographic, and functional neuroimaging evidence (Gordon et al., 2023; Hickok et al., 2023; Jensen et al., 2023; Silva et al., 2022). The present results show highly focal activations of this region were elicited using a reiterated nonword speech task. Group differences in lateralization and frequency band indicate that this task may have utility in the study of speech motor control during normal and atypical development of expressive speech.

Topic Areas: Language Production, Speech Motor Control

## Disruption of iron homeostasis in stuttering mice: Accumulation of iron deposits near regional astrocytes of GNPTAB-mutant mice

***Poster E3*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Camryn Bragg[1], Marissa Millwater[1], Max Weinhold[1], Afuh Adeck[1], Ruli Zhang[1], Shahriar SheikhBahaei[1]; [1]National Institute of Neurological Disorders and Stroke (NINDS), Neuron-Glia Signaling and Circuit Unit, Bethesda, MD, USA

Stuttering is a neurodevelopmental disorder characterized by involuntary disruptions in speech fluency and is linked to white matter abnormalities or dopamine hyperactivity in the basal ganglia. Recently, stuttering has been shown to link to point mutations in a gene involved in the lysosomal enzyme-targeting pathway (i.e., GNPTAB), though it remains unclear how such a mutation might relate to the stuttering phenotype. In addition, imaging data suggested that iron might be accumulated in the brain regions involved in speech production, however, the cellular and circuit mechanisms of this finding were unknown. In this study, we used mice engineered with a mutation in the GNPTAB gene found in humans who stutter and found increased iron deposition in the basal ganglia of these mice. Using Perl's staining method, we stained for iron in age-matched Gnptab-mutant and control mice and analyzed iron deposition based on the intensity of the chemical stain and percent area of deposition. There was an increase in iron deposition in the medial lateral, dorsal lateral, and central striatum of Gnptab-mutant mice when compared to the control animals. Further, these iron deposits localized predominantly with regional astrocytes when Perl's staining was combined with an astrocyte-specific marker S100ß. Astrocytes, the star-shaped glial cells in the brain, in the striatum were found to be less complex in the Gnptab-mutant mice. There was no cellular loss noted across cell populations, as determined by the quantification of cell bodies in the striatum. These findings support the hypothesis that iron homeostasis is altered in Gnptab-mutant mice and that regional astrocytic morphology differences may have implications for the traditional circuit-modulatory role of these glial cells. Here, we hypothesize a relationship between a missense mutation in a cellular housekeeping mouse Gnptab gene, iron homeostasis, astrocytes, and ultimately the stuttering phenotype that has long remained elusive.

Topic Areas: Language Production, Speech Motor Control

## The syllable frequency effect before and after speaking

***Poster E4** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speaking requires translating concepts into a sequence of sounds. Contemporary models of language production assume that this translation involves a series of steps: selecting the concepts to be expressed, access to grammatical and morpho-phonological representations of words, phonetic and articulatory encoding of the words. In addition, speakers monitor their planned speech output using sensorimotor predictive mechanisms. The current work concerns the hypothesized phonetic encoding stage and the speaker's monitoring of articulation. Specifically, we test whether monitoring is sensitive to the frequency of syllable-sized representations. Potential effects of syllable frequency stand to inform us about the tradeoff between stored versus assembled representations. To address this question, we run a series of immediate and delayed naming experiments in which adult native speakers of Dutch, on each trial, first read a (non-word) syllable (e.g., ‘kem’ or ‘kes’), prepare to produce it, and upon presentation of a production cue, say it. We exploit the syllable-frequency effect: in immediate naming, high-frequency syllables are produced faster than low-frequency syllables. The effect is thought to reflect the stronger automatization of motor plan retrieval of high-frequency syllables during phonetic encoding. We first replicate the behavioural result in immediate naming experiments in a sample of 20 Dutch adult native speakers. In subsequent experiments with approximately 30 participants (sample size based on power analyses conducted after the first set of experiments), we also record participants' EEG. In the phonetic encoding stage (i.e., a time window of ~450 ms prior to articulation), we perform standard waveform analyses and spatio-temporal segmentations to assess qualitative and quantitative processing differences. In a time window of 200 ms following articulation onset, we analyse auditory-evoked N1 responses that – among other features – reflect the suppression of one's own speech. For the phonetic encoding window, we predict that the production of high-frequency vs. low-frequency syllables will result in distinct neurophysiological patterns, including diverging ERP waveform amplitudes and different global topographies. For the window following articulation, we predict more attenuated auditory-evoked N1 amplitudes for high compared to low frequency syllables – on the view that high-frequency syllables yield stronger predictions and therefore more attenuated N1/P2 responses. The production of low frequency syllables, putatively less automatized, is expected to require more close monitoring and therefore larger N1/P2 amplitudes and longer latencies. Likewise, spectrotemporal and decoding analyses of the EEG data are predicted to reflect the syllable frequency difference. The results can be important as they will allow us to assess more precisely the role of syllabic units for setting sensory goals in the planning and monitoring of speech.

Topic Areas: Language Production, Speech Motor Control

## Single-Unit Recordings of Broca’s Area Indicate a More Cognitive Role than

## Speech Production

***Poster E5*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Erin Kunz[1], Francis Willett[2], Chaofei Fan[1], Alisa Levin[1], Darrel Deo[1], Foram Kamdar[1], Donald Avansino[2], Leigh Hochberg[3], Krishna Shenoy[1,2], Jaimie Henderson[1]; [1]Stanford University, [2]Howard Hughes Medical Institute, [3]Massachusetts General Hospital,Harvard Medical School; Brown University;VA RR&D Ctr. for Neurorestoration and Neurotechnology, Providence, RI

Broca’s area, located in the dominant inferior frontal gyrus (IFG), has long been thought to play a key role in the translation of thought into articulatory motor plans. However, its exact role in speech articulation is under debate [1-6]. In contrast to imaging-based localization of function, neurosurgical studies have increasingly cast doubt on the area’s role in articulatory control, as many patients with focal stroke or surgical resection of Broca’s area have failed to exhibit Broca’s aphasia [7-9]. Recent stimulation studies have shown that stimulation of IFG sites that induce errors in specific “speech” tasks also induce errors in non-speech behaviors, including music production as well as halting manual movements [10-11]. Neural recordings with a higher temporal and spatial resolution than neuroimaging studies may help to clarify the exact function of this area and its role in the cortical language network. Recent studies looking at direct cortical recordings using electrocorticography (ECoG) have shown that IFG is not active during overt speech production, implicating it instead in pre-articulatory lexical, grammatical or phonological processing [12-13]. Here we present data from the first IFG recordings from chronically-implanted intracortical microelectrode arrays during a variety of speech, language and other cognitive tasks. Our results align with previous ECoG studies revealing no discernible activity during overt speech production or motor planning, and implicate this region in having a more significant “domain-general” function [14-15]. A research participant with anarthria due to amyotrophic lateral sclerosis had two 64-channel recording arrays placed in dominant IFG (Brodmann’s area 44) and two in ventral precentral gyrus (area 6v). Most tasks included in this study were conducted in an instructed-delay paradigm: each trial was cued with sequences of displayed text or audio recordings during one or more ‘cue’ periods followed by a ‘go’ period, during which the participant attempted to vocalize the desired response or perform the desired action. We collected recordings during tasks spanning the space of overt speech production; semantic, lexical, phonological and prosodic processing; orofacial and limb movements; working memory; arithmetic; audio and musical processing; and multi-task combinations. While IFG recordings during overt speech production (repetition of single words and sentences, object naming) showed increased modulation from rest during cue presentation, they showed little to no cue-specific modulation that would indicate a direct role in speech production. By contrast, a wide variety of other tasks did evoke cue-specific modulation, such as rhythm repetition, arithmetic, spelling, and auditory working memory. Additionally, a task in which different cognitive operations (e.g. semantic analogy, grammatical manipulation, or repetition) resulted in the same set of spoken answer words showed stronger modulation differences by operation than by answer. Similarly, analyses of tasks that could be sub-divided by operations such as prosody (exclamatory, questioning, statement) and spelling (forwards vs. backwards) showed stronger decodability by operation than by word to which an operation was being applied. Further data collection and analysis will aim to elucidate a unifying role that IFG may play in this diverse set of cognitive tasks.

Topic Areas: Language Production, Speech Motor Control

## Phonoligical networks in speech perception and production tested with fMRI

***Poster E6*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Xenia Dmitrieva[1,4], Jean-Luc Anton[2,4], Amie Fairs[1], Bissera Ivanova[1,4], Elin Runnqvist[1,4], Bruno Nazarian[2], Julien Sein[2], Friedemann Pulvermüller[3], Sophie Dufour[1], Kristof Strijkers[1,4]; [1]Aix-Marseille University, CNRS, Laboratoire Parole et Langage, [2]Aix-Marseille University, CNRS, Institut de Neurosciences de la Timone, Centre IRM, [3]Freie Universität Berlin, Brain Language Laboratory, [4]ILCB

In human communication speech production and perception are tightly interlinked and historically have been studied separately. However, understanding the nature of this link and the degree of neural overlap between those two modalities, is a crucial question for brain-language models. Therefore in the current study we aim to compare phonological processing across word perception and production. Two classes of brain-language models with different predictions can be contrasted: Partial separation models (PSM) and Integration models (IM). According to PSM during speech production both frontal and temporal regions are recruited during phonological processing, while only temporal regions are needed for speech perception. In contrast, according to IM, both speech production and perception recruit the same frontal and temporal regions during phonological processing. In the current fMRI study to contrast these two models we are applying phoneme mapping utilising contrast between bilabial and alveolar phonemes, since there is evidence for dissociable brain activity in the inferior frontal motor cortex (iFMC) and the posterior superior temporal cortex (pSTC) between bilabial (b/p) and alveolar (d/t) phonemes in both production and perception. Specifically, we are using minimal phonological pairs of nouns starting with bilabial b and p, and alveolar d and t consonants (e.g., bilabilal: “ballon” Vs. alveolar: “talon”). The same 44 native French speakers performed picture naming (production) and passive listening (perception) tasks. In addition, a functional localiser task was included to define motor regions associated with production of lip (bilabial) and tongue (alveolar) consonants for each participant individually. Repeated measures ANOVA were performed to assess whether the same phoneme-specific regions in the motor cortex and the temporal cortex would be recruited during speech production and perception (as predicted by IM), or not (PSM). As expected, results in the motor cortex showed that in production bilabial-initial items recruited the lip-associated ROI more strongly than words starting with alveolar consonants and vice versa for the tongue-associated ROI. Interestingly, passive listening to bilabial-initial words also demonstrated stronger activation in the exact same lip-associated region as during production compared to listening to alveolar-initial items. For the tongue-associated ROI the effect did not reach significance in perception. In other words, both in production and perception a significant somatotopy-by-phoneme-specific effect was present, but with stronger magnitude in production. A similar pattern emerged in the temporal cortex, where the same regions for phoneme processing seem to be recruited across the two modalities, but again stronger so in production. Taken together, our data suggests evidence towards phonological networks being shared across the language modalities as predicted by IM.

Topic Areas: Language Production, Speech Perception

## Does prediction drive neural alignment in conversation?

***Poster E7*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Recent studies on neural alignment in language (i.e., brain-to-brain synchronisation between interlocutors) have shown that successful communication relies on the synchronisation of the same brain regions in both speakers. However, more explicit mechanistic links between neural alignment and specific linguistic functions of the communicative signal remain to be established. This project relies on the hypothesis that the degree of neural synchronisation between interlocutors depends on the degree of predictive processing: the more predictability between speaker and listener, the more their brain responses will align and display similar oscillatory dynamics (Pickering & Gambi, 2018). We are testing this hypothesis by isolating word semantics (e.g., animal vs. tool word category) in an experimental set-up where (a) prediction effects are tested at the behavioural level; (b) brain activity (EEG) of two interlocutors engaging in simple conversations is recorded simultaneously and analysed in an event-related fashion (i.e., at the word component level instead of the whole communicative signal). Experiment 1 presents a novel interactional task where participants are involved in an association game where speaker A names a picture (either an animal or a tool) and speaker B needs to respond with a semantically related word. Importantly, the predictability for the upcoming object is manipulated, i.e., prior to picture naming, participants hear either a highly predictable or non-predictable sentence up to the final word, which is then finished by speaker A naming an object. Data has been collected from 20 dyads, and the analyses of speech onsets showed a significant reduction of response latencies in the predictable condition, both for speaker A and speaker B. This demonstrates that semantic predictions influence dyadic interaction. In Experiment 2 (being currently analysed) participants are playing the same association game but without predictive priming, i.e., speaker A sees a picture and names it, and speaker B replies with an association. The relevant factor to explore now is whether we can find meaning-specific brain-to-brain synchronisation between tools vs. animals brain regions, which is the defining dimension by which participants need to perform the task. Importantly, tools vs. animals have well-know cortical dissociations in the brain (e.g., Grisoni et al., 2021). Apart from that, while we have no control about the exact words that an interlocutor will reply, we do control the semantic categories of the words, and therefore, this allows us to explore whether we can find brain-to-brain synchrony for specific word meanings (instead of for 'language' in general). The analyses methods that we are currently implementing include Riemannian geometry-based EEG decoding and source localisation. Experiment 3, also a dual EEG set-up, will test the hypothesis that this co-activation will be more in synchrony when semantic predictions have primed the target word. References: Grisoni, L., Tomasello, R., Pulvermüller, F. (2021). Correlated Brain Indexes of Semantic Prediction and Prediction Error: Brain Localization and Category Specificity. Cerebral Cortex, 31 (3), 1553–1568. Pickering, M. J., & Gambi, C. (2018). Predicting while comprehending language: A theory and review. Psychological Bulletin, 144(10), 1002–1044.

Topic Areas: Language Production, Speech Perception

## Electrophysiological correlates of word planning in context-driven object and action naming

***Poster E9*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Investigations of the neural organisation of nouns (objects) and verbs (actions), originally inspired by observations from clinical populations (e.g. Miceli et al., 1984), have a long history. However, to what extent object and action word retrieval are neurally similar remains debated, with mixed findings that are not easily explained by either differences in investigation techniques or experimental tasks (Crepaldi et al., 2015). Furthermore, the neural similarity of the processes has frequently been inferred based on the spatial overlap, which in itself is not sufficient to provide conclusive evidence for or against the similarity of function. Thus, the aim of the current study is to investigate object and action word retrieval not only examining the spatial, but also the frequency and time dimension of the electrophysiological responses. To achieve this, we will use a well-established context-driven object naming paradigm (Piai et al., 2014) as well as a similarly-designed novel action naming task. Each task comprises constrained (The farmer milked the… or There is a priest kneeling in the church. He…) and unconstrained sentences (The child drew a… or There is a dark-haired man in the room. He… ) that end with the target picture (“cow” and “prays”). Contrasting the two conditions (constrained - unconstrained context) in the pre-picture interval yields an index of conceptual-lexical retrieval measured as oscillatory activity, namely alpha-beta power decreases in temporo-parietal and (to a lesser degree) frontal areas of the left hemisphere (Piai et al., 2020). First, we collected response time (RT) data for the novel action naming task (university students, n=21, 5 male) to ensure the presence of the context effect at the behavioural level. The mean RT was 713 ms (sd = 300 ms) in the constrained and 1037 ms (sd = 308 ms) in the unconstrained condition, with the effect size of Cohen’s d = 2.14. These results point to a similar, yet stronger behavioural context effect in the action naming task as compared to the object naming task (with the effect size of Cohen’s d = 1.6, see Roos & Piai, 2020). Currently, we are collecting EEG data from healthy young adults (intended n = 25). First, we will compute time-resolved power of the pre-picture interval. Based on the behavioural findings, we expect the neural correlates of object and action retrieval to both be indexed by alpha-beta power decreases. Next, to reveal the spatial distributions of the word retrieval effects, we will perform source reconstruction of the oscillatory activity. In terms of spatial similarity, the findings in the literature are mixed, either indicating frontal-temporal or no segregation when comparing object and action naming (for review, see Crepaldi et al., 2015). Taken together, this EEG study aims at further characterising the electrophysiological (dis-)similarities between object and action word retrieval, by looking at time-resolved alpha-beta band power decreases and their spatial extent.

Topic Areas: Language Production,

## Neural response to complexity of mappings between meaning, syntax, and form in language production

***Poster E10*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A great deal of research has focused on the processing of syntactic complexity, as well as the complexity of conceptual/semantic representations and phonological representations. However, there is another kind of complexity that is not often considered, in the mappings between meaning and syntax and between syntax and form. For example, simple transitive verb phrases like “eat an apple” involve a verb and an object which can be mapped to their meanings fully transparently. In contrast, an idiom like “hit the sack” (go to sleep) involves one conceptual representation that maps onto a complex syntactic structure, while a phrase like “take a nap” involves a similar kind of syntactic and conceptual representation (sleeping), but the object is semantically transparent and can be substituted by a pronoun (John took a nap yesterday, and took one again today; c.f., * Mary hit the sack yesterday, and she hit one again today). Given that natural language has many examples of non-compositionality such as this, we also need to consider the mapping processes that are able to generate these kinds of utterances. How is the mapping process affected by factors such as the number of actions or entities involved in the conceptual representation, the size and complexity of the syntactic representation, and the transparency of the relationship between those two representations? Furthermore, in the mapping between syntax and form, there can also be a great deal of variability in how a single syntactic object is pronounced based on its syntactic context, constituting another kind of mapping complexity. Are all alternatives exhaustively considered when calculating the form of the utterance? To investigate the role of mapping complexity - independent of syntactic complexity - in modulating neural activity during language production, we will conduct an MEG experiment in which participants produce sentences which have the same basic syntactic structure ([V NP]), but which vary in the complexity of the meaning-syntax mapping and in the syntax-form mapping, as in the examples above. Before the experiment, participants will be familiarized with phrasal descriptions of a series of images, all with the same basic structure (“take a nap”, “eat the apple”, etc.). During the experiment, the images will be presented along with a question such as “What did John do yesterday?”, and the participants will prepare a response using the correct phrase label properly inflected for tense (“he took a nap”). Our analysis will focus on the neural activity during the pre-articulation period when the sentence structure is being planned. This proposed study will test the following predictions from Krauska & Lau (2023): 1) greater complexity in the meaning-syntax mapping should incur greater neural activity early in the production process (between approximately 200ms and 350ms post stimulus onset, consistent with stages of conceptual preparation and morphosyntactic composition observed by Sahin et al (2009)), localized to the middle temporal lobe; 2) greater complexity in the syntax-form mapping should incur greater neural activity later in the production process, localized to superior temporal lobe structures and the frontal lobe.

Topic Areas: Language Production,

## Low-frequency power decreases in temporal lobe network underpin verbal fluency performance: Evidence from intracranial EEG

***Poster E11*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Verbal fluency assessments are common in clinical testing of cognitive function. However, the neural underpinnings of verbal fluency are not fully understood and not widely researched. In this work, we examine the oscillatory dynamics related to word production in a verbal fluency paradigm. We re-analyzed intracranial EEG data from six epilepsy patients performing a verbal fluency task with both semantic cues (category, e.g. “animals” or “fruit”) and phonological cues (letter, e.g. “A” or “F”). Previously, this dataset has been analyzed with respect to high-frequency activity (Willams Roberson et al. 2020). In the current analysis we computed theta (4-7 Hz), alpha (8-12 Hz), and beta (13-30 Hz) power changes in an early time window (-750 to -250 ms) and in a peri-utterance time window (-250 ms to 250 ms) relative to speech onset. We included nine regions of interest in the left-hemispheric frontal, temporal (including the basal temporal language area), and occipito-parietal areas (246 contacts in total). Statistical testing against resting state activity was done at the individual participant level, using a permutation approach with a Max-T sum statistic. To derive an index of generalizability, we subjected the within-subject statistical results to a Bayesian population prevalence analysis. We observed high population prevalence for a decrease in low frequency activity in temporal regions for the early time window, with a frequency gradient from superior temporal gyrus (predominantly theta activity) to middle (predominantly theta and alpha activity) and inferior temporal gyrus (predominantly alpha and beta activity). The peri-utterance window was marked by a theta power decrease in the temporal regions, an alpha-beta decrease in inferior frontal gyrus, and theta-alpha decreases in occipito-parietal regions. An exploratory connectivity analysis of two data sets with sufficient coverage revealed a circumscribed network for one dataset (whereas no task-related connectivity at all was evident for the other data set). The temporal lobe network included parahippocampal regions and was driven by low frequencies. For the peri-utterance window, this network extended to frontal as well as occipital regions. Taken together, these results sketch a network possibly related to verbal fluency, with a high involvement of temporal-lobe regions. These findings are concordant with studies on word production using other tasks (e.g., visual and auditory naming or context-driven word production tasks), which suggest temporal regions play a role in lexical access and semantic processing. Interestingly, although the verbal fluency task did not include any visual stimulation, we find occipital involvement in both the low frequency power decreases as well as in the exploratory connectivity analysis. Whether this marks the extension of the semantic network to occipital regions or the recruitment of visual cortices for semantic processes will be an exciting topic for future research.

Topic Areas: Language Production,

## Social knowledge about the speaker constrains early-on ironic interpretation: Evidence from neural oscillations

***Poster E12*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Maud Champagne-Lavau[1], Deirdre Bolger[1], Madelyne Klein[1]; [1]Aix-Marseille University

Introduction Irony understanding requires the listener to integrate linguistic information and extra-linguistic information (e.g., contextual information, encyclopedic knowledge of the world, knowledge about the speaker) to identify what the speaker means (Pexman & Olineck, 2002; Rivière & Champagne-Lavau, 2020). Knowledge about the speaker such as occupation stereotypes has been demonstrated to influence the extent to which utterances are interpreted as ironic. However, none of the studies (Akimoto et al., 2017; Regel et al., 2014; Rothermich et al., 2022; Spotorno et al., 2013) characterizing the oscillatory dynamics during irony processing manipulated speaker information and its impact on irony processing. Thus, the aim of the present study was to investigate the neurocognitive processes underlying the integration of linguistic and extra-linguistic information during irony comprehension. Using time-frequency analysis (TFA), we explored neuronal oscillatory activity during a task of irony understanding where implicit information about the speaker (i.e., speaker occupation stereotypes) was manipulated to cue, or not to cue, ironic intent. Methods We recorded EEG of twenty-two native French speakers during a task of irony comprehension. In this task, we manipulated the type of context (literal, ironic) and the presence of a speaker occupation stereotype (i.e., sarcastic versus non-sarcastic), thereby cueing or not ironic intent. TFA was performed on the neural oscillatory activity in the theta band (4-7 Hz), the alpha1 band (8-10 Hz), the alpha2 band (11- 13 Hz), the beta1 band (14-20 Hz), the beta2 band (20-30 Hz), the gamma1 band (30-40 Hz) and the gamma2 band (60-80 Hz). Results The main results showed that information about the speaker were taken into account in the early stage of irony processing. This early effect was evidenced by a greater synchronization (ERS) in the upper gamma band (in the 150-250 ms time window) when the speaker had a sarcastic occupation, by a greater desynchronization (ERD) for ironic context compared to literal context in the alpha1 band and by a greater ERS in the theta band when the speaker had a non-sarcastic occupation. Other main results showed, in the later stage of processing (500–800 ms time window), a greater ERS for ironic context in the theta band and a greater ERD in the alpha1 band when the speaker occupation did not constrain the ironic interpretation. Here, the interpretation of the utterance as ironic was revealed as resource-demanding and requiring pragmatic reanalysis. Conclusions These findings confirm predictions of the constraint satisfaction model suggesting that activation of the ironic interpretation is considered as soon as there are sufficient cues supporting it (Campbell & Katz, 2012). In the present study, speaker characteristics conveyed by occupation stereotypes influence early-on the linguistic comprehension process. This knowledge is integrated with linguistic and contextual information to constrain the interpretation. Our study also showed that inferential processing costs increase when the ironic interpretation was not expected as this is the case when the speaker occupation did not constrain the interpretation (non-sarcastic occupation condition).

Topic Areas: Meaning: Discourse and Pragmatics,

## Feeling is believing: The effects of mood on the semantic processing of fake news

***Poster E13*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In the political, social, and economic context of recent years, the phenomenon of fake news, particularly those that originated and shared on social networks, has acquired unprecedented features and expansion. Main international events such as presidential elections, migration movements, climate change, and the official advice linked to the coronavirus (COVID-19) pandemic have raised concerns about misinformation widespread by these means. Behavioral studies have demonstrated that emotionally evocative news is more credible. In this vein, people who experience more intense emotions are more likely to believe false news, and focusing attention on one's own emotions increases belief in this type of headline. In this experiment, we aim to extend previous evidence by investigating the effects of mood on the semantic processing of fake news, using Event Related Potentials (ERPs). We collected 160 fake and real news from specialized web platforms published from 2020 to 2023. These materials were classified by topic, and rated in their emotionality, degree of conspiracy, and psycholinguistic variables affecting semantic processing. Participants were instructed to read the set of fake/real news, presented using different media and social networks frames. Importantly, the mood was induced by a series of 1-min videos with a newscast format in a block-wise design every 5 news presentations. In one block, videos were highly arousing and negative (information about war, pandemic, natural disasters…) and, in the other block, videos were low arousing and contained neutral information (information about traffic sign changes, repair of the facilities of a public building, chess competition, …). We observed a main effect of the type of news in the P600/LPC, showing a larger amplitude for fake compared to real news in parietal regions. Further, this effect was driven by an interaction between the type of news and mood induction: the enhanced P600/LPP effect was only apparent during the neutral (low arousing) induction, but not for the negative (high arousing) mood induction. In sum, fake news, in comparison to real news, generally induce a repair and reanalysis process to achieve a meaningful understanding; but being in a negative mood blur such a difference, making fakes more real.

Topic Areas: Meaning: Discourse and Pragmatics,

## Do language and vision employ the same mechanism for tracking individual representations? An ERP study

***Poster E14*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language comprehension oftentimes requires tracking representation of entities in working memory. That is also the case with visual perception, but it’s yet unclear whether the same neural mechanism is used for the two. As a preliminary attempt to explore this question, we are collecting data for an ERP study that investigates whether tracking discourse entities in language comprehension induces sustained neural activity, which previous vision studies found to reflect the tracking of visual objects. Vogel and Machizawa (2004) found that increasing the number of visual objects represented in working memory induces increased sustained ERP response. If language comprehension yields representations supported by the same neural mechanism as visual perception does, then presumably we would expect to see the same sustained response as people track entities conveyed by language. Interestingly, sustained ERP responses with a similar distribution have been observed in King and Kutas (1995) for object relative clauses compared to subject relative clauses (e.g. ‘The reporter who the senator harshly attacked’ vs. ‘The reporter who harshly attacked the senator’), and in Cruz Heredia et al. (2021) for wh-questions compared to polar questions (e.g. ‘What did the commentary from the spokesman…’ vs. ‘Did the commentary from the spokesman…’). Although these kinds of responses have often been interpreted as reflecting syntactic working memory, an alternative interpretation is that these responses are induced by tracking the extra entity conveyed by the object and the wh-word. In order to test

this hypothesis, we use a novel ERP paradigm designed to emphasize natural referential processing of language input, through the use of spoken materials and connected narratives. We present audio recordings of short stories that introduce varying numbers of discourse referents. To encourage participants to build a rich discourse representation, we used dramatic storylines and a continuation task in which participants are asked to 'tell how the story ends'. For each story item we created two versions that diverge at a point in which a second character is introduced in one version but not the other. This brief divergence in content is immediately followed by a subsequent region in which material across versions is again matched. Our critical ERP time-window is the first 2000ms of this matched region, immediately after the introduction of a new discourse-relevant entity in one condition but not the other. If our hypothesis holds, we expect to see a sustained neural response increase in the two-character stories compared to their one-character counterparts in this time-window, due to the continued tracking of this extra referent.

Topic Areas: Meaning: Discourse and Pragmatics,

## Speakers' privileged knowledge affects the listeners' processing of counter-expectational meaning in discourse comprehension

***Poster E16*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Counter-expectation sentences, featured by a counter-expectation marker, are used to describe events contrary to speakers' expectation, as in "Inside the spectacle case should (jingran: counter-expectation marker) be a bracelet". Previous studies have been found that the world-knowledge shared by the speaker and the listener influence the listener's comprehension of counter-expectation sentences. However, little is known about how the listener could use the speaker's privileged knowledge to process counter-expectation sentences. We conducted an EEG experiment and asked participants to read simple conversational scenarios, each consisting of a context and a directly-quoted utterance. The context described whether the speaker saw a third person placing objects in a location (S: see vs. NS: no see) and the utterance, in the form of "Locative +counter-expectation marker + verb + object", described an event of high-likelihood (HE, e.g., Inside the jewel case is a bracelet) or low-likelihood (LE, e.g., Inside the spectacle case is a bracelet). After reading each scenario, participants were asked to make a comprehension judgment. Analyses of event-related potentials (ERPs) on the following critical words showed that: 1) Counter-expectation marker: In 200-800ms, compared with the NS conditions, the S conditions evoked a more sustained positivity in the centro-parietal and parietal regions; 2) Object noun: In 370-460ms, for the S conditions, compared with the HE condition, the LE condition elicited a larger negativity; this effect was absent in the NS conditions. In 600-800 ms, for S conditions, no significant difference was found between the HE and LE conditions. However, for NS conditions, compared with the LE condition, the HE condition elicited a larger negativity. We argue that: 1) The effect on the counter-expectation marker reflects the listener's detection of a conflict between the marker and the context in which the speaker actually saw what has happened (and hence should not use the counter-expectation maker); 2) The effect on the object noun reflects the constraint of the speaker's privilege knowledge on the listener's processing of the object noun. When the speaker actually has seen what happened (the S condition), the listener only computes the event possibility based on his real-world knowledge, without computing the counter-expectational meaning. However, when the speaker did not see what happened (the NS condition), the listener could adopt the speaker's privileged knowledge and re-interpretate incongruent HE sentences. Key words: speakers' privileged knowledge, counter-expectation sentences, ERP, sustained positivity, early negativity, late negativity

Topic Areas: Meaning: Discourse and Pragmatics,

## The effect of social status of interlocutors on the interpretation of the addressee-dominant we in different contexts

***Poster E17** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Mengting Gao[1], Xiaoming Jiang[2], Wenshuo Chang[3], Xiaolin Zhou[4]; [1]Shanghai International Studies University

Depending on communicative contexts, the speaker's intended referent of the first person pronoun (we) can shift towards the addressee, henceforth the addressee-dominant we, as a doctor says to his patient "Now, have we taken our medicine?". Results of previous corpus analysis suggest that the addressee-dominant we is possibly associated with the speaker's consideration of being polite and not threatening addressee's face. However, it is unclear how the addressee-dominant we is interpreted in conversational scenarios. The current study asked participants to read scripts with face-threatening or face-boosting contexts in which interlocutors of different social status employed we to indicate either both the interlocutors (i.e., prototypical use of we) or only the addressee (i.e., the addressee-dominant we). In Experiment 1, participants indicated the referent(s) of we and to rate the extent of addressee-dominance of the speaker using we, the appropriateness and politeness of the speaker using we. In Experiment 2, participants rated the politeness and social distance between interlocutors when the speaker using we, and wrote down the addressee's possible emotions induced by the use. Results revealed that we was more likely interpreted as addressee-dominated in the face-threatening context than in the face-boosting context. Moreover, compared with the speaker of lower status, the use of addressee-dominant we by the speaker of higher status was interpreted as more polite and drawing closer the social distance between interlocuters regardless of the context of face orientation, but was regarded as more appropriate and inducing more positive emotions in the addressee only in the face-boosting context. On the other hand, compared with the speaker of lower status, the use of addressee-dominant we by the speaker of equal status was interpreted as more polite, drawing closer the social distance between interlocuters, and inducing more positive emotions in the addressee only in the face-threatening context. Taken together, the current results suggest that the addressee-dominant we is interpreted as a communicative behavior to save the addressee's face in the face-threatening context, but to enhance the positive face for the speaker himself in the face-boosting context. Moreover, the relative social status between the interlocuters modulates the appropriateness and socioemotional functions of the use of addressee--dominant we. Key words: the addressee-dominant we, social status, face, socio-pragmatic functions

Topic Areas: Meaning: Discourse and Pragmatics,

## Early language exposure affects neural mechanisms of semantic representations

***Poster E18*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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One signature of the human brain is its ability to derive knowledge from language inputs, in addition to nonlinguistic sensory channels such as vision and touch. How does human language experience modulate the mechanism by which semantic knowledge is stored in the human brain? Recent work using sensory-deprivation models suggests that a specific brain region (the dorsal anterior temporal lobe, dATL) may represent fully non-sensory knowledge, presumably derived from language. The positive evidence for the necessity of language experiences for the neural semantic representation here is still lacking. We investigated this question using a unique human model with varying amounts and qualities of early language exposure: early deaf adults (delayed signers) who were born to hearing parents and had reduced early exposure and delayed acquisition of any natural human language (speech or sign), with early deaf adults (native signers) who acquired sign language from birth as the control group that matches on nonlinguistic sensory experiences. Sixteen native deaf signers and 23 delayed deaf signers were recruited for the study. In the MRI scanner, participants were presented with 90 written words that were highly familiar to both groups and were instructed to think about word meanings and to perform an oddball one-back semantic judgment task. Group differences were examined first in three regions of interests (ROI): the left dATL, the left posterior middle temporal gyrus, and the left inferior frontal gyrus, followed by whole-brain exploratory analyses. We found that the deaf group with reduced early language exposure, compared with the deaf control group, showed reduced semantic sensitivity, in both multivariate pattern (semantic structure encoding) and univariate (abstractness effect) analyses, in the left dorsal anterior temporal lobe (dATL). These results provide positive, causal evidence that language experience drives the neural semantic representation in the dATL, highlighting the roles of language in forming human neural semantic structures beyond nonverbal sensory experiences.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## Word learning patterns in toddlerhood reflect semantic categorical organization: converging evidence from 21 languages

***Poster E19*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Semantic knowledge in humans is organized into different categories (e.g., animals), permitting efficient processing of complex information in daily life. How children develop the semantic categories has been a research focus in recent years. Behavioral studies explicitly probing the knowledge of conceptual relationships in children reveal the awareness of the categorical relationships in preschoolers or older. By contrast, early sensitivity to diagnostic perceptual information (e.g., visual features) associated with the categorical information has been demonstrated in infants using both behavioral and neuroimaging methods. Therefore, it is still an open question as to whether the categorical information is encoded when children begin to develop conceptual knowledge, and to what extent this categorical sensitivity is universal across

different languages. To address these questions, the current study examined the categorical effects reflected in the word learning behaviors of toddlers across 21 languages. Methods: The Wordbank dataset collects parental responses on the MacArthur-Bates Communicative Development Inventory. Here we examined children's expressive vocabulary of four semantic categories that are reliably observed in adults, which are animals, body parts, scenes, and small manipulable artifacts. For each language, the learning curve of each word was calculated as the percentages of children who can speak this word at each month from 16 to 36 months of age. Pearson correlation was conducted between the learning curves of each word pair. Similarities in the learning curves of words of the same category (i.e., within-category similarity) and those of words from different categories (i.e., between-category similarity) were compared across all 21 languages. To ensure the observed categorical effects were not confounded with phonological properties of words, a validation analysis was carried out by including phonological similarity of each word pair (estimated using eSpeak) as a covariate. Results: Across 21 languages, similarities in word learning curves were significantly higher for word pairs of the same category compared to the between-category pairs for all four semantic categories (animals: t20 = 8.82, pFDR-corrected < 0.001, Cohen's d = 1.92; body: t20 = 8.68, pFDR-corrected < 0.001, Cohen's d = 1.89; scene: t20 = 8.41, pFDR-corrected < 0.001, Cohen's d = 1.83; artifacts: t20 = 12.16, pFDR-corrected < 0.001, Cohen's d = 2.65). Close examination of individual languages revealed the similar patterns (within-category similarity > between-category similarity), with significant results in all 21 languages for the scene category (pFDR-corrected < 0.05) and in 20 languages for the other three categories. Moreover, the same categorical effects could be replicated when controlling for the phonological similarity of word pairs. Summary: Our results revealed a consistent pattern in the word learning behavior of toddlers across 21 languages that the learning process of words in the same semantic category conforms to a specific learning curve that is distinctive from that in other categories. These universal category-specific patterns in word acquisition thus suggest the emergence of the categorical organizations during the initial conceptual development through vocabulary learning.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## The influence of contextual variability on the learning and retention of novel words: Does the type of variability matter?

***Poster E20*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Adults predominantly learn new vocabulary from reading, and contextual variability benefits such learning. Importantly, contexts are never entirely repeated or entirely changing, and it remains unclear what features of variability lead to better learning of words and their meanings. In this project, we designed a web-based learning experiment, and used short fictional narratives to examine this issue. Participants encountered 8 novel words, each one in a block of 3 successive narrative contexts that could be identical or could vary to different extents. We manipulated variability in non-core object features (e.g. color, size) and variability in situational features of the stories in which target words were encountered (e.g. protagonists, locations, events). For each target word, 2 semantic features were consistent across all stories and were considered core semantic features of the target word (e.g. “can be grasped”, “sticks”). After each story, participants were invited to define the target word through typing. An immediate lexical decision task was performed to investigate word recognition. While learning occurred in a first session, we conducted a follow-up session, 1 day later, which also included the definition task and the lexical decision task. A thorough coding procedure of the definitions was developed and several scores were computed. Scores included notably the number of core features mentioned per definition, and the number of explicit references to variability (e.g. lists of different options of a feature by use of modal verbs and quantifiers). The number of words correctly recognized, operationalized as a lexical decision score, was also used as a dependent variable. The study was pre-registered on OSF (https://osf.io/6gezm) and power analysis was based on pilot data. Final dataset included 280 participants. Definition scores indicated significantly better learning of core semantic features in the conditions with situational variability, including the condition with variability in both object and situational features (i.e. main effect of variability in situational features: $F(1, 279) = 82.4$, $p<0.001$). Target words were also better recognized in those conditions ($F(1, 279) = 25$, $p<0.001$). Although performance dropped at follow-up up 1 day later, performance remained higher in the conditions with situational variability. Our results suggest that situational variability in narrative contexts support word learning as well as learning and retention of core semantic features of words. We suggest that the simulation and integration of variable contexts allows us to better identify consistent semantic features and to form a unified memory representation that is more resistant to decay. We discuss how the paradigm could be adapted for experiments using electroencephalography to track the neural correlates of lexical-semantic representation under the influence of contextual variability.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## From Neural Matter to Symbolic Representation and Rapid Learning in Mind and Brain

***Poster E21*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To grasp the meaning of words and their relationship to the outside world, higher cognitive processes unique to the human brain are at work. However, despite decades of research on the neural substrates of conceptual processing, a consensus about the functions and components of the semantic system has not been reached among neuroscientists. Additionally, the unique striking ability of humans to instantaneously map a novel word together with its related referent, known as "fast mapping", poses several further challenges to research in the neurobiology of language and acquisition. A fruitful approach to examining the brain mechanisms underlying conceptual representation and learning is the use of computational neural networks that resemble critical functional and physiological features of the human brain and open a unique avenue to investigate symbolic representation at neural and synaptic level. Following this strategy, a biologically constrained cortex model that mimics the anatomical and physiological features of the frontotemporal-occipital regions was used to simulate the learning of new words in the context of object perception and action execution, mimicking typical language acquisition scenarios. The simulations demonstrate that meaningful linguistic units in the brain are represented in the form of cell assemblies that have spontaneously arisen through the mutual interaction of a single set of biological mechanisms operating within specific neuroanatomical structures. Crucially, when implementing the model with a two-step learning process, equipping the networks with a pre-existing repertoire of referential and phonological representations before word meaning mapping takes place, it enables ultra-rapid associative semantic learning, as documented in empirical studies. Overall, we will demonstrate that through the mutual effect of learning, cortical semantic areas and connectivity structure are sufficient to provide a straightforward explanation for conceptual representations in mind and brain and offer an account for the rapid semantic interlinking of phonological and conceptual circuits.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## Neural specialization for living things does not require visual experience

***Poster E22*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A key question in philosophy and cognitive science concerns the role of sensory experience in concept formation. Visual experience is thought to play a particularly important role in the acquisition of knowledge about ‘living things,’ such as animals and plants, compared to inanimate entities, such as places and artifacts (Kim et al., 2019). According to one influential view, semantic deficits for ‘living things’ occur because of damage to visual knowledge (Warrington & Shallice, 1984; Farah & McClelland, 1991; Gaffan & Heywood, 1993). Previous studies have failed to find neural specialization for living things in adults born blind (Bi, Wang, & Caramazza, 2016). However, these studies focus on activity in ventral occipito-temporal cortex, which even in sighted people responds only to images of living things (Mahon et al., 2009). Several recent experiments have implicated the dorsal precuneus in representing abstract animacy concepts among sighted individuals (Fairhall et al., 2013a, 2013b; Deen et al., 2022). We tested the hypothesis that higher-order responses to living things would be preserved in blindness using multivariate and univariate functional magnetic resonance imaging (fMRI). Sighted (n=22) and age and education matched congenitally blind (n=21) adults heard pairs of nouns and verbs in a blocked design and judged how similar in meaning the word pairs were on a 4-point scale while undergoing fMRI. Stimuli were matched for length and familiarity, and were previously validated in a separate fMRI experiment with sighted adults (Elli et al., 2019). Analysis focused on the comparison between ‘living’ nouns (birds, mammals) and inanimate nouns (manmade places, natural places). We first looked at responses to living and inanimate entities in regions with a general preference for entities (nouns > verbs): left precuneus, inferior temporal cortex (IT) and the inferior parietal lobule (IP). A linear support vector machine classifier (Hanke et al., 2009) trained on multivariate patterns of activity in this network classified living from inanimate entities in both blind and sighted people. Further, when the classifier made errors, it confused birds with mammals more often than with places. These findings indicate that living things are neurally separable from inanimate entities. Next, a direct univariate contrast between living > inanimate entities revealed a preference for living things in a dorsal sub-region of the precuneus in both sighted and blind participants (cluster-corrected at p<.01 family wise error rate). This animacy response overlaps with previously reported responses to animate entities in the dorsal precuneus of sighted participants (Fairhall & Caramazza, 2013). Conversely, preferential responses to inanimate places (inanimate > living entities) were observed in medial ventral temporal cortex near the canonical location of the parahippocampal place area in both groups (Weiner et al., 2017). In conclusion, we find evidence for a robust dissociation of living things and inanimate entities throughout the entity-responsive network, particularly in dorsal precuneus, in both sighted and blind individuals. Our results suggest that neural specialization for living things does not require visual experience, pointing to the amodal nature and possibly innate basis of animacy representations.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## The effect of emotional content and concreteness on word processing in second language learners: event-related potentials study

***Poster E23** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In second language learning, vocabulary knowledge is crucial. However, most research has primarily focused on concrete word learning, while abstract words have received less attention. Abstract and concrete words possess distinct characteristics, suggesting that they might be learned differently. The process of learning abstract words is not yet fully understood, with some proposals suggesting that emotional experiences play a key role in their acquisition. This question holds significance for theories of both first language (L1) acquisition and second language (L2) learning. To investigate the role of emotion and concreteness in L2 learning, we conducted an event-related potentials (ERP) experiment in a group of unbalanced bilinguals. Forty-two university students who were learning English as their L2, with Spanish as L1. During the experiment, participants completed a semantic lexical task while their EEG was recorded. We implemented a 2x2x3 experimental design with language (L1 vs. L2), concreteness (concrete vs. abstract words), and emotional valence (positive, negative, neutral words) as factors. The study aimed to test the hypothesis that emotional abstract words are processed more efficiently than neutral abstract words during the early stages of L2 acquisition. We predicted that this effect would be reflected in two ERP components: the early posterior negativity (EPN) and the late positive complex (LPC). We identified six regions of interest: left anterior (electrodes FC1, F3, FC5 & F7), right anterior (FC2, F4, FC6 & F8), left central (C3, CP1, CP5), right central (C4, CP2, CP6), left posterior (P3, PO3, O1), and right posterior (P4, PO4, O2). Two time-windows corresponding to the EPN (200-400 ms) and LPC (400-650 ms) components were analyzed. Data from each region were subjected to a mixed-effect linear regression with language, concreteness, and valence (using neutral words as the reference group) as fixed effects. We included random intercepts for participants and items, and valence as random slopes for participants. Our results revealed significant interaction effects between language and valence in the LPC time-window at the right anterior region. These effects were observed for both the positive versus neutral (β=0.22, se=0.08, t-value=2.82, p-value=0.005) and negative versus neutral (β=0.16, se=0.08, t-value=2.07, p-value=0.038) valence conditions (see Conrad et al., 2011; Velez-Uribe and Rosselli et al., 2020 for similar effects in central electrodes). No other significant effects were observed. Notably, we observed a more positive amplitude for positive words (compared to neutral) in L1, whereas the opposite pattern emerged for L2. Additionally, we found a more positive amplitude for neutral words (compared to negative) in L2, whereas no difference between negative and neutral words was evident in L1. These results align with previous findings presented by Velez-Uribe and Rosselli et al. (2020), who observed a distinct pattern of LPC response in L1 (English) compared to L2 (Spanish) in unbalanced bilinguals. In sum, unbalanced bilinguals process emotional words differently in L2 compared to L1. Interestingly, we did not observe any interaction between concreteness and valence. These findings provide valuable insights into the varying impact of emotion during second language acquisition.

Topic Areas: Meaning: Lexical Semantics, Language Development/Acquisition

## A rose by any other name: Neural correlates of taxonomic and thematic naming errors post-stroke

***Poster E24*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: People with aphasia make various types of naming errors (e.g., phonological, semantic). Neural correlates of different error types reveal the organization of the lexical-semantic system. The current study focused on two subtypes of semantic errors: taxonomic and thematic. If shown a dog, taxonomic errors are producing a category coordinate (wolf), superordinate (animal), or subordinate (schnauzer). A thematic error is producing a word that is associated via events or actions (leash). Neural correlates of taxonomic and thematic errors are partially dissociable, but the specific mechanisms remain controversial. Prior work from our group has shown that compromised white matter connectivity of left temporal pole is associated with higher proportion of thematic errors. Here, we add insight by using three complementary lesion-symptom mapping (LSM) techniques in both left and right hemisphere: voxel-, connectome-, and activity-based LSM (VLSM, CLSM, ALSM). Methods: Seventy-nine adults with aphasia completed the Philadelphia Naming Test (PNT) outside the scanner. In a separate session, they underwent anatomical scanning and a functional scan during which they named pictures (an in-house task with different stimuli than the PNT). PNT errors were coded in accordance with PNT scoring guidelines. Taxonomic and thematic error counts were converted to proportions out of the total error count (including phonological and other error types). We then conducted V-, C-, and ALSM to examine the neural correlates of taxonomic and thematic error proportions. Shared variance between the error type proportions were regressed out from each other (henceforth called TaxProp and ThemeProp). VLSM finds associations between damage to voxels and errors. CLSM uses a matrix of region-to-region white matter connectivity derived from probabilistic tractography and finds where weaker connectivity between a given pair of regions is related to errors. ALSM uses the BOLD signal during the independent picture naming task and finds where less brain activity during picture naming is associated with errors.

Analyses were restricted to a bilateral mask of 26 Johns Hopkins University atlas regions (13 in each hemisphere) that covered much of the temporal, parietal, and frontal lobes. All analyses controlled for lesion volume and were permutation corrected for multiple comparisons (1000 perms, $p < .05$). Results: VLSM showed that damage to left middle temporal gyrus (MTG) was associated with higher ThemeProp. CLSM showed that weaker connectivity between regions in left anterior temporal lobe (ATL) and bilateral posterior cingulate (PCC) and right temporal gyri were associated with higher ThemeProp. V- and CLSM did not reveal results for TaxProp. However, ALSM showed that lower activity in bilateral PCC, right angular gyrus (AG), and right inferior frontal cortex (IFC) was associated with higher TaxProp. Trending ALSM results ($p < .1$) showed that greater activity in left IFC and left ATL was related to higher ThemeProp and TaxProp, respectively. Discussion: We used complementary techniques to demonstrate that the neural correlates of taxonomic and thematic errors are partially dissociable. Thematic errors were associated with disconnection between left ATL and bilateral lexical-semantic regions, and taxonomic errors were associated with lower brain activity in right inferior frontal and parietal cortices.

Topic Areas: Meaning: Lexical Semantics, Language Production

## Profiling the linguistic and neural heterogeneity and similarity of semantic and logopenic PPA variants

***Poster E25*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Aims: According to the current criteria the semantic (sv) and logopenic (lv) variants of Primary Progressive Aphasia (PPA) are typically characterized by semantic impairment, and by lexical/phonological processing and verbal working memory deficits, respectively. However, lexical impairments have been reported also in svPPA, and semantic deficits may be present in lvPPA. We applied a multidimensional approach considering the core language components specific for svPPA and lvPPA, in order to characterize overlaps and differences of the two syndromes, aiming at a precise definition of PPA language profiles and of their anatomical counterparts at individual level. Methods: Sixty-seven patients (22 svPPA, 23 lvPPA, 19 lvPPA+, and 11 sv-lv-mixed-PPA) completed the SAND battery and underwent an FDG-PET scan. Semantic (SEM), phonological (PHON) and working memory (WM) errors were quantified from the SAND tests. Metabolic values were extracted from 9 ROIs, selected according to the previous literature. Behavioral data were entered into the Profile Analysis based on Multidimensional Scaling (PAMS), which identifies core profiles, representing the prototypical response pattern of the data, as well as the respective distance of each patient from the core profiles. Each patient could belong to one or to the combination of more core profiles. Correlation analysis was performed between metabolism and significant tasks for each profile in the whole group. Results: Four core profiles were extracted: the 1st profile reflected a lexical retrieval impairment (reduced production of nouns in a picture description); the 2nd profile showed an impairment at SEM level (naming, semantic association) with preserved PHON (in non words repetition); the 3rd showed a pattern of impairment encompassing PHON/WM abilities (in non words repetition and sentence comprehension). The majority of svPPA showed a predominant impairment at lexical and SEM level with preserved PHON/WM. The majority of lv-PPA and some mixed PPA showed lexical and PHON/WM impairment. Some svPPA, lvPPA and mixed PPA showed a pattern of impairment at lexical and WM level. The majority of lvPPA+ showed lexical and PHON/SEM impairment. A reduced number of nouns was predicted by metabolism in the left posterior middle temporal gyrus (MTG), superior temporal gyrus (STG) and anterior STG. SEM errors in naming task were predicted by the metabolism in the fusiform gyrus, PHON errors in non-words repetition by the anterior fusiform gyrus and posterior MTG, WM errors in sentence comprehension by the activity of the middle/superior frontal gyrus, the inferior parietal lobe and the posterior MTG. Conclusions: Contrary to svPPA, both logopenic and mixed-PPA patients are identified in several profiles. Overall, our results suggest the importance of individual heterogeneity, interpretable in terms of both differences and overlaps in linguistic performance and neural correlates, easily represented along a multidimensional space.

Topic Areas: Meaning: Lexical Semantics, Language Production

## Context dependent neural representations of semantic categories: An MEG study using words and images

***Poster E26*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Recent research on human conceptual knowledge has revealed that semantic categories are encoded by neural activities (Fernandino et al, 2022; Nishida et al, 2021). However, it is also known that words or objects are recognized differently depending on their contexts (Yee and Thompson-Schill 2016; Gao et al., 2023). In this study, we examine the extent to which neural representations of semantic categories change depending on their contexts, and when such context effects emerge during semantic processing. Using MEG, we measured the neural activities of participants as they were visually presented with pictures/images and words in two distinct contexts: homogeneous and heterogeneous. Preliminary analysis using the Representational Dissimilarity Matrix (Kriegeskorte and Bandettini, 2008) revealed that dissimilarities among semantic categories are larger in a heterogeneous context compared to a homogeneous context when participants process words, but no distinct difference was observed when participants processed picture images. Additionally, these dissimilarities vary according to the time-course of semantic processing. Methods: Eight native Japanese speakers underwent MEG recording (whole-head 64-channel MEG system (Sumitomo Heavy Industries, Ltd.)) while they performed picture-naming and word familiarity rating (four-point scale) tasks. Stimuli (pictures or words) were projected onto a screen within MEG through a prism glass. The tasks were divided into contextualised and decontextualized conditions: a homogeneous block where concepts from the same category were presented consecutively, and a heterogeneous block where concepts from different categories were presented randomly. Each trial consisted of a fixation cross followed by the presentation of a picture/word for 300ms. We prepared eight objects for each of eight semantic categories (Animal, Human, Body part, Vehicle, Food, Inanimate, Man-made place, and Tools/Artefacts). Picture images were selected from the Bank Of Standard Stimulus (BOSS) (Brodeur et al, 2014). Objects were randomly presented six times, yielding 384 trials per condition. The recorded data was preprocessed and analysed using the MNE-Python software package (https://mne.tools/stable/index.html). RDMs were computed based on MEG data averaged across epochs within a category using DTW (dynamic time warping) and a sliding window approach (window size: 100ms, step size: 50ms). Results: Our preliminary analysis from one subject suggests that the temporal pattern of MEG amplitudes in the familiarity rating task is similar between categories sharing similar semantic features (e.g., Man-made places and Humans), while the patterns diverge for category pairs sharing fewer semantic features (e.g., Vehicles and Food). Among the stimulus types (pictures vs words), words tend to be more influenced by context than pictures. Additionally, the dissimilarities in MEG patterns between each pair of categories tend to increase the further away from the stimulus onset. We plan to further compare MEG patterns between contextualised and decontextualized conditions across subjects to elucidate the spatiotemporal and spectral characteristics of modality-specific context sensitivity.

Topic Areas: Meaning: Lexical Semantics, Language Production

## Exploring the representational space of abstract concepts

***Poster E27** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Concepts are traditionally treated as a dichotomy between “concrete” concepts – such as dogs and cars— and “abstract” concepts that lack perceivable features – such as love and despair. A central goal of cognitive science is to understand the representational space of all concepts. However, most research has focused on concrete concepts and the relatively few attempts to examine abstract concepts often use methods that are not well-suited to studying them (e.g., asking people to list features of concepts or rate them on experimenter-defined dimensions). We sought to uncover the core dimensions that underlie the representational space of 378 abstract words from the Abstract Conceptual Feature database using an odd-one-out similarity task, in which participants chose which of three abstract words was least like the other two across many trials, in combination with an approximate Bayesian method for embedding the concepts in a vector space, called VICE (Variational Interpretable Concept Embeddings). A total of 6,248 participants (3,221 female; mean age=43.1, s.d.=12.3) completed the odd-one-out triad task on Amazon’s Mechanical Turk. During the experiment, each participant completed twenty triads and four catch trials. Data were discarded if the participant missed a catch trial and the triads were reposted until completed. Data were used from 4,637 participants, each of whom could complete the experiment up to five times. We collected 396,368 trials for the main experiment and an additional test set of 20,000 triads, in which twenty participants each completed 1,000 random triads. We then used VICE to embed the concepts in a vector space. VICE does this by obtaining sparse, non-negative representations from the data with uncertainty estimates for the embedding values. These estimates are then used to automatically select the dimensions that best explain the data. We randomly split the data into a 90% training partition and 10% validation partition and ran VICE twenty times starting from random seeds for a range of hyperparameter settings. The best hyperparameter set was chosen based on the average cross-entropy on the validation set, averaged across the twenty seeds. For that chosen hyperparameter set, we estimated the model performance on the test set to obtain an upper bound on the optimal model performance in the main experiment. First, we found that the upper bound of the best achievable accuracy is 69% and the VICE model obtained 61.5 – 62.5% accuracies across twenty seeds. Thus, the VICE model achieved ~90% of the best possible accuracy at predicting human behavior. Second, we identified fourteen reproducible dimensions using single-linkage agglomerative clustering on the union of all dimensions from each of the twenty seeds, merging similar dimensions (cosine distance < 0.04) iteratively, and keeping only the dimensions that were reproduced in at least fifteen out of twenty seeds. These results give us an interpretable multi-dimensional representational space of abstract concepts, in which each word has a distributional weighting across the dimensions. In addition, the dimensional weightings can be used in a variety of applications, including clustering abstract concepts into categories and designing fMRI experiments.

Topic Areas: Meaning: Lexical Semantics, Meaning: Discourse and Pragmatics

## Asymmetries in the stem and affix masked priming response: a large-scale online study

***Poster E28*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Roberto Petrosino[1], Jon Sprouse[1], Diogo Almeida[1]; [1]New York University Abu Dhabi

The research on morphological decomposition of the past 20 years has capitalized on the visual masked priming response elicited in pairs of words sharing the same root/stem (“stem priming”: driver-DRIVE), which has been shown to be robust across languages (a.o., English, French, Italian, Spanish), regardless of concatenativity of word formation (e.g., Arabic, Hebrew). On the other hand, the masked priming response to words sharing the same affix (“prefix priming”: disembark-DISPROVE; “suffix priming”: lovable-TAXABLE) has been reported not as consistently. This asymmetry seems to support a model of lexical access in which affixes are initially stripped in a first access stage and morphologically complex words are initially accessed via their stems ("prefix-stripping model of decomposition": Forster & Davis, 1975). Here we point out two potential confounds at play. First, affix masked priming is not directly comparable to stem masked priming: the former cannot be elicited on its own (since affixes are bound morphemes by definition), whereas the latter can, but only in “word-based” languages such as English, in which bare words may surface as phonologically overlapping with the underlying stem. We believe this property of English (and similar languages) is rather idiosyncratic and not very common cross-linguistically; and, more importantly, may hinder the direct comparison between the affix and stem masked priming responses, and as a consequence complicate the detection of potential differences (or lack thereof). Second, previous studies were relatively underpowered and therefore unable to detect medium-to-small effects (<=15 ms). To tackle the first confound, this study elicited the online stem, prefix, and suffix priming response to comparable word pairs (i.e., all involving bimorphemic words), while taking into account the unavoidable and uncontrollable properties of each morpheme type. In experiment 1, we elicited the priming response to prefixes and suffixes (retouch-RESALE, jogger-PLANNER) and stems of prefixed and suffixed words (disuse-MISUSE; lovable-LOVELESS); and to identical (scorpion-SCORPION), orthographically-related (advertise-ADVENTURE), and semantically-related words (particle-ELECTRON). To control for potential confounds, in experiment 2 we elicited the stem priming response from prefixed (skillful-SKILL) and suffixed words (unleash-LEASH), along with the same identity, semantic and orthographic conditions defined above. To tackle the second confound, we ran a series of power simulations, which suggested that a sample size of 6,000 subjects (each experiment) would ensure 80% power for effects equal to or larger than 5 ms. Before collection of the full sample, we ran a pilot experiment (N=240) to assess the reliability of the stimulus delivery program used (Labvanced). While the results validated the expected pattern for the identity condition (strong priming), and semantic and orthographic conditions (small-to-none priming), they showed small effects for both stem and affix priming, which at the moment prevents us from ruling out whether affix priming (i) actually exists and (ii) is different from stem priming at all. We anticipate that the full experiment (currently being collected) may clear up the issue, and reliably quantify the dissociation between stem and affix priming.

Topic Areas: Morphology, Reading

## Syntactic vs. semantic computation in posterior temporal lobe: an MEG study on Bangla nominal prefixes.

***Poster E29*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Reading morphologically complex words involves at least two distinct stages of interpretation (Manouilidou & Stockall 2014; Schreuder & Baayen 1995). The first stage involves verification of the stem's syntactic category (*re-flat, re-make). The second focuses on evaluating the semantic compatibility of the affix and stem (*re-smile, re-make). Violations of syntactic category restrictions are faster to reject compared to semantic violations. Left posterior temporal lobe activation increases for syntactic category violations around 200–300ms, and orbitofrontal cortex activation increases for semantic category violations around 350–400ms. However, these studies have been conducted primarily in European languages written with an alphabet (English, Greek). We extend this paradigm to Bangla, an understudied non-European language written in abugida. Furthermore, previous studies have examined deverbal morphology, whereas here was focused on nominal derivational morphology. In contrast to previous findings, we found that posterior temporal lobe activity increases for semantic violations in Bangla. [METHODS] N=22 Bangla speakers participated in a lexical decision task, while brain activity was recorded with a 208 axial gradiometer MEG. Stimuli included morphologically complex, grammatical stimuli with prefixes prôti- and duḥ-. These prefixes attach to nouns with abstract senses, and imply a reversal of a process (prôti-; prôti-hiṁsa 'violence' = 'revenge') or add negative affect (duḥ-; duḥ-+ghôṭôna 'event' = 'accident'). Syntactic Category violations included prôti- and duḥ- attached to adjectival stems (*prôti-kalo 'black'). Semantic Category violations included prôti- and duḥattached to nouns with a main concrete sense (*prôti-rôktô 'blood'). [RESULTS] We conducted two-stage regression analyses, in which regressions were fit to each time and source point. Significant clusters were identified using spatio-temporal cluster-based permutation tests on the t-statistic from one-sided t-tests on regression beta values. We conducted regressions with factors Prefix × Condition over left temporal lobe from 200–300ms, and orbitofrontal cortex from 300–500ms. Stronger activation was elicited by Semantic Violations, 173–197ms, in the left posterior temporal lobe ($p = 0.05$). The orbitofrontal cortex analysis revealed an interaction between Prefix × Condition, 330–342ms, such that Semantic Violations with prôti- elicited greater activity ($p < 0.01$). [CONCLUSION] Our findings reveal a similar spatial and temporal profile to previous MEG studies on morphological decomposition in English and Greek (e.g., Manouilidou & Stockall 2014). However, in contrast to previous findings, our results show that posterior temporal activity is more responsive to semantic violations, and the subsequent orbitofrontal activity shows a more complex pattern. We suggest that these results could arise from some property of the morphological properties of Bangla and prôti- and duḥ-, both of which are fossilized prefixes from Sanskrit. More likely, we suggest that the concrete/abstract distinction is faster to access than the kinds of semantic restrictions previous studies have investigated (e.g., repeatable state of an internal argument); supporting this, previous EEG findings reveal distinctions between concrete and abstract nouns ~200–400ms (Holcomb, Kounios, Anderson, & West 1999). If the nature of the semantic violation explains the difference between Bangla nominal prefixes and English/Greek deverbal affixes, then the posterior temporal lobe activity may not necessarily index syntactic computation.

Topic Areas: Morphology,

## Neurobiological bases of morphological decomposition and recomposition in Tagalog: MEG evidence from inflectional morphology

***Poster E30** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Morphological decomposition and recomposition stages were recently investigated in English (Stockall et al., 2019) and Greek (Neophytou et al., 2018), with evidence emerging for three distinct processing stages: [1] a decomposition stage, where morphologically complex words are segmented into morphological units in the left visual word form area (VWFA) between 100-200ms; [2] a syntactic category licensing stage, where the category of the stem and affix are checked for compatibility, potentially localized in the left posterior temporal lobe (PTL) around 200-300ms; and [3] a semantic composition stage, where semantic well-formedness of the affix and the stem combination is examined, potentially localized in the left orbitofrontal cortex (OF) around 300-500ms. In both languages, greater brain activity was found in the left PTL for pseudowords with a verbal affix attached to a noun (*re-idea, syntactic category violation) than pseudowords with the same affix attached to a verb with the wrong argument structure (an unergative verb, *re-smile, argument structure violation), while the reversed activation pattern was observed in the left OF. However, both of these studies looked at derivational morphology. The present study investigates whether these three morphological processing stages and the brain activation associated with them are universal, and also triggered by Tagalog inflectional prefixes, na- and nag-, both marking agent voice and grammatically combine with verbal stems.

Nag- requires an external argument and attaches to unergative and transitive verbs, and is therefore incompatible with unaccusative verbs; while na- attaches to unaccusative and transitive verbs, but is incompatible with unergative verbs (Nie, 2020). Methods/Design: 19 native Tagalog speakers participated in a visual lexical decision task with concurrent MEG recording. The task had three conditions: (a) grammatical items that correctly combine nag-/na- to verbal stems (nagsimula 'started'); (b) syntactic category violation items was created by combining these affixes with stems that are unambiguously nouns (*nagpusa 'catted', *nabintana 'windowed'); and (c) argument structure violation items was formed by attaching nag- to unambiguously unaccusative verbs (*nagguho 'collapsed'), and na- to unambiguously unergative verbs (*naluksa 'mourned'). Results: we found a significant correlation between stem:whole word transition probability (a measure of morphological complexity) and activity in the left VWFA between 100-150ms (p=0.024), suggesting that the grammatical items are decomposed into morphological units. Regression-based spatio-temporal cluster permutation tests revealed a significant cluster in the left PTL between 200-220ms, with argstrucviol condition showing greater activation than synviol condition. Finally, a marginally significant cluster emerged in the right OF between 357-387ms (p=0.056), with greater activation for synviol condition than argstrucviol condition. Overall, our findings support the three-stage morphological processing model and the role of left VWFA for decomposition, left PTL for syntactic category licensing, and OF during argument structure composition stage. This is the first such a study that looks at inflectional morphology in Tagalog, thereby adding ontological breadth to the existing literature. Note that the activation pattern is reversed in the present study compared to previous results from Greek and English, and the OF activation is right lateralized, thereby showing potential variability in the neural bases of complex word processing.

Topic Areas: Morphology,

## Feeling the L1 pressure: How Chinese-English Bilinguals differentially engage with betting in their two languages

***Poster E32*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Wenwen Yang[1], Yufen Wei[1], Guillaume Thierry[1]; [1]Bangor University

Previous studies have suggested that bilinguals make decisions differently in different language contexts. This effect has been attributed to a reduction in emotional sensitivity in the second language. However, few studies so far have looked at differences between decisions made in good faith and deceptive ones. Here, we measured event-related potentials (ERPs) in 27 Chinese-English bilinguals as they played a computerized coin-drawing game against a virtual opponent to examine potential differences between native and foreign language contexts when they had to make betting decisions. The stimuli comprised the statements "You have a coin"/"You don't have a coin" in English (and translation equivalents in Chinese), indicating whether participants had drawn a coin or not in each trial. After knowing the outcome of a draw (Coin/No Coin), participants registered their decisions to either bet or drop. When participants drew a coin, they had to bet (Truth condition) but when they did not draw a coin, they had the choice of betting (Lie condition) or not playing (dropping). Participants were explicitly instructed to engage in strategic deception as needed to maximise their score, taking into account feedback (Accept/Reject) from the virtual opponent. The coin game was played once in a Chinese and once in an English context with language blocks counterbalanced between participants. Behaviourally, participants responded faster in a Chinese than in an English context. They responded also faster when betting than dropping if they did not have a coin. However, no significant difference across languages was found between truth and lie conditions. ERPs time-locked to the outcome of the coin draw showed that a main effect of language (250–350 ms) initially prompted by the statement in English or Chinese quickly gave way to a main effect of draw condition (450–650 ms). Conversely, ERPs elicited by participants' decision to bet showed the reverse sequence of effects depending on the coin draw. Namely, a main effect of draw status (150–300 ms) indicated participants' differentiation between conditions ignoring language, followed by another, subsequent language main effect (300–500 ms). Furthermore, ERPs triggered by opponent feedback mirrored participants' betting decisions, revealing a swift transition from feedback processing (100–300 ms) before a third period of language focus (450–600 ms). Taken together, the results show that early effects associated with statements provided in different languages were soon replaced by effects indexing decision-making (bet/drop) or feedback processing (Accept/Reject) with language effects resurfacing when participants anticipated a decision or outcome. This means that participants could not ignore the language context in which they found themselves and that making decisions in Chinese, their native language, appeared to cause them more concern, resulting in deeper cognitive processing indexed by more negative ERP amplitudes. This shows that bilinguals tend to process information and make decisions differently depending on the language context in which they find themselves, which may have societal implications (e.g., diplomacy, immigration, etc).

Topic Areas: Multilingualism,

## Decoding bilingualism: Insights from resting-state oscillatory network organization

***Poster E33*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Bilingual experience is known to shape resting-state connectivity, especially along language and cognitive control networks. However, little is known about the topological and frequency-specific signatures of this effect, precluding the integration of neurocognitive models of bilingualism and neuro-architectural accounts of experience-driven plasticity. To bridge this gap, we recorded resting-state MEG activity in highly proficient Spanish-Basque bilinguals and Spanish monolinguals and calculated topological network properties using graph theory analysis at canonical frequency bands. These features were jointly fed into a machine learning classifier to establish how accurately they discriminated between bilingual and monolingual individuals at a probabilistic subject-level. The multi-feature model showed robust classification (~90%) between individuals, mainly driven by node strength in delta (2-4 Hz) and beta (15-30 Hz) networks. These effects spanned fronto-parietal and temporal hubs implicated in cognitive control and linguistic processing. Complementary evidence from a multiple regression analysis showed that these top-ranked features better discriminating individuals

during rest were also the most predictive of second-language proficiency and age of acquisition in the bilingual group. These findings suggest that the strength of connectivity in delta and beta oscillations, previously associated with interference suppression and language processing, respectively, is influenced by lifelong exposure to two languages. These results underscore the importance of incorporating subject-level, fine-grained oscillatory measures to gain a more comprehensive understanding of the impact of bilingualism.

Topic Areas: Multilingualism,

## Independent effects of multilingual experience on resting-state functional connectivity across the adult lifespan

***Poster E34*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Bi-/multilingualism has been shown to contribute to the accrual of neurocognitive reserve and resilience against decline in cognitive aging (CA) (Bialystok, 2021; Gallo et al., 2022). However, most research on multilingualism and neurocognition in aging examines older individuals, thus limiting our understanding of how multilingualism affects neurocognition throughout adulthood. Furthermore, most studies investigating bi-/multilingualism and CA operationalize multilingualism as a categorical variable, overlooking the heterogeneous nature of individual language experiences (DeLuca et al., 2019). Lastly, bi-/multilingualism is not the only contributor to individual variability in CA trajectories. Other lifestyle factors, such as education and occupational attainment (Darwish et al., 2018), sustained engagement in physical exercise (Young et al., 2015), and healthy dietary patterns (Clare et al., 2017) are also suggested to contribute to the building up of reserves against CA symptoms (Stern et al., 2020) and correlate with improved brain and cognitive outcomes in older age. However, these factors are seldom accounted for in detail in the bi-/multilingualism literature. To address these gaps, the present study investigated the neurocognitive effects of individual differences in multilingual experience across a wide age range. A large sample of bi-/multilingual native speakers of Norwegian with English as one of their additional languages was recruited (N=136, mean age = 46.53, SD=18.43, range 18-82). Participants completed a battery of questionnaires tapping into their language background (LHQ 3.0, Li et al., 2020), engagement in physical exercise (IPAQ-SF; Craig et al., 2003), diet (SFFFQ; Cleghorn et al., 2016), social networks (SNI; Cohen, 1997), and overall cognitively active lifestyle (CRS; León et al., 2014). Additionally, a resting-state electroencephalography (rs-EEG) recording was collected. Rs-EEG coherence was calculated, as it has been previously found to index increased resilience against CA (Fleck et al., 2017, 2019). Coherence was computed between electrode regions-of-interest (ROIs) across EEG frequency bands (following Bice et al., 2019, Pereira Soares et al., 2021). Multilingual language experience was operationalized via the multilingual diversity score (MLD), an entropy-based continuous measure of multilingualism (e.g., Gullifer & Titone, 2019) from the LHQ. Robust linear mixed-effects models were employed to examine the effects of age and MLD on coherence across the ROIs while controlling for other lifestyle factors. For each frequency band, the model specified ROI, age, sex, MLD, and various lifestyle scores as fixed effects, as well as interaction terms between ROI, MLD, and age. Higher MLD scores were associated

with increased coherence between the left parietal and the right anterior electrode clusters across the alpha, low beta, and high beta bands, and between the left frontal and right parietal electrode clusters in the high beta band, with increasing age. Additionally, higher MLD scores were linked to decreased coherence between the mid-frontal and right parietal electrode clusters in the high beta band with increasing age. Taken together, these findings suggest the degree of multilingual engagement impacts functional coherence across the adult lifespan and independently contributes to increased reserves against CA effects. Moreover, they highlight the need to consider multilingualism in the context of other lifestyle factors when examining CA trajectories.

Topic Areas: Multilingualism,

## Predictive Processing in Spanish-English and Chinese-English bilinguals: An ERP investigation.

***Poster E35*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Elaina Jahanfard[1], Haitong Zhu[1], Tamara Swaab[1]; [1]University of California, Davis

There is abundant evidence to suggest that actively predicting upcoming language input (Predictive Processing) facilitates language comprehension. Studies of PP in bilingual language users have yielded mixed results. Some studies have found no evidence of facilitation of prediction on L2 (Grüter et al., 2012) and some show that facilitation due to PP in L2 is delayed (Frenck-Mestre & Pynte, 1997; Chun and Kaan 2019; Trenkic et al., 2014). More recently, Zirnstein and colleagues (2018) have demonstrated that language experience and use are critical predictors of facilitative effects of PP on L2, which could explain the mixed findings observed in previous research. To further examine the role of language experience and use on the effects of prediction in L2, an ERP study will be conducted with two groups of bilingual participants who are undergraduate students at UC Davis: 1) Spanish-English heritage speakers (N=30) who have lived in an English dominant language environment, and Chinese English bilinguals (N=30) who learned English at a later age, and who have lived in a Chinese dominant language environment until they came to UC Davis. Participants in both groups will be proficient in English as established by the LHQ-3 and LexTALE. All participants will participate in a two-word visual priming paradigm. Half of the target words are related in meaning to the prime word, and half are unrelated. The task of the participants will be to predict the target word (before it is presented) after they have seen the prime. ERPs to target words will be compared in three conditions for the two 1) unrelated target words, 2) related target words that were accurately predicted 3) related target words that were not predicted. Results of a study in monolingual English speakers (Trammel et al., under revision) showed earlier and greater facilitation (reduced N400) to related target words that were correctly predicted relative to related incorrectly predicted target words and unrelated target words, indicating primacy of prediction over semantic relatedness. Furthermore, effects of concreteness and orthographic neighborhood were only observed for the unrelated and incorrectly predicted target words. This indicates that both semantic and orthographic features of the target word were pre-activated when they were correctly predicted. It is predicted that this pattern of results will replicate for the Spanish-English bilinguals. For the Chinese English bilinguals, it is predicted that they will show delayed facilitative effects of correct prediction. Given the differences in script, it is further predicted that Chinese-English bilinguals will not show evidence of pre-activation of orthographic features. Results of this study will contribute to a better understanding of individual differences in PP in bilinguals as a function of the age of acquisition, the dominant language in their environment, and differences in script.

Topic Areas: Multilingualism,

## A simple psychophysical procedure separates sensory and cognitive components of impairments of speech prosody perception after right-hemisphere stroke

***Poster E36*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction After a right hemisphere stroke, more than half of the patients present a communication disorder such as aprosodia, the impossibility to produce or comprehend speech prosody. Despite its social-cognitive implications for patients, aprosodia following stroke has received scant attention: first, existing assessment tools based on simple perceptive tasks are insufficiently sensitive; second, we lack a mechanistic understanding of why patients perform poorly on such tasks and therefore practical therapeutic targets for rehabilitation. In this report, we introduce a psychophysical procedure which, by combining systematic digital manipulations of speech stimuli and reverse-correlation analysis, allows estimating the internal sensory representations that subtend how individual patients perceive speech prosody. We compare its validity to the existing gold standard for diagnosing aprosodia (Montreal Evaluation of Communication; MEC). Methods Participants N=22 brain stroke survivors (male:17; M=57 yo), and N=12 age-matched controls (male: 6; M=59 yo) participated in the study. All patients had a history of supratentorial right-hemisphere ischaemic stroke dating less than 1y, were first-language French speakers, and had no deficits of language comprehension or major hearing impairment. Procedure: We recorded a 500-ms utterance of the French word « vraiment » (« really »), and generated random prosodic variations by dividing it into six successive segments and randomly manipulating the pitch of each segment. We then presented participants with 150 successive pairs of manipulated utterances (« really/really? ») asking them to judge, within each pair, which sounded most interrogative. Patient responses were then fitted with a 2-stage psychophysical model, consisting, first, of a prosodic template (or "internal representation") to which sound stimuli are compared and, second, of a level of "internal noise" which controls how consistently this representation is applied to incoming stimuli. Results In the control group, internal representations of interrogative prosody exhibited a typical final-rise contour, with a marked increase of pitch at the end of the second syllable. In contrast, patients' internal representations had lower amplitude, more variable shape across individuals, and were applied with higher levels of internal noise (M=+2.40, Mann-Whitley's U(-0.83)=628, $p<0.001$). Within the patient group, larger internal noise values were associated with more severe scores on the MEC prosody comprehension scale ($R2 = 0.263$, $t(20)=-2.66$, $p=.015$). Second, both atypical representations and internal noise had good symptom specificity, as neither correlated with the MEC score for prosody repetition (representation: R2: 0.00, p=.94; noise: R2=0.039, p=.38). Finally, both measures had good sensitivity, as they allowed separating patients above the pathological cut-off (9/12) on the MEC prosody comprehension scale (N=11/22) from controls

(N=12), both in terms of typicality of representation (M=-0.14, U(0.9)=7, p<.001) and internal noise (M=0.85, U(-0.68)= 71, p<.015). Conclusion. The representation+noise model paints a simple yet potent portrait of the variety of sensory/cognitive mechanisms that can explain impairments of prosody processing after stroke. By separating these different profiles of pathology, it is our hope that the method will provide more effective and individualized therapeutic targets for the rehabilitation of individuals with impaired speech prosody perception than existing measures.

Topic Areas: Prosody, Disorders: Acquired

## Prosodic phrasing in six-month-old Dutch-learning infants

***Poster E37*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: The sentence 'Miffy says Snuffy is my best friend' may leave you puzzled as to who declares the friendship status to whom. In West-Germanic languages, speakers can resolve the ambiguity by inserting an intonational phrase (IP) boundary after 'Miffy says' or surrounding 'says Snuffy'. Such boundaries can be marked by three types of prosodic cues: a rise in pitch and lengthening of the IP-final syllable, and a pause following the IP. Behavioral research shows that infants need fewer cues to recognize IP boundaries as they age, e.g., English-learning infants distinguish fully-marked boundaries at four months and only need pitch rise and another cue at six months. Similarly, six-month-old German-acquiring infants become less dependent on pauses at eight months. An EEG study on German-learning infants' IP boundary processing, reflected in the ERP component Closure Positive Shift (CPS), showed that they rely on final lengthening in the absence of pauses and do so already at six months. The change in infants' sensitivity to IP boundary cues depends on the relative importance of the cues in the native language. English speakers rely mostly on pitch rise but German speakers on final lengthening. Past research suggests that Dutch speakers mostly use pauses. However, recent findings show that Dutch adult speakers mostly rely on final lengthening to produce IP boundaries, similar to German speakers. This raises the general question whether Dutch-learning infants acquire IP boundaries similarly to German-learning infants. Specifically, we have addressed the following questions: 1) Do six-month-old Dutch-learning infants show CPS after hearing two-cue boundaries, and 2) is the CPS larger after fully-cued boundaries? || Methods: Thirteen Dutch-learning infants (mean age: 6m21days) listened to sequences of three names connected by 'and' (Dutch: en). Adopting the paradigm of the German ERP study, the stimuli were recorded by a female speaker of Dutch and manipulated to create three conditions: A) without a boundary, B) a boundary cued by pitch rise and final lengthening after the second name, and C) a fully marked boundary after the second name. ERPs were computed from the acoustic onset of the boundary in four scalp regions (left and right frontal and posterior, LF; RF; LP; RP respectively). || Results: Linear mixed models revealed that the two-cue boundary in comparison to the no-boundary elicited global positivities in the RF, LP, and RP regions (p<0.001, p=0.021, and p=0.001 respectively) and a negative shift in the LF region (p<0.001). The fully-marked boundary resulted in larger positivities than the two-cue boundary in the RP region (p<0.001) and in less positivity in the right frontal region (p<0.001). || Conclusion: Six-month-old Dutch-learning infants processed two-cue IP boundaries as shown by a broad positivity, which we interpret as the CPS. A fully-marked boundary resulted in a stronger CPS in the RP region, but weaker in the RF region. These findings suggest that Dutch-learning infants are similar to their German-learning peers and can already process IP boundaries in the absence of the pause cue at the age of six months.

Topic Areas: Prosody, Language Development/Acquisition

## Dual functionality of the Swedish word accents

***Poster E38*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Swedish word accents are known to have a stronger grammatical function than semantic distinction, although they are shaped by morphological, lexical, and information structures (Bruce, 1977). Recent studies have found evidence that the major role of the word accents is to facilitate a prediction for the upcoming morphological structure through decompositional and full-form processing routes (Roll, 2015; 2022; Schremm et al., 2018; Söderström et al., 2016; 2017). However, as a pitch accent occurs on the stressed syllable of a word, allowing maximum one pitch accent realisation per word, it is hypothesised that the semantic aspects of a word and its tonal realisation would also have an association. In the present study, a sentence comprehension task was conducted, where native South Swedish speakers were to make a quick decision on what they had heard. Stimulus sentences led the listeners to build an expectation for certain semantic aspects about the upcoming target words, while the target words unfolded with a pitch contour that was either congruent or incongruent with the sentence context. EEG was recorded using 32 channels. The behavioral data revealed a significant delay in reaction time for decision-making, indicating word accents contribute to lexicosemantic processing at the sentence level. An N400 effect was observed between 300-500 ms after the tone onset for the incongruency between the context and the target word pitch realization. A functional difference between the two word accent types was also observed at 250-400 ms post tone onset, supporting the previous studies on the prediction-based character of the pre-activation negativity (PrAN). The data seems to indicate that the Swedish word accents are lexically contrastive. Further analysis is ongoing to investigate the effect of contextual constraints. //References// Bruce, G. (1977). Swedish word accents in sentence perspective. Gleerups.// Roll, M. (2015). A neurolinguistic study of South Swedish word accents: Electrical brain potentials in nouns and verbs. Nordic Journal of Linguistics, 38(2), 149–162. // Roll, M. (2022). The predictive function of Swedish word accents. Frontiers in Psychology, 13.// Schremm, A., Novén, M., Horne, M., Söderström, P., van Westen, D., & Roll, M. (2018). Cortical thickness of planum temporale and pars opercularis in native language tone processing. Brain and Language, 176, 42–47.// Söderström, P., Horne, M., Frid, J., & Roll, M. (2016). Pre-activation negativity (PrAN) in brain potentials to unfolding words. Frontiers in Human Neuroscience, 10(OCT2016).// Söderström, P., Horne, M., & Roll, M. (2017). Stem Tones Pre-activate Suffixes in the Brain. Journal of Psycholinguistic Research, 46(2), 271–280.

Topic Areas: Prosody, Meaning: Lexical Semantics

## MEG evidence for ultrarapid phrase structure detection at 100-200ms in parallel visual presentation

***Poster E40*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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While in speech, linguistic input enters our brains slowly, through the visual modality we can also comprehend entire sentences from a 200ms rapid parallel visual presentation (RPVP; Snell & Grainger, 2017). RPVP research on short sentences has identified a so-called “sentence superiority effect" (SSE), defined as facilitated processing for grammatical as compared to scrambled sentences, indicating rapid detection of sentence structure from parallel input. In RPVP, processing is not constrained by any temporal order in the input, which allows us probe the brain's inherent way of ordering computations. We tested whether the earliest neural correlates of the SSE reflect syntactic processing, such as rapid phrase structure detection akin to Phase 1 in Friederici (2002), or an early stage of combinatorial semantic processing, as observed in MEG studies of minimal phrases (Pylkkänen, 2019). Stimuli consisted of Subject-Verb-Object (SVO) sentences, semantically related and unrelated noun lists, and pseudoword lists. The sentences were also presented with noun-verb agreement errors, thematic role reversals, and as object relative clauses. During an MEG recording, participants saw 300ms flashes of the stimuli followed by either a sentence identical to the stimulus, or a sentence with one word replaced by a length-matched, semantically plausible substitution. Participants indicated via button press whether the second sentence was the same as the first. Results yielded a clear behavioral SSE with faster and more accurate matching responses for the grammatical SVO sentences as compared to all list stimuli, including related lists. For a neural SSE, a spatiotemporal clustering analysis revealed two clusters of increased source-localized MEG activity for grammatical SVO sentences over lists in left posterior temporal cortex as early as 111-221ms, and later in left superior temporal and inferior parietal cortices at 195-285ms. To query what type of processing these effects reflect, we tested whether they would replicate if the sentence was replaced by an erroneous stimulus containing an agreement error or a role reversal, or by a syntactically more complex relative clause. For the earlier cluster, the agreement violations and role reversals replicated the effect, but relative clauses did not. This suggests a rapid sketch of phrase structure with no encoding of agreement or thematic roles, since violations of these aspects of the representation did not affect the activity. Further, since the effect did not obtain for the object relative clauses, it appears that the underlying mechanism is unable to compute this more complex structure. The earlier effect also disappeared for double violations of agreement and thematic roles, suggesting that these stimuli were no longer sufficiently sentence-like. In contrast, the second, later SSE effect replicated for all sentence types, leaving open the possibility that it could be driven by the sheer presence of a verb. This study provides a spatiotemporal localization of rapid sentence comprehension for a short visually presented full sentence. Our results suggest that the first stage of this process involves a quick sketch of basic phrase structure with syntactically canonical word order, more in line with Friederici (2002) than Pylkkänen (2019).

Topic Areas: Syntax and Combinatorial Semantics,

## Manipulating syntax without taxing working memory. MEG correlates of syntactic dependencies in Danish

***Poster E41*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Simone Krogh[1], Liina Pylkkänen[1]; [1]New York University

Querying the neural indices of syntax is difficult since syntactic manipulations often tax working memory and introduce semantic confounds. Here we tackle both challenges in a study of Danish syntactic dependencies. First, we utilize two-word Danish yes/no questions, formed from declarative Subject-Verb sentences with a word order swap (Verb-Subject) while keeping the lexical material constant. We also vary argument structure by including verbs hypothesized to trigger argument-movement (unaccusatives and alternating unaccusatives; Perlmutter, 1978), and ones that do not (unergatives). Second, we utilize Rapid Parallel Visual Presentation (RPVP; Snell & Grainger, 2017) as our stimulus delivery method. In this approach, a full sentence is presented at once, for just a few hundred milliseconds. RPVP served to eliminate working memory-related costs and additionally allowed us to investigate the neural bases of the so-called Sentence Superiority Effect (SSE) observed in prior RPVP literature. This effect refers to the advantage in rapid processing observed for structured vis-à-vis unstructured representations. We showed our two-word sentences and control two-verb lists for 300ms in a simple matching task during a magnetoencephalography (MEG) recording (n = 29) as well as in a behavioral-only version (n = 30). Our regions of interest were the left inferior frontal gyrus (LIFG), which has been implicated for long-distance dependencies since Stromswold et al. (1996), and the left posterior temporal lobe (LPTL), an emerging candidate for syntactic processing (Matchin & Hickok, 2020; Flick & Pylkkänen, 2020). The left anterior temporal lobe (LATL; Bemis & Pylkkänen, 2011) and inferior parts of the parietal lobe (IPL; Williams et al., 2017) were also examined given their implication in syntax and/or semantics. Spatio-temporal clustering analyses tested two time windows for all search areas and their right hemisphere homologues: An early time window (100-500ms) targeting the N400-like SSE reported by Wen et al. (2019) and a later window (500-800ms) motivated by the P600 literature on syntactic processing (Kaan et al., 2000; Gouveau et al., 2010). The behavioral results (n = 59) revealed a clear instance of the SSE—consistently faster responses for sentences than lists—and an effect of syntactic frame with faster responses to declaratives than interrogatives. Neurally, we find bilateral SSEs in the IPLs, localizing first in the left (250-290ms) and later in the right hemisphere (420-455ms), as well as a marginal effect in the LATL (435-460ms), broadly conforming with the previously reported N400 effect. A 2(syntactic frame) x 3(argument structure) ANOVA for the sentence stimuli revealed an effect of syntactic frame in the left IPL (510-590ms), with declaratives eliciting more activity than interrogatives, and an effect of argument structure in the right IFG (580-625ms), with unaccusatives eliciting the most activity. To summarize, our working-memory-free paradigm revealed a neural processing cost exclusively for argument movement, while verb-movement in yes/no questions resulted in a decrease in neural activity. Notably, neither effect localized in traditional syntactic hubs like the LIFG or the LPTL. This suggests that the neural processing of displacement may differ significantly from conventional perspectives when dissociated from the confounds typically associated with serial stimulus presentation.

Topic Areas: Syntax and Combinatorial Semantics,

## The Cognitive Throttle of Language: Exploring the Limits of Information Processing

***Poster E42*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Memory is short-lived. To avoid information loss, humans have to chunk continuous speech into discrete units, each containing multiple words. Earlier work has shown that auditory short-term memory is limited to 2-3 seconds (Baddeley et al., 1975). For language, a proposed window of 6 words (Frazier and Fodor, 1978) translates to 2.4 seconds when assuming a rate of 150 words per minute (Tauroza and Allison, 1990). This time constraint may come from the limited duration of the underlying electrophysiological windows. It has been suggested that cycles of low-frequency neural activity serve the formation of multi-word chunks. Previous studies have shown that phase angles of oscillatory activity in the delta band (<4 Hz) predict the offsets of multi-word chunks (Meyer et al., 2016), in particular when these occur after 2.7 seconds (Henke and Meyer, 2021). In the current project, we pursue the possibility that this constraint does not only reflect time, but also relates to the amount of information per chunk. Prior studies have shown similar information rates (~39 bits/s) for syllables across different languages, implying that the brain can handle a constant amount of information per incoming syllable (Coupé et al., 2019; Pellegrino et al. 2011). For higher levels, the uniform information density (UID) hypothesis in psycholinguistics also suggests that speakers prefer utterances that convey/distribute information uniformly across speech signals (Aylett and Turk 2004; Jaeger 2010). Accordingly, there might be an upper limit to the amount of information that can be processed within a given time window. Here, we investigate if chunk boundaries are defined by the (accumulated) amount of information. In particular, we aim to examine if chunking-related neural activity correlates with chunk boundaries as defined by the cumulative sum of word surprisals. We will analyze chunking-related neural activity (i.e., delta-band oscillations) in the electroencephalography while participants listen to a naturalistic story. We define a chunk boundary as a time point when the accumulated sum of surprisal values–which are extracted from GPT-2 –exceeds a certain threshold. We compare different cut-off thresholds to determine if multi-word chunking indeed relates to the amount of processed information: We hypothesize to observe delta-band phase clustering at the end of a chunk for the surprisal threshold that defines an optimal amount of accumulated information. Additionally, we may also observe a closure positive shift (CPS) that reflects the closure of a chunk. Overall, our results will help to understand cognitive limitations on language processing. Specifically, we will uncover whether limitations of information processing determine multi-word chunks and are reflected by neural processing windows.

Topic Areas: Syntax and Combinatorial Semantics,

## The Time Course of Verb-Specific Priming

***Poster E43*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Certain aspects of lexical information can be primed by recent usage, such as a homonym's subordinate meaning (Rodd et al., 2013) or a word's dispreferred grammatical class (Mak et al., in press). The magnitude of this priming is also maintained when participants sleep soon after initial exposure to primed information (Gaskell et al., 2019; Mak et al., in press). The supporting role of sleep can be explained by the episodic context account (Gaskell et al., 2019). This theory suggests that during discourse processing, a context-specific representation of the linguistic episode is encoded in episodic memory. These representations bind together key elements of the episode, potentially biassing how previously encountered words are later processed. Crucially, these episodic representations are potentially subject to sleep-related consolidation, in which sleep facilitates the integration of episodic memories into long-term knowledge, thereby maintaining their utility over extended periods. In this study, we investigated priming effects in relation to syntactic structure. Previous work has revealed malleability of specific verb biases based on recent experience, persisting for at least two minutes (Ryskin et al., 2017). We aimed to extend these findings further by investigating the longer-term persistence of verb-specific priming and possible mechanisms that may support it. We made use of syntactically ambiguous sentences, such as "The woman verb-ed the dog with the stick". Verbs such as "hit" favour an instrument interpretation (the woman used the stick), whilst verbs such as "chose" favour a modifier interpretation (the dog possessed the stick). In Experiment 1, participants (n=60) first completed a study phase, where 12 (of 24) verbs were primed towards their dispreferred syntactic interpretation. This was achieved by presenting verbs within sentences along with visual scenes that constrained the dispreferred interpretation. ~20 minutes later in a test phase, both primed and unprimed verbs were encountered in syntactically ambiguous contexts. That is, after processing a sentence containing the verb, participants were visually presented with both syntactic interpretations and were asked to select their favoured one. Selected interpretations were analysed via generalised linear mixed-effects modelling. We observed an interaction between priming and pre-existing verb bias, suggesting that prior exposure influenced how verbs were processed ~20 minutes later. In Experiment 2 (n=111 participants), a ~12 hour delay that included a period of sleep separated the study and test phases. Here, there was no interaction between priming and pre-existing verb bias. As an exploratory analysis, we analysed the data from the two experiments collectively. This revealed a significant interaction between priming and pre-existing verb bias, but no three-way interaction that included priming, verb bias and experiment, suggesting similar patterns of priming across experiments. These results suggest that verb-specific priming can persist ~20 minutes after initial exposure. Further, given exploratory evidence of similar patterns of priming across experiments, this could suggest that priming persists at longer intervals of ~12 hours, possibly due to sleep-related consolidation of encoded knowledge. This finding is broadly consistent with the episodic context account, although future studies would need to address the potential benefit of sleep more directly.

Topic Areas: Syntax and Combinatorial Semantics,

## At-a-glance sentence comprehension involves bottom-up composition in left inferior temporal cortex and top-down composition in middle posterior temporal cortex at 300-450ms

***Poster E45*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Although natural reading typically involves eye movements, skilled readers are also able to understand messages that are flashed quickly, such as notifications on a phone or messages on the road. A growing psycholinguistic literature has provided evidence of rapid sentence composition in such circumstances with a technique called rapid parallel visual presentation (RPVP; Snell and Grainger, 2017; Massol et al., 2021). However, the neural mechanisms of such rapid combinatory computations are not yet understood. The behavioral RPVP evidence shows that subjects perform better when all words in a stimulus form a grammatical sentence as opposed to an ungrammatical string, a so-called Sentence Superiority Effect (Snell and Grainger, 2017). Additionally, subjects often miss errors when presented with sentences that contain an inner transposition such as you that read wrong (Mirault et al., 2018). In our MEG experiment, we sought to characterize the earliest neural correlates of the sentence superiority effect. Our main goal was to assess whether at that stage, neural signals would also "miss" an inner transposition, meaning that such errors would pattern with grammatical sentences due to top-down impact of grammatical knowledge, or whether inner transpositions would diverge from grammatical sentences, indicating a more detailed, bottom-up analysis. Using RPVP, we presented 25 participants with four-word sentences that were either fully grammatical (all cats are nice), contained an inner transposition between the second and third words (all are cats nice), or contained two transpositions resulting in a backwards sentence (nice are cats all). A spatiotemporal clustering ANOVA was performed over the entire left and right hemispheres to identify the neural correlates of sentence superiority and sensitivity to the transpositions. The clustering analysis revealed two significant activity clusters in the left hemisphere, and none in the right hemisphere, suggesting strict left laterality. The first cluster showed a two-way distinction between the grammatical (no-transpositions) and the ungrammatical (one or two transpositions) sentences and localized to the left anterior and inferior temporal regions around 310ms to 400ms after stimulus onset. This effect conformed to our bottom-up hypothesis. Its localization was also consistent with prior findings on rapid bottom-up composition that shows sensitivity to the form typicality of the stimulus (Flick and Pylkkänen, 2021; Matar et al., 2021). But we also identified a second cluster, localized in the left posterior temporal lobe (LPTL), with greater activity for the grammatical and one-transposition conditions as compared to the two-transposition sentences at 375 - 440ms after stimulus onset. This effect patterned according to our top-down hypothesis, with a localization consistent with prior proposals about the neural basis of top-down syntactic predictions (Matchin et al., 2017). In sum, we discovered that the early stage of comprehending a rapidly flashed full sentence contains both a bottom-up and a top-down mechanism, with the bottom-up mechanism emerging first in inferior temporal cortex and the top-down mechanism immediately following in posterior temporal cortex.

Topic Areas: Syntax and Combinatorial Semantics,

## Friends will be friends: Brain potential evidence of social presence effects during syntactic sentence processing

***Poster E46*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Although traditionally most studies have been conducted in social isolation, how language processing is affected by social presence has recently received increased attention. In this regard, they have been reported that ERP responses to syntactic errors are modulated by the mere presence of an unknown confederate, as opposed to alone conditions. However, the social distance between the participant and the confederate has not been tested, even when there is evidence that the strength of the collaboration with friends would be greater than with non-friends. In the present study, we used event-related potentials to investigate how situating language in a social context influences syntactic processing as a function of whether the participant and the co-present person are friends or unknown people. Thirty-six native Spanish speakers read sentences that could contain morphosyntactic anomalies either alone or in the presence of a friend. The Social presence of a friend seemed to affect syntactic processing. Compared to the alone condition, the mere presence of a friend modulated the biphasic LAN/P600 ERP pattern to morpho-syntactic violations: While the LAN component increased, the P600 component vanished in response to incorrect words. This pattern, which contrasts with the results obtained when the accompanying person is unknown, has generally been interpreted as a result of a more efficient processing of syntactic information. Thus, the present results suggest that syntactic language processing could be facilitated in natural scenarios where friends are present.

Topic Areas: Syntax and Combinatorial Semantics,

## Sentence-level meaning and compositionality in a left fronto-temporal network

***Poster E47*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Neurobiological systems which process syntactic and semantic information are relatively well studied compared to those which support the integration of information across these domains. This type of integration is often critical for computing the sentence-level meaning of a given sentence, and is therefore of importance to neurobiological models of language which extend beyond single words. The known role of the left inferior frontal cortex (LIFC) in integrating linguistic and non-linguistic information (Lai et al., 2015; Özyürek et al., 2007; Willems et al., 2007) —as well in supporting combinatorial operations within linguistic domains (Hagoort, 2014)—suggests that it might also be involved in integrating information across linguistic domains. Based on this prediction, we conducted a 3T FMRI priming experiment (N=19) to investigate the role of the LIFC and the left perisylvian cortex in supporting cross-domain integration, which results in the compositional outcomes that give rise to sentence-level meaning. METHODS: In the experiment, participants were asked to read well-formed sentences and scrambled versions of these sentences, in which the word order did not form a proper sentence. In the critical condition, the prime was followed by a target word that was related to the sentence-level meaning of the prime, and was expected to reactivate this meaning more so than the other experimental conditions. There were four priming conditions in the experiment: (1) target primed by the sentence-level meaning of the sentence prime, (2) target primed by a repeated word embedded in the sentence prime, (3) target primed by a repeated word in the scrambled sentence prime, (4) target unrelated to any of the words in the scrambled sentence prime. Condition 1 was the critical condition, and the other conditions were included to account for the effect of sentence reading and for priming effects related to the reactivation of individual words and their local context. Data were analyzed both in native and MNI normalized space. An FROI analysis was performed in native space to identify the effects of the sentence meaning prime in regions throughout left perisylvian cortex. In addition, a task-dependent connectivity analysis was performed to assess the interaction between LIFC and left temporal regions known to be involved in sentence processing. RESULTS: The findings of this analysis demonstrate that a portion of the left mid temporal cortex supported syntactico-semantic integration at the level of sentence meaning in a network with the left inferior frontal cortex. This region was distinct from a more posterior left temporal region which was likely involved in lexical level processes and the integration of individual words into the sentence context. We also demonstrate that connectivity between the LIFC and left posterior temporal cortex was not modulated by the difference between sentence-level meaning and words read in sentence context, despite their previously observed role in combinatorial operations (Snijders et al., 2009; 2010). In light of these results, we propose the left mid temporal cortex/LIFC network as a target for future research on the neurobiology of the syntax-semantic interface.

Topic Areas: Syntax and Combinatorial Semantics,

## Situating the Neural Basis of Adjectival Modification Across Typologically Diverse Languages

***Poster E49*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Natalia Bekemeier[1], Marianne Hundt[1], Lena Jäger[1], Fernando Zúñiga[2], Xin Sennrich[1], Jon Lapresa-Serrano[1], James Magnuson[3], Nicola Molinaro[3], Alexis Hervais-Adelman[1]; [1]University of Zurich, [2]University of Bern, [3]Basque Center on Cognition, Brain & Language

Analysis of word classes, even across typologically diverse languages, supports the existence of a number of parts of speech (PoS) that have different functional roles, for example: nouns (reference), verbs (predication) and adjectives (modification) (Bisang, 2010). The supposition that these PoS are functionally different has been investigated using the tools of cognitive neuroscience and multiple investigations have distinguished between neural representations of verbs and nouns, at least in prototypical cases of these (Kemmerer, 2014; Vigliocco et al., 2011). However, cross-linguistic comparisons indicate that existence of a distinct PoS Adjective may not be universally supported, or that the nature of adjectives is highly variable across languages (Croft, 2022). Compare, for example Basque, where the syntactic behaviour of adjectives approaches that of nouns, with Mandarin Chinese, where modification is often realised by means of verbs. Most cognitive neuroscience studies on compositional semantics of modifying expressions have been conducted on English (Zhang & Pylkkänen, 2018; Ziegler & Pylkkänen, 2016) or other Germanic languages (Norwegian Bokmål: Fritz & Baggio, 2022, Dutch: Kochari et al., 2021), and assume a priori the existence of a prototypical Adjective category. To determine neurobiological reality of PoS, it is necessary to probe the categorical construct of PoS across typologically distinct languages and to test the possibility of distribution of modifiers along a noun-verb continuum. The present project combines neurolinguistic and computational approaches, with a focus on the word-intrinsic and context-mediated attributes that are presumed to determine their meaning and function. It further seeks to determine whether the linguistic constructs of PoS are predictive of the way the brain processes linguistic stimuli. To advance our present understanding of the representation and organisation of adjectives we plan a cross-linguistic MEG investigation that will (i) elucidate the neurobiological signatures of the core PoS and combinatorial operations involved in phrase structure building in three typologically different languages (English, Basque and Mandarin Chinese) and (ii) generate a cross-linguistic MEG database from naturalistic linguistic stimuli in the auditory modality in these three languages. The study will employ naturalistic stimuli (excerpts from an audiobook). The effects of lexical semantics and local syntactic structure building will be controlled for by means of a Jabberwocky condition (content word roots will be substituted with Jabberwocky pseudowords, while preserving the original sentences' syntactic structure) and scrambled sentences, respectively. Data will be analysed within and across languages employing: (i) mCCA to ensure optimal spatiotemporal alignment of the data across individuals and (ii) cross-validated regression of the source-localised signals (Arana et al., 2020; Heilbron et al., 2022; Huizeling et al., 2022). We will evaluate multiple encoding models that will include theoretical PoS predictors as well as metrics from language-specific embedding models. Across languages, the models that incorporate contextual predictors, such as predictability and surprisal, are expected to demonstrate the most consistent fit. The models that include syntactic structure vs. lexical root distribution predictors should fit differentially as a function of the linguistic structure of individual languages. Our results will promote insight into how PoS information contributes to the phrase structure building.

Topic Areas: Syntax and Combinatorial Semantics,

## Frontal callosal microstructure and longitudinal recovery of comprehension and production after stroke

***Poster E50*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: The frontal segment of the corpus callosum forceps minor (F-minor) is highly susceptible to microstructural deterioration in aging1,2, and measures of its integrity have been successful in explaining cognitive heterogeneity in healthy aging1-4, neurodegeneration5,6, and stroke7. The potential prognostic role of frontal callosal microstructure has been neglected in aphasia research. Given the hypothesized role of callosal connections in enabling right-hemisphere compensation after stroke8, reduced microstructure within F-minor may hinder optimal engagement of compensatory networks and have a detrimental impact on language recovery. Aims: Here, we aimed to investigate the extent to which the early subacute microstructure of the F-minor contributes to longitudinal outcomes in poststroke aphasia. We hypothesized, based on findings in healthy ageing1,3,4 and disease5,6, that a region-wise averaged radial diffusivity of F-minor (RD F-minor) would explain variance in longitudinal language comprehension and production after stroke. Methods: 32 individuals with aphasia were included at baseline (<6 weeks), and 25 of these completed the chronic assessment (6 months). Spoken language comprehension and production abilities were assessed at both timepoints using word and sentence-level tasks. All neuroimaging data was acquired at the early subacute stage (<6 weeks). T1-weighted MRI sequences were used to calculate overall percentage of stroke lesion load within the F-minor. Diffusion magnetic resonance imaging (dMRI) data was pre-processed using MRTrix (www.mrtrix.org), F-minor was automatically reconstructed in DSI Studio (http://dsi-studio.labsolver.org) and RD in F-minor metric was extracted. Stepwise multiple regression models were used to test if percentage stroke lesion load and RD in F-minor, together with demographic variables (age, sex, education), explained variance in outcomes at both timepoints. Chronic models likewise controlled for early subacute performance. Results: Spoken Comprehension: At early subacute stage only age, percentage stroke lesion load and sex explained variance in spoken comprehension (model statistics: $R2 = .59$, $F(3, 28) = 13.68$, $p < .001$). RD in F-minor did not explain additional variance ($p = .08$). At the chronic timepoint, education, early subacute scores and RD in F-minor explained variance in spoken comprehension ($\beta = -44.37$, $t = -4.88$, $p < .001$) (model statistics: $R2 = .82$, $F(3,21) = 33.25$, $p < .001$). Spoken Production: at the early subacute stage, only RD in F-minor explained variance in outcomes ($\beta = -82.20$, $t = -2.38$, $p = .024$) (model statistics: $R2 = .17$, $F(1, 27) = 5.67$, $p = .024$). At the chronic timepoint, only early subacute scores explained variance in outcomes (model statistics: $R2 = .83$, $F(2,19) = 48.48$, $p < .001$). RD in F-minor did not explain additional variance ($p = .37$). Discussion: We provide initial evidence that early subacute microstructure in frontal callosal connections could serve as an independent biomarker of comprehension and production outcomes after stroke. The differential relationship between callosal microstructure over time and different aspects of language highlights the need for detailed consideration. By leveraging early subacute dMRI data (<6 weeks), to minimize the extent of stroke-induced secondary degeneration9, our study demonstrates the importance of pre-stroke callosal microstructure in language recovery after stroke.

Topic Areas: Disorders: Acquired, Speech Perception

## The functional connectome and neural tracking of natural speech in post-stroke aphasia

***Poster E51*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Aphasia is an impairment of language processing most commonly caused by a stroke. Using EEG, we recently detected significant alteration of functional network properties in persons with chronic post-stroke aphasia (PWA) as compared with healthy controls (HC) during natural speech listening [1]. Furthermore, we reported between-group differences in neural tracking of natural speech ([2], [3]). Here we combine the two approaches to assess the functional connectome associated with neural tracking of natural speech and its alteration in PWA. Our participant cohort comprised 23 HC and 43 PWA. EEG (64 channel) was recorded while the participants listened to a 25-minute-long story. After undergoing pre-processing, the recordings were filtered within theta (4.5-7 Hz) and low-gamma (31-49 Hz) frequency bands, where a functional network disruption emerged for the EEG time series [1]. Neural tracking of the speech envelope from each EEG signals was estimated as temporal mutual information function (TMIF) [4], and connectivity between TMIFs was computed as weighted phase lag index. Significant within-group and differential between-group network patterns were assessed using the Network-Based Statistics (NBS) toolbox. Functional network properties were investigated by means of graph theory. Accuracy of EEG-based network metrics to classify individuals as HC or PWA was explored by means of a random forest classifier. The NBS revealed a significant TMIF-network component in both theta- and low-gamma-bands ($P < 0.001$). However, only the latter showed an alteration in PWA, namely a weaker cluster connecting frontal with left and right temporo-occipital scalp regions (P <

0.005). Neural tracking in PWA exhibited a more pronounced small-world network compared to HC, together with higher network segregation. Altogether, TMIF-network metrics could correctly classify the participants with area under the receiver operating characteristic (ROC) curve of 74%. Our combined analysis proved that neural tracking of natural speech across different brain regions occurs in a functionally connected manner, and that this process is affected in PWA. Interestingly, only the low-gamma-band exhibited altered between-region TMIF synchronization in PWA, despite differences between groups were previously detected also in the theta-band for both connectivity of EEG time-series [1] and neural tracking [3]. Overall, these novel findings further contribute to disentangling the neurobiological mechanisms associated with language processing in aphasia. References: [1] R. Mehraram, J. Kries, P. De Clercq, M. Vandermosten, and T. Francart, 'EEG reveals brain network alterations in chronic aphasia during natural speech listening', bioRxiv, p. 2023.03.10.532034, Mar. 2023, doi: 10.1101/2023.03.10.532034. [2] J. Kries et al., 'Exploring neural tracking of acoustic and linguistic speech representations in individuals with post-stroke aphasia', bioRxiv, p. 2023.03.01.530707, Mar. 2023, doi: 10.1101/2023.03.01.530707. [3] P. De Clercq, J. Kries, R. Mehraram, J. Vanthornhout, T. Francart, and M. Vandermosten, 'Detecting post-stroke aphasia using EEG-based neural envelope tracking of natural speech', medRxiv, p. 2023.03.14.23287194, Mar. 2023, doi: 10.1101/2023.03.14.23287194. [4] P. De Clercq, J. Vanthornhout, M. Vandermosten, and T. Francart, 'Beyond linear neural envelope tracking: a mutual information approach', J Neural Eng, vol. 20, no. 2, p. 026007, Mar. 2023, doi: 10.1088/1741-2552/ACBE1D.

Topic Areas: Disorders: Acquired, Speech Perception

## Leftward shift in dichotic ear advantage associated with temporal lobe lesions but not contralesional supranormal language activity in chronic post-stroke aphasia

***Poster E52*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Dichotic listening involves simultaneously presented, conflicting auditory tokens to each ear. When speech stimuli are presented, right-handers exhibit a classic right-ear advantage (REA), more frequently reporting the right-ear percept due to greater connectedness to the left, language-dominant hemisphere. Prior studies have found that lesions can cause a reversed, left-ear advantage (LEA). While some have interpreted a LEA as evidence for a hemispheric reversal in language dominance, the more common explanation involves the left-ear percept reaching left-hemisphere processors via an extra right-hemisphere auditory relay. But this explanation is difficult to reconcile with damage to those processors, and does not account for evidence suggesting that frontal lobe and attention might be involved in the interhemispheric transfer. Localization of lesions causing a LEA has been inconsistent, although most work implicates damage to Heschl's gyrus and the geniculo-temporal pathway. Here we aimed to localize lesions associated with a LEA in chronic left-hemisphere stroke-survivors with aphasia, and test whether patients with LEA exhibit supranormal contralesional language activation. Participants were selected from patients (N=72, M/F=36/36, Age=61.2(11.5)) and controls (N=90, M/F=51/49, Age=60.7(12.1)) were selected from an ongoing cross-sectional study of stroke aphasia outcomes. All participants underwent neuroimaging including structural scans, from which lesions were traced, and an fMRI language-mapping task. The task involved decisions on written stimulus-pairs, with alternating blocks of semantic relatedness judgment on words (SEM) and identity judgment on false-font strings (VIS). All participants completed a fused CV dichotic test. Lesions associated with ear advantage were localized using multivariate lesion-symptom mapping (LSM), controlling for lesion size (voxelwise P<.005, clusterwise, P<.05, 10,000 permutations). Right-hemisphere atlas parcels were examined if they overlapped with the left-right flipped LSM result. Then a two-sample t-test measured if activation (SEM>VIS) within qualifying parcels was greater in LEA or REA patients than controls (P<.05, Bonferroni corrected). Of 64 dextral controls, 41 showed a REA and 3 showed a LEA. Of 56 reliable patients, 16 showed a REA and 22 showed a LEA. Ear-advantage was associated with one damage to the superior temporal gyrus (22.6cc; y ~ -38 to +19), underlying white matter, and posterior insula. Two of 24 right-hemisphere parcels showed supranormal activation in LEA patients, including anterior insula (t(59)=3.80, P_bf=.004) and Rolandic operculum (t(59)=3.70, P_bf=.006). The same supranormal parcels were found in the REA patient group. LEA was associated with neither aphasia severity (WAB, t(39)=-0.99, P=.33) nor lesion size (t(39)=1.49, P=.15). Patients were almost eight times more likely than controls to exhibit a left-ear advantage. Lesions associated with ear-advantage involved expected temporal lobe regions but extended beyond classic speech processing areas. Supranormal activity was observed in contralesional frontal lobe and insula in both LEA and REA patients. These findings suggest that lesions to the ascending auditory pathway and temporal lobe can cause a LEA, but do not support a right-hemisphere account for the LEA.

Topic Areas: Disorders: Acquired, Speech Perception

## Variability in Online Speech Comprehension in Aphasia as Evidenced by Event-Related Potentials

***Poster E53*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Anna Krason[1], Erica L. Middleton[1], Matthew E. P. Ambrogi[1], Malathi Thothathiri[2]; [1]Moss Rehabilitation Research Institute, [2]The George Washington University

Comprehension deficits in aphasia are common but less widely studied and understood than production deficits. Behavioral responses alone may provide an incomplete picture, with different individuals potentially showing decrements in accuracy for different reasons. We show here–in both healthy controls and persons with aphasia (PWA)–that similar behavioral performance is accompanied by distinct event-related potential (ERP) patterns, suggesting underlying variability in speech processing. Two adults with agrammatic (A1,A2) or mild aphasia (M1,M2), and two controls (C1,C2) participated in two (M1,M2,C1,C2) or three (A1,A2) EEG sessions. Participants completed two auditory acceptability judgment tasks with (i) 50 syntactic (e.g., "The press often compares she to Marilyn Monroe") and (ii) 50 semantic (e.g., "The cowboy saddled his necklace") anomalous or acceptable sentences per session. We measured accuracy and mean amplitudes at posterior electrodes (A8, O1, Pz, Oz, Cz) within 600-800ms for (i) and (A8, Pz, POz, Cz) within 400-600ms for (ii) following critical anomalous/acceptable words. We used LMER with mean amplitude as the dependent variable and sentence (acceptable vs. anomalous) as the independent variable. Prior literature would predict a positivity (P600) and a negativity (N400) for syntactic and semantic anomalies, respectively in group analyses. However, we evaluated individual-level results to uncover potential variability in underlying mechanisms. Behaviorally, mild aphasics and controls performed at ceiling in both tasks (>88%). A1 was 57% and 72% accurate and A2 was 80% and 82% accurate in (i) and (ii), respectively. Trial rejection rate due to artifacts was within conventional limits across participants: mean=0.08 (SD=0.10) for (i) and mean=0.14 (SD=0.13) for (ii). As expected, group analysis showed a significant P600 for (i) (β=1.31,SE=0.55,t=2.37,p=.02) and N400 for (ii) (β=-1.07,SE=0.45,t=-2.38,p=.02). Looking at individuals, for (i), there was a significant P600 for C1 (β=4.05,SE=1.08,t=3.74,p=.001) and M1 (β=3.47,SE=0.97,t=3.59,p=.002) only. For (ii), there was a significant N400 for A1 (β=-2.45,SE=1.05,t=-2.32,p=.02); a marginal N400 for M1 (β=-1.56,SE=0.81,t=-1.91,p=.06); a significant N400 for C2 but in a later time window of 600-800ms (β=-3.11,SE=1.47,t=-2.12,p=.04); and a significant positivity for A2 (β=1.29,SE=0.62,t=2.08,p=.04) that extended to the 600-800ms interval (β=3.09,SE=0.72,t=4.29,p<.001). In controls and participants with mild aphasia, ERP differences despite similarly high accuracy suggest variability in sentence processing (lack of P600 for C2 and N400 for C1, lack of P600 and N400 effects for M2 but not M1). In individuals with agrammatism, neither participant showed a P600, suggesting difficulty in online syntactic processing even though A2 performed better than A1. For semantic anomalies, A1 showed an N400 and A2 did not and yet the former did worse behaviorally. These discrepancies between behavioral and ERP results in each individual suggest distinct underlying mechanisms of speech comprehension, particularly when one needs to make a judgment decision requiring intact cognitive control. If instead cognitive control is impaired, it can contribute to comprehension deficits in aphasia. In sum, despite finding predicted group-level P600 and N400 effects, individual analyses unveiled significant variations among adults who look similar on the surface. Uncovering and understanding these differences can provide valuable theoretical and clinical insights into mechanistic accounts of speech comprehension, predicting language outcomes, and personalized treatments.

Topic Areas: Disorders: Acquired, Speech Perception

## Which language domains are assessed the most often in the first year after brain tumor surgery in Europe? Towards a (Neuro)psychological Toolbox for Brain Surgery Aftercare

***Poster E54*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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[Objective] Surgery for brain tumor removal compromises a person´s physical, cognitive, and psychological health and requires multidimensional aftercare planning. Here we extend our previous report surveying the character and frequency of post-surgical assessments and interventions (Sierpowska et al., 2022), by examining the specific language domains covered by these assessments. The ultimate applied goal of this research line is to build a proposal for an optimal language and (neuro)psychological assessment toolbox in brain surgery aftercare. [Participants and Methods] Healthcare professional teams from 38 institutions in 15

European countries completed an online survey inquiring about the methods they use for speech and language and (neuro)psychological postoperative assessments at their institutions. Additionally, we specified five time points at which these assessments are usually performed: (1) bedside = 1-10 days after surgery, (2) acute stage of recovery = 11-60 days, (3) early recovery = 2-5 months, (4) late recovery = 5-12 months, and (5) long term = 1 year after surgery. Participants could select the language test/domain from proposed options (e.g. Boston Naming Test, semantic fluency, verb generation) and/or add their own suggestions in a free-text manner. Quantitative results were analyzed using descriptive statistics and comments were interpreted and summarized qualitatively. [Results] For analyses reported here, we first grouped all timepoints together. We considered that centers have a preference for a specific domain when minimally 80% of responding centers assess it. Data showed that, overall and in terms of language and speech (which is offered by 30/38 surveyed European centers), there exists a preference for assessing spontaneous speech, comprehension, phonological and semantic fluency, and object naming. When analysing timepoints separately, we could observe that more than 80% of institutions built their protocols centered on these specific tests/domains: (1) spontaneous speech - bedside (20/22), acute (5/5), early recovery (19/21), late recovery (10/10), long term (15/15); (2) interview - (acute 4/5), early (18/21), late recovery (10/10), long term (15/15), object naming - bedside (18/22), acute (5/5), early (17/21), late (10/10), long (14/15), comprehension - acute (5/5), early (17/21), late recovery (9/10), long term (13/15), phonological fluency - acute (5/5), late recovery (9/10), long term (13/15), semantic fluency - acute (5/5), early (17/21), late (10/10), long term (15/15), reading & writing (acute 5/5), late recovery, (10/10), semantic matching (acute 4/5), late (8/10), orophonatory praxis (acute 4/5), repetition (words and nonwords) (acute 4/5), action naming (acute 4/5). [Conclusions] This study reports on the most common language domains assessed during the first year of recovery after brain tumor removal and at long term (12 or more months after surgery). This information will be further used to propose a neuropsychological toolbox for medical professionals working with individuals after brain surgery. There, we will provide practical information about each task structure and usage, and approximate assessment time. It will be organized in a manner that allows institutions to either build a new protocol from scratch or to expand on an existing one in a flexible manner (e.g., to accommodate time constraints, language-specific availability of tests, and/or individual patients' needs).

Topic Areas: Disorders: Acquired, Speech-Language Treatment

## Factors influencing the effect of gesture on lexical retrieval in aphasia.

***Poster E55*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Anomia, or word-finding difficulties, is common in post-stroke aphasia. Some individuals with aphasia (PWA) benefit from observing meaningful gestures alongside speech, improving naming (e.g. Bonifazi et al., 2013; Murteira & Nickels, 2020). However, outcomes for PWA vary and, crucially, the role of individual differences and lexical factors in moderating any gesture effect is uncertain, making it challenging to design personalized rehabilitation approaches. This study aimed to investigate whether gesture observation facilitated naming in face-to-face interaction and whether any effect was impacted by lexical variables. We hypothesized that meaningful co-speech gestures used by interlocutors would facilitate later lexical retrieval in PWA, leading to improved naming by enhancing semantic activation. We predicted that PWA would exhibit higher naming accuracy when interlocuters used co-speech gestures than when they did not. Further, we expected interactions between gesture condition, word length and lexical frequency, with PWA predicted to name longer and less frequent words more accurately when gestures were present. We recruited 28 English-speaking PWA with mild-moderate aphasia (24 males, 4 females) from the UK and USA (mean WAB-R Aphasia Quotient: 77.8, SD: 14.1). Participants played an interactive picture naming card game with researchers, 'Go Fish!', where players took turns asking each other for cards depicting everyday objects and actions. In half of trials, researchers used gestures semantically-related to the target words when asking for cards; in the other half, researchers did not gesture. Gesture presence/absence was blocked and counterbalanced. Naming accuracy was measured based on participants correctly naming the images on their cards in subsequent trials. Only trials where researchers had previously named the target words prior to PWA's attempts at naming were included in the analysis. 945 observations were included in a logistic mixed effects regression analysis. Preliminary results indicated no significant effect of gesture presence/absence on naming. However, very considerable inter-subject variability was observed, such that some PWA showed gesture benefit (range 5%-48% improvement with gestures) while others performed more poorly with gestures (range 2%-48% decrement with gestures). Moreover, a significant interaction between gesture condition and word length (no. phones) was observed ($p < 0.001$). Contrary to predictions, we found no significant effect of gesture condition on naming accuracy or interaction with lexical frequency. At the individual level, however, we observed several PWA whose naming appeared to benefit from gesture. Moreover, a significant interaction was observed between word length and gesture condition: longer words were named less accurately overall but accuracy improved when gestures were present, indicating that gesture presence ameliorated the effect of word length. Limitations of the study included a small sample size excluding PWA with severe aphasia. Our preliminary findings suggest gesture observation interacts with other factors, including lexical variables, to facilitate naming in PWA. Due to high variability in gesture response among participants, we will collect additional data to explore how individual differences in aphasia severity, lesion characteristics, limb apraxia severity, semantic access and cognitive functioning moderate gesture benefit. These findings may have important implications for the development of personalized rehabilitation approaches.

Topic Areas: Disorders: Acquired, Speech-Language Treatment

## Electrophysiological correlates of recovery from anomia

***Poster E56*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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After stroke, a reorganization of the language network is generally observed, both spontaneously (Cappa et al., 1997) and induced by therapy (Saur et al., 2006). Most studies were carried out with neuroimaging techniques with high spatial resolution (PET or fMRI), but recovery may also induce changes in brain activation dynamics during language processes. Few studies have investigated event-related potential (ERP) changes during recovery from aphasia showing normalization relative to control participants in pre- and post-test comparisons (Cocquyt et al. 2020), even though difference increases have also been observed (resting state: Meinzer et al., 2004). Laganaro and colleagues (2008) reported in four patients with anomia simultaneously normalization in time-windows associated with preserved encoding processes and abnormal amplitudes and/or topographic maps in time-windows associated with the language processes responsible for the underlying impairment. However, ERP studies of word production in larger groups of patients with anomia remain limited, especially when trying to link with recovery. Thus, the present study aims to explore the electrophysiological correlates of anomia recovery in a group of patients with aphasia after a two-week of therapy. 12 patients with aphasia suffering from anomia following stroke underwent a two-week therapy protocol of digitalized treatment. A first assessment (pretest) was performed at the beginning of the two weeks followed by three posttests (one after the first week when only half the stimuli were treated, a second after the second week and one as a follow-up one week later). Test sessions included a 56-items picture naming task presented twice and EEG recordings. So far analyses have been carried out only on the comparison between the pretest and the second posttest. Accuracy analysis on the group demonstrated significant improvement between the pretest and the second posttest ($z = 7.2$, $p <.001$, $\beta = 0.97$, $SE = 0.13$). On ERPs, amplitudes and the global dissimilarity index were compared for each patient based on matched epochs between pretest and posttest2 using parametrical analyses with FDR for amplitudes and a permutation procedure on the global dissimilarity (TANOVA). Across 12 patients, waveforms differed in four time-windows: from 125 to 190 ms after picture onset, from 245 to 330 ms, from 370 to 420 ms and from 600 to 750 ms; the same time-windows yielded differences in the TANOVA analyses, except for the 370 to 420 ms. A spearman correlation was performed between the number of electrodes yielding significant differences in each participant in each of these time-windows and the percentage recovery in the naming task following therapy. Changes in the time period between 245 and 290 ms are highly correlated with recovery, for both changes in amplitudes ($r = 0.72$, $p < .01$) and in global dissimilarity ($r = 0.71$, $p < .01$). These results thus indicate changes in brain activity in the 245-330 ms time period, that has previously been associated to lexical selection and phonological processes and are positively correlated with a good recovery after anomia therapy on 12 patients. Further analyses will be performed on the same data and on a larger group.

Topic Areas: Disorders: Acquired, Speech-Language Treatment

## Brain regions associated with rule-based and observational learning abilities in post-stroke aphasia

***Poster E57*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Individuals with stroke-aphasia present with reduced comprehension or expression of language. While language is the primary factor that determines the targets and goals of therapy for people with aphasia (PWA), research is increasingly drawing attention to co-occurring cognitive deficits. Importantly, cognition might play a role in response-to-intervention (Gilmore et al., 2019). We examine rule-based and observational (implicit) learning ability in PWA to expand upon work that suggests that method of instruction may play a role in learning success for PWA (Middleton et al., 2015, 2016; Vallila-Rohter et al., 2013) as it does in other clinical populations such as those with Parkinson's Disease or Amnesia (Knowlton et al., 1994; Filoteo et al., 2005). We apply voxel-based lesion symptom mapping (VLSM; Bates et al., 2003) to better understand how damage to specific brain regions might contribute to reduced rule-based and/or observational learning. Enrolled participants completed two computer-based artificial grammar learning (AGL) tasks: one learned through observation (AGLObs) and another learned via rule instruction (AGLrb). For each AGL task, four unique geometric shapes (circle, pentagon, diamond, triangle) were arranged into three-to-six shape sequences according to AGL rules (Knowlton et al., 1992). For AGLObs training, participants saw 23 unique sequences, each presented twelve times in a passive match, non-match decision task. For the AGLrb, participants learned five rules of the AGL dependency structure through computerized training. Rules were taught one at a time with visual and audio supports and feedback-based practice. Each rule practice was followed by a criterion test. Participants had to achieve 65% accuracy to advance to the next rule. For both tasks, a testing phase immediately followed training in which participants judged the grammaticality of 30 sequences each presented twice. Eligible participants completed an MRI scan on a 3-T Siemens scanner with 32-channel head coil to obtain MPRAGE (176 interleaved slices, 1mm isotropic voxels, TR=2530ms, T1=1200ms) and FLAIR sequences. Lesion masks were manually drawn on axial slices using FSLView and confirmed by a neurologist. Images were skull stripped and spatially normalized to the Montreal Neurological Institute (MNI) template. Fourteen PWA have been enrolled. Eleven have completed all behavioral tasks, six have additionally completed an MRI scan. Average AGLObs and AGLrb learning scores did not differ (MObs= 60.76, SD =14; Mrb= 68.72, SD = 17.98). At the individual level, seven PWA scored above chance on AGLObs. Nine scored above chance on AGLrb, with four learning in one condition but not the other. Whole-brain percent spared tissue has been examined as well as percent spared tissue in regions of interest that include the caudate nucleus, posterior cingulate cortex, inferior frontal gyrus, precuneus and insula. Percent spared tissue in each of these regions currently ranges from 47.2 to 100. Learning ability does not correlate with overall lesion size. Data collection and analyses are ongoing. Results expand on research suggesting that variability in learning arises in PWA. Language ability does not predict learning ability. A better understanding of cognitive, linguistic and neural bases of learning in aphasia may help align language intervention with learning profile.

Topic Areas: Disorders: Acquired, Speech-Language Treatment

## Recovery in Chronic Aphasia Correlates with Language Lateralization Independent of Lesion Volume

***Poster E59** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Objective: The relationship between language laterality and recovery in post-stroke aphasia remains unclear. Greater left hemisphere activation post-stroke is typically associated with better outcomes, particularly when lesions are small to moderate in size. Leftward lateralization is also inversely correlated with lesion size, however, leaving it unclear whether leftward language lateralization is associated with recovery independent from lesion size. Methods: 17 individuals (10F, 7M, avg 52months post stroke) completed a semantic and a phonological adaptive language mapping (ALM) fMRI task. Semantic and phonological ROIs were derived from activation maps in a previous healthy control sample (Wilson et al., 2018). Lateralization index (LI) values were calculated using a multi-threshold weighted average approach (Wilke & Schmithorst, 2006) separately in semantic and phonological ROIs during the corresponding ALM tasks. LIs range from -1 to 1, with positive values indicating leftward lateralization. Individuals also completed 4 tasks outside the scanner emphasizing semantic and/or phonological processes: picture naming, silent nonword rhyme matching, nonword repetition, and semantic picture matching. Results: Mean semantic and phonological LI values were strongly left-lateralized, with substantial individual variation. The overall hemisphere and frontal semantic and phonological ROIs were positively correlated with ALM task accuracy and average difficulty level, and negatively correlated with reaction time (RT), indicating better performance with greater leftward lateralization. These relationships remained significant after the inclusion of lesion volume as a predictor, except for the correlations of semantic hemisphere ROI and semantic frontal ROI with difficulty level. The phonological LI derived from a parietal ROI was positively correlated with accuracy on nonword repetition, nonword rhyme matching, and picture naming outside the scanner. There were no correlations between any semantic LI values and accuracy on these tasks, and no correlations between semantic picture matching and any LI value. Partial correlations controlling for the effect of lesion volume revealed persistent positive correlations between the parietal ROI phonological LI and accuracy on repetition and picture naming. Interestingly, nonword repetition accuracy was negatively correlated with frontal and hemispheric semantic LI values after including lesion volume in the regression. Discussion: The results suggest that leftward lateralization is associated with better performance on both semantic and phonological tasks, even after lesion volume is taken into consideration. In general, faster, more accurate, and higher difficulty level achievement on the ALM tasks was associated with greater left lateralization in frontal and hemispheric ROIs. Greater left lateralization of phonological processing in the parietal region was associated with better repetition, silent rhyme matching, and picture naming ability, independent of lesion size. In contrast, greater left lateralization in the semantic network was associated with poorer nonword repetition, suggesting that stronger left lateralization in the semantic network is an indirect marker of greater damage to the phonological system.

Topic Areas: Disorders: Acquired,

## Fiber Length, Aphasia Severity, & Cognition

***Poster E60*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Severity of post-stroke aphasia and cognitive function is typically predicted by lesion size and location followed by age at stroke; however, there is unexplained variance when considering these factors. Previous work shows that the health of spared tissue, i.e., structural network integrity, plays a role in both aphasia severity and recovery trajectories. Specifically, fiber length has been shown as a predictor of aphasia severity (as measured by the Western Aphasia Battery) and as a mechanism of aphasia recovery (naming improvements) 1,2. There is evidence showing that long-range fibers are particularly susceptible to injury due to their metabolic load, and long-range fibers may be a particularly useful measure of structural network integrity in individuals with cerebrovascular events like stroke 3,4. Methods: In this study, we examined 88 participants with chronic aphasia (> 12 months post-stroke) following a left hemisphere stroke. Participants were tested for aphasia severity and cognition, including the following tests at baseline: Western Aphasia Battery- Revised (WAB)5, Philadelphia Naming Test (PNT)6, Pyramids and Palm Trees Test (PPTT)7, and the Matrix Reasoning subtest from the Wechsler Intelligence Test8. Participants also underwent T1, T2, and diffusion weighted imaging at baseline. This allowed us to create an individualized structural connectome for each participant, calculate Euclidean distance between each pair of ROIs in the Johns Hopkins University Atlas, and categorize fibers as short, medium, and long in length. We then computed a ratio of long to short range fibers normalized by total number of fibers in order to measure structural network integrity. Multiple linear regression were then run to examine the relationship between baseline variables and structural network integrity. Results: Structural network integrity, lesion volume, and age, explained 37.2% in WAB-AQ ($F=16.56$, $p<.001$), 32.3% in WAB Naming ($F=13.27$, $p<.001$), 31.2% in WAB Repetition ($F=12.71$, $p<.011$), 30% in WAB Comprehension ($F=11.99$, $p<.001$), 34.3% in WAB Spontaneous Speech ($F=14.61$, $p<.001$), 30.1% of correct items on the PNT ($F=12.06$, $p<.001$), 14.9% for correct items on the PPTT, and 25.5% on the Matrix reasoning subtest ($F=4.89$, $p<.004$). Discussion: Our results demonstrate that non-lesioned tissue, i.e., structural network integrity, is an important predictor of aphasia severity and cognitive function in individuals with chronic post-stroke aphasia. Our results fit with previous work indicating structural network integrity and fiber length as important predictors of aphasia severity and recovery1,2 and extend these results by examining a ratio of long to short fibers across several behavioral measures. Overall, we demonstrate the importance of white matter structural integrity in relation to aphasia severity and cognition.

Topic Areas: Disorders: Acquired,

## Speech-specific or domain general timing in stuttering

***Poster E61*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A shared neural architecture supports fine-grained control of internally timed and precise motor movements required for speech production. This subcortical-cortical network also supports speech perception and overlaps with a rhythm processing network. Previous studies show correlations between performance on rhythm tasks and speech/language tasks, and short-term rhythm-based interventions have been linked to improved performance on language measures in typically developing children (see Fiveash et al., 2021; Ladányi et al., 2020; Nayak et al., 2022). Most studies focused on either perception or production tasks, or speech versus nonspeech tasks; however, little research has comprehensively examined speech and non-speech timing in the same individuals. Here we measure performance on speech versus nonspeech synchronization and rhythm tasks, in both production and perceptual domains, in adults without

speech/language disorders. Establishing potential relationships between these measures can serve as a baseline for comparing with adults who stutter (AWS). Atypical rhythm has been linked to neurodevelopmental disorders affecting speech and language (dyslexia, developmental language disorder, stuttering). Stuttering is hypothesized to involve deficits related to speech motor coordination, initiating motor programs to produce fluent speech, and/or a more generalized timing deficit. AWS exhibit atypical performance relative to controls in speech timing tasks (e.g., timing of speech onsets, articulator coordination, responses to auditory feedback perturbation) as well as nonspeech tasks (e.g., auditory rhythm discrimination [Garnett et al., 2023], tapping-to-tones tasks, e.g., synchronizing finger taps with isochronous tones and then continue tapping at the same pace when the tones stop). Therefore, a secondary purpose of this study was to address an open question as to whether timing deficits in stuttering are specific to speech or represent a domain general timing deficit by collecting the same data in AWS. Thirty-seven typical adults (13F; ages 18-43 years) and 9 AWS (5F; ages 20-48 years) completed the following tasks across two visits: 1) speech-to-speech synchronization, 2) synchronize-continue tapping (tapping-to-tones) at four different tempos, 3) two rhythm discrimination tasks, and 4) a measure of working memory. For controls, phase-locking values (PLVs) for speech-to-speech synchronization were positively correlated with tapping-to-tones synchronization, $r(35) = 0.36$, $p = 0.03$. Rhythm discrimination measures were positively correlated with both speech-to-speech synchronization, $r(35) = 0.48$, $p = 0.002$, and tapping-to-tones synchronization, $r(35) = 0.47$, $p = 0.004$. Operation span was not significantly correlated with any perception or production measures (all p's > 0.05). Preliminary results for AWS show a marginally significant correlation between non-speech perception and production measures, $r(7) = 0.66$, $p = 0.05$, but no relation between speech-to-speech synchronization and either the non-speech rhythm perception ($r(7) = 0.28$, $p = 0.46$) or production measures ($r(7) = 0.50$, $p = 0.17$). Data collection is ongoing, particularly for AWS. For controls, robust correlations between speech and non-speech rhythm perception and production measures support a shared general timing mechanism for speech and non-speech timing in perception and action. Results from the AWS group are expected to clarify if purported timing deficits in stuttering are domain general or limited to speech, which may have implications for rhythm-based treatments for developmental stuttering.

Topic Areas: Disorders: Developmental, Speech Motor Control

## Corpus callosum development in children who stutter

***Poster E63*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: The corpus callosum (CC) supports interhemispheric communication and cerebral specialization through lateralization of human motor and language systems. Among adults who stutter, atypical hemispheric lateralization has been identified in regions associated with language and motor functioning, as well as differences in white matter volume and fractional anisotropy (FA) in anterior and posterior regions of the CC. Reduced FA values have recently been identified in the anterior CC of neonates at risk of stuttering, while an overall reduced growth rate of FA was found in children with persistent stuttering compared to those who recovered. This study investigated CC development in children who do (CWS) and children who do not stutter

(CNS). We hypothesized that, when compared to CNS, CWS would show reduced growth rate of FA in anterior CC segments associated with motor regions, as well as in posterior segments associated with auditory and somatosensory communication across hemispheres, with potential differences in posterior development being associated with stuttering persistence. Methods: Participants included 172 children between 3-12 years of age (81 CWS, 38 females; 91 CNS, 44 females), with CWS categorized as persistent (CWS-P; n=62) or recovered (CWS-R; n=19). Children were scanned yearly up to 4 times, resulting in 431 datasets with useable DTI and structural MRI data. Diffusion weighted imaging data were preprocessed using MRtrix and individual FA values > 0.25 were projected to a white matter skeleton using FSL's tract-based spatial statistics algorithm. We divided the CC into 5 equal segments along the anterior-to-posterior (Y) axis (anterior, mid-anterior, central, mid-posterior, posterior). For each participant, voxel-wise FA values in each CC section were extracted and averaged using AFNI. Each CC sub-region was analyzed using linear mixed-effects models with interactive factors of group (CNS, CWS-R, and CWS-P) and age to investigate differences in FA growth rate. Sex, IQ, and SES were included as covariates. Individual variability was controlled for by treating participant as a random intercept. Results: Using LMM analyses we found that among children who persisted to stutter, FA values in the mid-posterior CC decreased with age (CWS-P x Age: $p = .03$). FA values tended to be larger in boys compared to girls in the mid-posterior CC (Sex M: $p = .006$). However, stratified analyses revealed significant decreases in FA values in both mid-posterior ($p = .02$) and central ($p < .05$) CC among female CWS-P. Summary: We found significant sex-based differences in WM development in the mid-posterior CC – a region of extended growth during childhood (Luders, Thompson, & Toga, 2010). Preliminary results showed that in CC regions reported to support communication between primary motor (central) and somatosensory cortices (mid-posterior), FA decreases were associated with stuttering persistence, most significantly for girls. This study will further explore the influence of stuttering severity on FA growth rate among CWS. The current findings lend further support to 1) possible inefficiencies in sensorimotor integration and motor control, and 2) atypical lateralization of sensory and motor functioning in persons who stutter, in which this commissural fiber tract plays a critical role.

Topic Areas: Disorders: Developmental, Speech Motor Control

## Brain responses to speech sounds and their associations between reading skills in adults with and without childhood dyslexia

***Poster E64*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Developmental dyslexia is a difficulty in learning to read despite normal intelligence, educational opportunities and sensory acuity. Deficit in phonological processing is one of the key risk factors associated with developmental dyslexia. Previous studies have also shown deficit in speech sound processing in dyslexia, which could be linked to atypical phonological processing. The neural basis and the development of speech sound processing deficit in developmental dyslexia has been widely studied in childhood, but how it persists into adulthood, remains poorly understood. Here we examined 1.) how persistent the group differences in brain responses to speech sounds are between individuals with and without childhood dyslexia at the age of 26 years, and 2.) the associations between adulthood reading skills as a continuous variable and source level brain activity. Methods. The present study is a part of the Jyväskylä longitudinal study of dyslexia (JLD). Participants were approximately 26 years of age, and they have been involved in JLD since their birth. They have been divided into three groups (research question 1) based on their childhood reading skills at the end of grade 2: reading disabilities and family risk (RDFR, N=15), typical readers and family risk (TRFR, N=34) and typically reading controls (TRC, N=35). We investigated brain responses to bisyllabic pseudowords (/at:a/, /ata/, /ap:a/) presented in an oddball paradigm using event-related potentials/fields in combined electroencephalography (EEG) and magnetoencephalography (MEG) recordings. In this poster we report cluster-based permutation statistics to investigate the differences in ERPs at the sensor level between the groups following the same time window as in school age measurements (50-900 ms). The further plan is to investigate the source level brain activity and its association with reading skills in adulthood as a continuous variable. Preliminary results. The ERPs followed the typical time course of auditory responses. Cluster-based permutation statistics comparing the groups did not reveal any significant differences between the groups for standard /at:a/ responses. In contrast, deviant /ata/ responses showed group differences between RDFR and TRFR, and deviant /ap:a/ responses showed group differences between RDFR and both TRFR and TRC. In childhood group comparisons the same tests revealed significant differences for /ata/ between RDFR and the other two groups, while for /at:a/ and /ap:a/ no significant group differences were found. Associations between brain activity and adulthood reading skills will be examined in the next analysis step. Conclusion. Results show that group differences to speech sounds continue in adulthood. However, the result pattern is different from the one observed in childhood. While the group difference was in the same direction at both ages for deviant /ata/, the group difference in adulthood was weaker. In contrast for /ap:a/ the group differences were more robust in adulthood than in childhood. This could be due to extensive exposure to speech sounds that modifies the phonological representations. Alternatively differences in the RDFR sample size between childhood and adulthood could have an effect that needs to be examined further.

Topic Areas: Disorders: Developmental, Speech Perception

## Differences in Neural Encoding of Speech Emerged in Preschool Years in Children Speaking a Tone Language

***Poster E65*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Aspects of sound processing such as perception of lexical tones by tone-speaking children has shown to be a feature of Autism Spectrum Disorder (ASD). Neurophysiological research also found less robust speech encoding in both tone-language speaking school-age children and adults with ASD, suggesting that speech encoding deficits may emerge early in life (Lau, 2020). The current study examined neural encoding of speech in preschool children with and without ASD in order to better understand its developmental time course. Methods: We recruited fifty Cantonese-speaking children with ASD aged between 2 and 5 years; Autism Diagnostic Observation Schedule, Second Edition was conducted to further confirm their ASD condition. Forty-nine typically developing (TD) children with no reported developmental conditions were drawn from a larger pool of subjects as control. The children in the two groups were matched in age, gender, and gestation age using propensity score. Demographics data, including age, sex, household income, parents' age and education level, were collected, which showed no significant differences between groups. The mean age was 36.29 months; 69.7% of the subjects were male. During EEG recordings, children were seated on their caregivers' laps watching a silent movie of their choice or sleeping while listening to Cantonese speech stimuli in three lexical tones (/ga2/, /ga3/ and /ga4/). A Neuroscan system was used to examine their neural encoding of sound. Continuous EEG data were collected from Ag/AgCl electrodes at Cz, M1 and M2 at a 20 kHz sampling rate with CPz as a reference and Fpz as a ground. Cz data was re-referenced offline with the average of M1 and M2 for the subsequent analysis. A number of time- and frequency-domain measures were extracted for each tone including the frequency-following response (FFR) Signal-to-noise ratio (SNR), Noise root-mean-square, Fast Fourier transform power (low, middle and high), inter-trial phase coherence (low middle, high and maximal), pitch strength, peak amplitude, response consistency, pitch tracking, pitch error, response correlation, stimulus-response delay, peak latency and long-latency response SNR. Support Vector Machine (SVM) was applied, with EEG measures and demographic data as input to predict binary diagnostic outcome (ASD vs TD). A leave-one-out cross validation procedure was employed. The classification performance was assessed by sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and diagnostic accuracy. Results: Using solely demographics data, the diagnostic accuracy was only 60.6%; by adding FFR measures from different lexical tones into the SVM models, the classification accuracy improved. The model that included demographics data and FFR measures from all lexical tones outperformed the others with a sensitivity of 84.0%, specificity of 79.6%, PPV of 80.8%, NPV of 83.0%, and diagnostic accuracy of 81.8%. Conclusion: Differences in neural encoding of speech between ASD and TD children seem to emerge as early as preschool years in tone-learning children. Future research should examine whether these differences emerge from infancy and toddlerhood. EEG, coupled with machine learning, has the potential to be an automatic, objective tool to augment the autism diagnostic process to classify children at individual-subject level.

Topic Areas: Disorders: Developmental, Speech Perception

## Differential entrainment of neural oscillations during spoken word processing in children who stutter

***Poster E66*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Stuttering is a neurodevelopmental disorder that affects speech fluency. Stuttering can be temporarily alleviated through external rhythmic cues (e.g., metronome-timed speech); however, it remains unclear how external cues interact with intrinsic neural oscillations to support speech perception and production in stuttering. In this study, we investigated whether and how rhythmic tones preceding the spoken word would affect word perception, and whether and how children who stutter (CWS) show different patterns of oscillatory neural activity for spoken word perception. Methods: Data were acquired from 14 CWS and 34 age- and gender-matched children who do not stutter (CNS) (mean age=10.5±1.9 years, age range from 7.2-13.7 years, 7 CWS girls, 16 CNS girls). All participants spoke English as their primary language and performed within the normal range on a battery of standardized speech, language and cognitive assessments. Participants performed a spoken word perception task. Trials began with a visual cue indicating the block condition (i.e., listen), followed by four pure tones presented rhythmically at 2.5 Hz or non-rhythmically varying at 1.6 Hz – 4.5 Hz. Following the presentation of the tones, a target object (e.g., picture of a cat) was presented on the screen, along with the auditory presentation of the word spoken by a female speaker delivered via insert earphones (e.g., "cat"). EEG data were recorded from 64 scalp sensors using the Brain Vision system, and preprocessed using EEGLAB-based HAPPE pipeline. The neural oscillatory data were analyzed in the 1 second period following the target (onset of the spoken word). Specifically, power and phase consistency in the delta (rate of tone presentation, 1-3 Hz) and theta (syllable timing-related, 4-7 Hz) bands during spoken word perception were extracted and evaluated for each condition (rhythmic, non-rhythmic) and each group (CWS, CNS), to test rhythmic effects and group differences in neural activity underlying spoken word perception. Results: Time frequency decomposition revealed increased delta and theta power following the spoken word presentation in both rhythmic and non-rhythmic conditions across participants. CNS showed increased delta power in the rhythmic compared to the non-rhythmic condition in the left frontal region ($p<0.05$); no such difference was observed in CWS. Meanwhile, CWS showed increased delta power in the non-rhythmic compared to the rhythmic condition in the left parietal region ($p<0.05$), a pattern not seen in CNS. For theta power, there were no rhythmic effects or group differences. CNS showed more delta phase consistency in non-rhythmic than rhythmic conditions in the frontal central region ($p<0.05$) while CWS did not show rhythmicity differences in delta phase consistency. There were no rhythmic effects or group differences for theta phase consistency. Conclusions: CWS responded differently to rhythmic entrainment relative to CNS, indexed by different patterns of delta power and phase consistency during speech perception. Enhanced delta band neural oscillations are associated with better processing of acoustic and temporal markers in speech, and are attenuated in neurodevelopmental disorders such as dyslexia. Differences in delta band neural oscillations may reflect inefficiencies in predictive timing that affect speech perception and speech motor control in CWS.

Topic Areas: Disorders: Developmental, Speech Perception

## Decoding auditory feedback during speech production with fMRI

***Poster E67*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Dominant models of speech motor control assume the primacy of a prediction error coding scheme for representing speech sensory feedback i.e. one in which top-down predictions are subtracted from bottom-up sensory feedback, with neural activity representing the remaining unexpected features. However, an alternative coding scheme for prediction exists in the perceptual processing literature, and has recently been applied to motor control in non-speech domains (Yon et al., 2018). These 'sharpening' accounts propose that predictions are instead used to enhance representation of expected features in sensory input. Observations of suppressed univariate activity when speaking with veridical versus altered auditory feedback have been interpreted as evidence for prediction error coding within the field of speech motor control. However, a sharpened representation would likely be manifest also as an overall reduction in the summed magnitude of activation within an area due to a more precise representation, with lower representation of noise. Speaking-induced suppression in univariate activity is therefore predicted by both accounts, making this type of evidence unsuitable for discriminating between them. In speech perception, a unique neural signature of prediction error coding has been demonstrated using multivariate decoding methods that look at the content of auditory cortex representations (Blank & Davis, 2016; Sohoglu & Davis, 2020). In the current planned experiment, we aim to test for the presence of the same neural signature during speech production (i.e. processing of self-produced speech auditory feedback). Specifically, this requires crossing the usual manipulation of speech expectedness with a manipulation of speech clarity. If auditory cortex activity encodes prediction error, the effect of clarity on decoding success will depend on the level of expectedness. At low expectedness, increasing clarity will result in a greater mismatch with predictions yielding a more informative prediction error and thus better decoding; conversely, at high expectedness, increasing clarity will result in a more precise match with predictions yielding greater cancellation and thus poorer decoding. Alternatively, if auditory cortex uses a sharpening coding scheme, expectedness and clarity should have additive effects, such that decoding of activity patterns is always most successful for stimuli that are clearer, regardless of how expected they are. In our planned work, we will first investigate the effects of expectedness and clarity during speech production on participant's explicit reports of (1) the clarity of their speech feedback and (2) detection of changes to their speech feedback. For these perceptual measures, we predict additive effects of clarity and expectedness, as seen for perception of speech produced by others. Expectedness will be manipulated using real-time perturbation of formants as in altered auditory feedback experiments. Clarity will be manipulated using real-time noise vocoding, a technique that degrades the level of spectral detail in the speech signal. We will then use this paradigm in an fMRI study, to investigate the effect of clarity and expectedness on decoding of auditory feedback representations within auditory cortex during speech production. Additive effects would provide evidence for a sharpening coding scheme, whereas an interaction would be uniquely predicted by a prediction error account.

Topic Areas: Speech Motor Control, Speech Perception

## Conscious and unconscious contributions to auditory feedback control of speech — Neural correlates and behavioral effects

***Poster E68*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Motor control of speech strongly relies on auditory feedback. While efficient auditory feedback control of speech likely builds on unconscious processes, sometimes individuals need to consciously monitor and adjust their speech. However, the role and neural correlates of conscious auditory feedback control of speech remains open. Auditory feedback control of speech can be studied experimentally by exposing individuals to altered (i.e., "perturbed") real-time auditory feedback. In this pre-registered study, we exposed participants (N = 30) to individually calibrated perceptual threshold-level pitch perturbations. This allowed us to vary the participants' conscious perception of the altered auditory feedback while keeping physical stimulation (i.e., the size of the pitch perturbation) constant. We tested 1) how conscious perception of the perturbation modifies vocal responses to the perturbation, and using event-related potentials, 2) examined which electrophysiological processes correlate with conscious perception of the perturbed auditory feedback. We observed that the early part of the vocal response to the perturbation was mediated by unconscious processes. Reported conscious perception of the perturbation modified vocal responses during later time-windows (500–700 ms). Conscious perception of the altered auditory feedback correlated with event-related potentials (ERPs) in two time-windows, roughly between 100–200 ms, and 300–500 ms after perturbation onset. Consistent with some models of speech motor control, both of the correlates were right-lateralized. The results indicate that auditory feedback control of vocalization is mediated by both unconscious and conscious perceptual processes. While the ERP results suggest that perturbations to auditory feedback gain rapid access to conscious perception through right-lateralized neural circuitry, additional processing time is needed to modify vocalization based on conscious perception. Our results help integrate models of speech feedback motor control, and models of auditory perception.

Topic Areas: Speech Motor Control, Speech Perception

## Auditory-Motor Synchronization and Perception Suggest Partially Distinct Time Scales in Speech and Music

***Poster E69*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Whether the different dominant rhythmic structure in speech (~4.5 Hz) and music (~2 Hz) emerges from distinct neural auditory or motor related mechanisms is debated. We provide a new perspective by investigating the effect of different articulator systems and their auditory-motor cortex coupling (as estimated by perception-production synchronization strength) on rate-specific processing in both domains. In a behavioral protocol (n=60), a perception and a synchronization task involving speech (syllable sequences) and music (piano tone sequences) stimuli and articulators typically investigated in the speech and music domain (whispering and tapping), were conducted at slow (~2 Hz) and faster rates (~4.5 Hz). In the synchronization task, participants were instructed to synchronize their production to the presented stimuli. In the perception task, participants detected temporal deviations in sequences of isochronous tones and syllables. The normalized phase-locking value (PLV) was used to quantify the auditory-motor synchronization performance. In a linear mixed effects model (LMM), the synchronization strength was predicted from the stimulus type, the articulator type, and the presentation rate. In order to extract independent auditory-motor synchronization components, principal component analysis (PCA) was conducted on the normalized PLVs. Finally, a generalized linear mixed effects model (GLMM) was used for predicting accuracy in the perception task from the stimulus type, the articulator type, the presentation rate, and the retrieved PCA components, including their interactions. Although synchronization performance was generally better at slow rates, the results suggest domain-specific rate preferences. Tapping synchronization was advantaged compared to whispering at slow but not at faster rates. Synchronization was domain-dependent at slow, but highly correlated across domains at faster rates. Syllable and tone deviance detection in the perception task was optimal at different rates -faster and slower respectively- and predicted by synchronization strength. Our data suggests partially independent articulator system related mechanisms mediating an impact of the motor system on the optimal processing rates for speech and music.

Topic Areas: Speech Motor Control, Speech Perception

## Microstructural white matter correlates of performance on a speech adaptation task

***Poster E70*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The advancement of in-vivo neuroimaging and neuromodulation has furthered refined understanding of the speech-related brain networks and the mechanisms underlying various components of the speech process, including speech adaptation. We aimed to define the associations of key nodes in the speech neural network with performance on a speech adaptation task using multimodal structural neuroimaging. 39 participants completed an auditory perturbation task and underwent MRI imaging at Holland Bloorview Kids Rehabilitation Hospital. Audapter and MATLAB were used to administer the speech perturbation protocol in a sound isolation booth. The auditory perturbation paradigm involved a start phase (30 trials), ramp phase (30 trials), stay phase (60 trials), and end phase (30 trials). During the start phase, participants performed the task while listening to unaltered auditory feedback of their own voices. During the ramp phase, perturbation of the auditory feedback was gradually shifted until it reached a maximum of a 25% increase in the F1 formant and 12.5% decrease in the F2 formant. During the stay phase, this maximum perturbation was maintained, and then removed again in the end phase. The stay phase responses represent the participants' online compensation for the perturbation, whereas the end phase responses represent lingering adaptive effects of motor learning from the previous perturbed state. T1-weighted and Multi-shell diffusion (b=1000, b=1600, b=2600) MRI sequences were acquired using a 3 Tesla Siemens scanner. T1 images were analyzed in Freesurfer version 7.3.2 to obtain mean cortical thickness in the temporal plane of the superior temporal gyrus, superior temporal sulcus, opercular part of the inferior frontal gyrus, and inferior part of the precentral sulcus. Fixel-based analysis was applied to multi-shell diffusion images using MRtrix3. Mean fiber density (FD), cross-section (FC), as well as combined FDC in the bilateral arcuate fasciculus (AF), inferior fronto-occipital fasciculus (IFO), inferior longitudinal fasciculus (ILF), middle longitudinal fasciculus (MLF), and uncinate

fasciculus (UF). Tracts were delineated by applying TractSeg to the study-specific population template. Cortical thickness, as well as FD, FC, and FDC were correlated with performance on the speech motor adaptation task, measured by the F1 and F2 mean formant ratio. N=32 of the participants were responders, n=2 were non-responders, and n=5 were followers. Across all participants, increased FDC in the bilateral AF (Spearman Rho=.40, P<0.05, FDR corrected), MLF (Spearman Rho=.43, P<0.05, FDR corrected), and UF (Spearman Rho=.46, P<0.05, FDR corrected), correlated with increased mean formant ratio in the F1 vowel formant. This was driven by differences in fiber cross-section. Increased log-FC in the AF (Spearman Rho=.46, P<0.05, FDR corrected), IFO (Spearman Rho=.37, P<0.05, FDR corrected), ILF (Spearman Rho=.39, P<0.05, FDR corrected), MLF (Spearman Rho=.45, P<0.05, FDR corrected), and UF (Spearman Rho=.51, P<0.01, FDR corrected) correlated with increased mean formant ratio in the F1 formant. There were no correlations with cortical thickness any of the speech-related gray matter regions (P>0.05, FDR corrected) with either F1 or F2 mean formant ratios. These results from the fixel-based analysis highlight key regions of the neural network supporting speech adaptation that are related to performance on a speech motor adaptation task.

Topic Areas: Speech Motor Control,

## Distinct frequency channels for motor and sensory processing in speech production

***Poster E71** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Speech production involves the interaction between action and perception. The successful integration between motor output and sensory input ensures the fluency that we typically experience during speech production. Motor and sensory systems deal with information having different physical properties (i.e., muscle contraction and air vibration). Different sources of information undergo a series of transformations at the brain level. Following these transformations does the brain operate in a common space or in separate spaces to integrate motor and sensory information? In other words, does sensorimotor integration involve conjoined or separated processing in motor and sensory cortices? Given the fast temporal rates that characterize speech production and perception, a fast neural mechanism is necessary for sensorimotor integration. One candidate mechanism to underwrite fast temporal aspects is neural oscillations. Frequency specific power modulations have been associated with both motor and sensory processing. Previous studies show that power desynchronization in alpha (8-12 Hz) and beta (13-30 Hz) frequency bands - collectively referred to as motor unit, or mu rhythms - is observed during motor execution. Mu rhythms are generated not only during overt but also during covert motor execution. If mu rhythms were generated only during overt motor execution, they could be a by-product of the different physical properties pertaining to input and output. Instead, the fact that mu rhythms are generated in the absence of movement and its sensory consequences suggests that they reflect neural computations independent from movement outcome. Mu rhythms are generated during a variety of motor tasks including limb and speech movements. Regardless of the movement effectors, mu rhythm generation has been localized to the motor and sensory cortices. Previous studies have grouped alpha and beta frequency bands together under the mu rhythm umbrella. However, this grouping may be misleading and fail to recognize the multifaceted nature of both alpha and beta frequency bands. In this study, we investigate the extent to which alpha and beta frequencies perform different functional operations during speech production. To this end, we used magnetoencephalography (MEG) to assess alpha and beta frequency band segregation in the time-frequency and spatial domain. Participants produced syllables (presented visually) either covertly (i.e., silently, imagined speech production, N=40) or overtly (i.e., aloud, N=40). Time-frequency analyses show robust alpha and beta desynchronization at the time of covert and overt speech production. Cluster-based permutation analysis across subjects shows a segregation of alpha and beta frequency bands into two different time-frequency clusters. The two clusters differ in timing: the beta cluster (200-300 ms) precedes the alpha cluster (400-500 ms). MEG source reconstruction shows that the beta cluster is localized in motor areas while the alpha cluster is localized in temporal areas. The results suggest that beta is primarily involved in motor planning and execution while alpha is primarily involved in sensory processing. We discuss the implications of having two separate frequency channels for sensorimotor integration in speech motor control.

Topic Areas: Speech Motor Control,

## Iceberg or cut off – how adults who stutter articulate fluent-sounding utterances

***Poster E72*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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It is unclear where fluent speech ends and where stuttering begins, i.e., whether the border between fluent speech and stuttering is a ‘gradual transition’ or an abrupt ‘all or none’ phenomenon. The gradual transition assumption would mean that stuttering is a continuous phenomenon audible only when reaching a certain threshold. This view has been illustrated as an iceberg, where the visible part is only a small fraction of the true phenomenon. By contrast, the ‘all or none’ view which we call ‘cutoff’ implies that stuttering events are categorically different from fluent speech. A distinction between these two cases is vital to facilitate the disorder's neurophysiological basis and instruct therapeutic strategies. We used real-time MRI (rtMRI) to characterize the speech movements of inner articulators in 15 adults who stutter (AWS) and 17 fluent speakers (FS). Participants uttered the nonword "natscheitideut" 15 times in a 3 T MRI scanner while recording rtMRI videos at 55 frames per second in a mid-sagittal plane. Only fluent productions were considered for analysis. We defined fluent by the absence of typical stuttering characteristics such as repetitions of sounds, sound prolongations, or blocks. We discarded productions with longer pauses or hesitations between two words or within a word if they led to a pause of more than 250 ms and recordings with pronunciation errors. A customized MATLAB toolkit was used for the extraction of line profiles from MRI videos to quantify lip, tongue, and velum movements. We used penalized flexible, functional regression for modeling the movement of the tip of the tongue, lips, and velum using the group as an independent predictor and the subject as a random effect. We assessed the group effect on the movement patterns. The patterns differed significantly between subjects, but only slightly so, and showed a high similarity across subjects. Hence, movement patterns were distinguishable but still very similar across subjects, and only slight differences between groups were observed. We further analyzed whether participants were grouped due to distinguishable movement patterns across the three articulators. Therefore, we calculated all pairwise distances between the profile lines for each participant. The hierarchical clustering of participants based on these distances resulted in 3 clusters. Cluster one included predominantly AWS (11 AWS and 3 FS), and cluster two (1 AWS, 4 FS) and cluster three (2 AWS, 10 FS) included predominantly FS. An additional principal component analysis detected the same clusters. Here, the distances of the tip of the tongue to the other articulators explained the variance in the first component. To summarize, differing articulatory patterns separated AWS from FS. This distinction was evident in AWS` fluent productions of the nonword "natscheitideut". Our observation suggests that the transition between fluent and stuttered speech is not abrupt but rather a gradual continuum.

Topic Areas: Speech Motor Control,

## Linguistic tone is used in automatic lexical activation: an MMN study of Swedish nouns with word accents

***Poster E73** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The Dual Route Model [1] posits that morphologically irregular and frequent words are stored in the lexical memory as full-form representations while regular and infrequent words are decomposed into morphemes. However, to date, it is unknown which role lexically specified tones (e.g. word accents) play in automatic word activation, i.e. whether tones are processed as decomposable components or as an inherent feature of the word’s full form. We used the mismatch-negativity (MMN) paradigm in an oddball ERP experiment to investigate this question. Full-form storage manifests as a lexical MMN, where valid deviant stimuli elicit greater negativity than invalid ones [2]. Decomposition manifests as a syntactic MMN, where valid morpheme combinations presented as deviants elicit smaller negativity than invalid, rule-violating deviants [3]. In our study, we used Swedish words with valid and invalid combinations of tone and suffix. Swedish has two word accents, the low tone (accent 1) and the high tone (accent 2), which are assigned to the stem by the following suffix, e.g. singular definite suffix requires accent 1 on the stem while plural indefinite suffix requires accent 2 on the stem. These compositional properties make it possible to vary tone and validity without changing the actual word meaning (as would be the case in tone languages like Mandarin). We recorded ERP responses in 17 healthy native speakers of Swedish: They watched a silent movie and were instructed to ignore the stimuli played to them binaurally. The stimuli were four versions of the word “krok” – two valid and two invalid combinations of stem tone (high/accent1 or low/accent2) and suffix (sg.def “-en” or pl.indef “-ar”) – krok1-en, krok2-ar, *krok2-en and *krok1-ar. Each word was presented as a standard and as a deviant in four blocks, where validity and suffix varied orthogonally in a fully counterbalanced fashion. Identity MMN was calculated [4] using suffix onsets for time locking of ERP responses. Permutation analysis revealed an early increased negativity ($p = 0.033$) at 80-180 ms post-onset for valid combinations compared to invalid ones. This negativity had a frontocentral scalp distribution typical of MMN. We estimated cortical sources based on GFP peaks observed in this time window and found that during the early peak (120-140 ms), significant activity occurred in the right auditory cortex, generally associated with suprasegmental and pitch-related processing, while during the late peak (160-180 ms), significant activity occurred in the left mid-posterior temporal lobe, typically associated with retrieval of lexical units from long-term memory. Together, the findings suggest a lexical MMN, i.e. full-form storage, for tones. The results indicate an early and automatic full-form lexical retrieval of valid tone-bearing words. Moreover, this process appears to have two stages that engage different brain areas: first the right auditory cortex where the pitch contour of the word accent is established, and then the left lexical memory area, where the memory trace of the appropriate lexical unit is activated. REFERENCES: [1] https://doi.org/10.3765/bls.v17i0.1624 [2] https://doi.org/10.1016/s1053-8119(03)00261-1 [3] https://doi.org/10.1162/jocn.2007.19.6.971 [4] https://doi.org/10.1016/j.pneurobio.2006.04.004

Topic Areas: Speech Perception, Phonology

## Speech Recognition from a Familiar Speaker Engages the Person Identity Network

***Poster E74*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Numerous studies have found that phoneme perception is dependent on spectro-temporal features characteristic of the speaker’s voice. Furthermore, voice familiarity facilitates speech recognition in acoustically challenging scenarios. Such interactions between voice and phoneme processes are unexpected when considering their anatomical and functional underpinnings. Voice sensitive regions are primarily located along the right temporal lobe and are functional constituents of the person identity network. Phoneme recognition predominantly engages regions in the left temporal lobe which are part of the language network. Previous neuroimaging studies have identified two neurofunctional mechanisms which might support the interaction between voice and phoneme processes. Firstly, several studies have identified regions along the temporal cortices and in the right temporoparietal junction that are sensitive to both voice and phonetic information. Secondly, studies have found interhemispheric functional connectivity between right voice sensitive regions and left phoneme sensitive regions when recognizing speech from multiple speakers. Whether the same neural mechanisms enable the use of voice priors during speech perception has not yet been investigated. By means of fMRI, we investigated if recognizing speech from a familiar speaker elicits neurofunctional connectivity and activity distinct from perceiving speech from an unfamiliar speaker. Eighteen right-handed adult participants performed a phoneme recognition task on non-words enunciated by a familiar and an unfamiliar speaker. We employed an independent functional localizer to define as the voice sensitive area a cluster situated in the right Temporal Pole which extended into the right anterior Superior Temporal

Sulcus, and a cluster situated in the left posterior Superior Temporal Sulcus as the phoneme sensitive area. Our findings revealed the functional engagement of an extended network when processing speech from a familiar voice, rather than an increase in functional connectivity between phoneme and voice sensitive regions. The voice sensitive area exhibited greater functional connectivity with regions involved in person identity recognition, the anterior Cingulate Gyrus, and the left Frontal Pole. Furthermore, voice familiarity led to an increase in connectivity between the voice sensitive area and the right Supramarginal Gyrus, an area which is sensitive to phoneme predictability and to the typicality of the pronunciations of speakers. Better task performance with the familiar speaker correlated with greater functional anticorrelations between the voice sensitive area and two regions of the person identity network: the right Frontal Pole and left Superior Parietal Lobe. Finally, activity analysis revealed no differences between the familiar and the unfamiliar voices, but a task learning effect in the phoneme sensitive area evidenced by an increase of the BOLD activity as the experiment advanced. It has been shown before that voice-sensitive regions are recruited during speech recognition, but here we show for the first time that the extended person identity network is recruited for speech recognition as well. We propose that during speech perception, the person identity network builds predictions about the incoming sensory input and that the neural underpinning of said predictions is a network of higher-order regions which not only encode speaker voice properties, but semantic speaker knowledge.

Topic Areas: Speech Perception, Phonology

## Phonetic categorization and adaptation is impaired in adults with acquired lesions to the left hemisphere.

***Poster E75*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Categorical phoneme-perception is a cornerstone of language competence. Tuning into a given phonetic inventory starts in infancy and allows listeners to categorize the manifold acoustic realizations of a phoneme to successfully ‘map sound to meaning’. Phonetic boundaries are relevant for minimal pair differentiation (e.g., /dad/↔/bad/) and acquisition of written language, however, boundaries can be rapidly modulated, allowing for example for speaker adaptation. In the selective adaptation paradigm (1), repeated exposure to ‘prototypical’ phoneme-exemplars shifts the judgment on a continuum between, for example, /b/↔/d/ towards the prototype. More generally, repeated exposure to identical stimuli increases sensitivity to change detection, such as the frequency of tones. This adaptation process is called perceptual anchoring (2). Both, selective phoneme adaptation and perceptual anchoring have been proposed to be impaired in developmental dyslexia (2, 3). However, to our knowledge, data on individuals with an acquired lesion to the auditory/language-cortices are missing. The current project hence studies participants with unilateral left- or right-hemispheric lesions (including primary/ secondary auditory cortices) and age-matched neurotypical controls on selective phoneme adaptation and perceptual anchoring. Methods: The speech adaptation paradigm (1) required forced choice on the perception of /ba/ versus /da/ for 20 exemplars on a morphed continuum (/ba/↔/da/) (4). So far, we have included 10 participants with a left-hemispheric lesion (including primary/secondary auditory cortex) and 10 age-matched neurotypical controls. The task was administered monaurally (left/right ear); the other ear was masked with noise (dichotic presentation). Linear-mixed-model (LMM) analyses targeted participants' categorical speech perception (consistency of syllable identification) and speech adaptation (phonetic-boundary shift after adaptation to prototypical exemplars). For lesion effects and lateralization, the model included group (lesion/neurotypical) and presentation side (right/left-ear). Additionally, all participants completed a tone-discrimination task with/without perceptual anchor, requiring judgement on frequency differences between tone-pairs. For the anchor condition (first tone constant across trials) the just-noted-difference is expected to be smaller compared to the no-anchor-condition (first tone variable). Results: LMMs revealed lower speech adaptation to continuum endpoints in left-hemisphere-lesioned participants compared to controls ($F(1,18)=5.22$, $p=.035$, $\eta p2=0.22$), in particular for right-ear-presentation ($t(51.2)=3.20$, $p=.002$). Overall categorical perception was also impaired in the patient group ($F(1,18.47)=11.41$, $p=.003$, $\eta p2=0.38$). Preliminary analyses of the tone-discrimination task, confirm the smaller just-noted-difference for the anchor condition, however, differences between groups and right/left ear presentation were not significant. Discussion: We demonstrate that not only categorical phoneme perception but also speech-adaptation is altered after lesions to the left-hemispheric auditory/language cortices. The lateralization of the effect (right-ear-dominance) and the unaltered anchor-effect for frequency discrimination point to a language-related impairment. This is currently corroborated by increasing the sample size to the pre-registered n=16 and including participants with corresponding right-hemispheric lesions (n=7 at time of submission). Additional correlations with participants' patholinguistic profiles will address the relevance of deficits in perceptual anchoring and selective speech adaptation for speech comprehension in people with aphasia. Citations: (1) Eimas & Corbit, Cognitive Psychol 4:99-109 (1973). (2) Ahissar, et al. Nat Neurosci 9:1558-1564 (2006). (3) Ozernov-Palchik et al., J Exp Psychol General 151:1556-1572 (2022). (4) Stephens & Holt, Speech Commun 53:877-888 (2011).

Topic Areas: Speech Perception, Phonology

## Language familiarity dependent encoding of natural speech in human temporal lobe

***Poster E76** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Languages differ in the set of contrasting sounds (defined by phonetic features), and the ways in which these sounds are sequenced to produce units of meaning like words. By the time a speaker is proficient in a language, they have had extensive experience and exposure to both of these sources of information, which fundamentally alters how that signal is understood. It remains unknown, however, how such language experience affects the neural encoding and processing of this information at these phonological levels. Here, we exploit the high spatiotemporal resolution of direct high-density electrocorticography (ECoG) to identify neural populations that respond to speech in native vs. unfamiliar languages, and to address the extent to which phonetic and sequence-level encoding is dependent on language familiarity. We recorded ECoG while participants passively listened to natural speech in their native language and a language that was unfamiliar to them (either Spanish or English). We found that both native and unfamiliar languages elicited significant responses to speech in nearly all cortical sites throughout the human temporal lobe, suggesting that the same neural substrates are active regardless of language familiarity. However, within these active populations, the encoding of certain phonological information depended on language familiarity. Specifically, cortical sites in the superior and middle temporal gyrus showed significantly stronger encoding of language-specific sequence information and higher accuracy word boundary decoding in the native language, as compared to the unfamiliar language. In contrast, the encoding of phonetic features was similar regardless of language familiarity. Finally, we found that sequence-level and phonetic features were jointly encoded in a majority of neural populations, suggesting that the neural representation of natural speech in the human temporal lobe integrates information from across these phonological levels. Together, these results demonstrate how language familiarity affects the neural encoding of phonological information, and further, shows that this effect is strongest at the level of phoneme sequences and words.

Topic Areas: Speech Perception, Phonology

## Rapid adaptation doesn’t mean automatic perception: a non-native accent study

***Poster E77*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Non-native speech may present challenges to native listeners as it contains phonetic irregularities. For example, Spanish speakers pronounce English /p/ without aspiration which makes it confusable with a /b/ for a native English listener. Yet, listeners are able to overcome this problem by adapting to this and other non-native accent features. Based on previous studies that explored non-native accent adaptation using transcription tasks (Bradlow & Bent, 2008; Tzeng et al., 2016), we developed a series of experiments that explored how listeners’ adaptation to non-native accents changes perception at the sublexical level. English listeners were exposed to the speech of a Chilean speaker of English through sentences; then their adaptation to specific non-native sounds (e.g. unaspirated /p*/) was subsequently tested using a sound identification task where participants were asked to classify certain words depending on their initial consonant. In previous research, we found evidence of listeners’ adaptation at the sublexical level, i.e. sensitivity to non-native sounds increased with increasing exposure. In an EEG study that is currently underway, we investigate whether adaptation involves changes in the automaticity of non-native accent perception. We are using a combination of an oddball paradigm with Fast Periodic Auditory Stimulation (FPAS), a technique used to explore passive and automatic perception (Barbero et al., 2021). During this task, the participants’ ability to perceive non-native phonological contrasts was tested using a stream of syllables (e.g. prevoiced /b/ v/s unaspirated /p*/ in [ba-ba-ba-ba-pa*-ba-ba…]). To ensure listeners' attention, participants were instructed to press a button when a control syllable was presented (e.g. /ma/ in [ba-ma-ba-ba-pa*-ba-ba...]). Our results so far show evidence of accent adaptation in the behavioural tasks, mirroring our previous findings, but not in the FPAS-oddball task. This pattern suggests that when listeners undergo non-native accent adaptation, their perceptual retuning towards non-native sublexical units is a result of a process that is active and controlled rather than automatic. Barbero, F. M., Calce, R. P., Talwar, S., & Rossion, B. (2021). Fast Periodic Auditory Stimulation Reveals a Robust Categorical Response to Voices in the Human Brain. 8(June), 1–13. Bradlow, A. R., & Bent, T. (2008). Perceptual adaptation to non-native speech. Cognition, 106(2008), 707–729. https://doi.org/10.1016/j.cognition.2007.04.005 Tzeng, C. Y., Alexander, J. E. D., Sidaras, S. K., & Nygaard, L. C. (2016). The role of training structure in perceptual learning of accented speech. Journal of Experimental Psychology: Human Perception and Performance, 42(11), 1793–1805. https://doi.org/10.1037/xhp0000260

Topic Areas: Speech Perception, Phonology

## Investigating the roles of acoustic-phonetic and lexico-semantic processing in resolving perceptual ambiguity in Spanish-accented English

***Poster E78*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Listeners exhibit remarkable speed and plasticity in adapting to L2-accented speech. However, the neurocognitive mechanisms that drive these rapid adaptation effects are currently unknown. To investigate these mechanisms, we designed an EEG/ERP study focusing on voice onset time (VOT), the primary acoustic-phonetic cue that distinguishes voiceless stop consonants /ptk/ from their voiced counterparts /bdg/. Short-lag VOTs characterize /ptk/ in Spanish and /bdg/ in English. Since L1 Spanish bilinguals tend to transfer these short-lag VOTs for /ptk/ into their L2 English, Spanish-accented English /ptk/ are equally likely tokens of /ptk/ or /bdg/ from a listener’s perspective. Thus, listeners must learn new mappings between VOT and /ptk/ in order to achieve successful comprehension of Spanish-accented English. We wanted to track the time-course of this adaptation process with EEG. Seventy monolingual English speakers will participate in this study during Summer 2023. EEG will be recorded during a cross-modal priming task, in which participants indicate whether an auditory target matches a visual prime. Auditory targets are English nouns of two types: multisyllabic words without onset competitors (e.g., pencil/*bencil), to expose participants to voiceless stops in unambiguous lexical contexts, and monosyllabic words with relevant onset competitors (e.g., park/bark), to test learning over time in ambiguous lexical contexts. A Spanish-accented bilingual female speaker from Mexico City, Mexico, recorded the stimuli (432). Critical targets (72 each mono/multisyllabic) have /ptk/ onsets, while filler targets (144 each mono/multisyllabic) have /mnɹlhw/ onsets. Each target is proceeded by one of three Prime Types: Identity (e.g., park), Competitor (e.g., bark), or Control (e.g., wand). ERPs will be time-locked to the onset of each auditory target. We will conduct mixed-effects models on trial-level ERPs for critical monosyllabic targets in three time windows: 150-350 ms, 350-600 ms (N400), and 600-900 ms (late N400). We predict an interaction between Prime Type and Duration at 150-350 ms. As the experiment progresses, participants will learn to relate the Spanish-accented talker’s VOT distributions to the appropriate phonemes. To the extent that adaptation is similar to rule-learning, the difference between Identity and Competitor primes should emerge on the P2/P200 component. If this difference is observed on the N200/PMN, this would suggest that adaptation involves updating expectations about the speech signal. The emergence of neurocognitive differences between Identity and Competitor primes should also be reflected behaviorally, with decreasing RTs and increasing accuracy for Competitor primes over time. If the behavioral results do not demonstrate learning of Spanish-accented VOTs, this would suggest that online sensitivity to accent-shifted VOTs develops before offline performance improves. Control primes should elicit larger effects than Identity or Competitor primes throughout the experiment. On the N400, participants should show consistently larger effects for Competitor and Control primes than for Identity primes. If an interaction between Prime Type and Duration is observed on the N400 but not on the P2/P200 or N200/PMN, this would suggest a lexico-semantic mechanism for adaptation to L2-accented speech. Overall, this work unites behavioral measures of perceptual adaptation with neurocognitive measures of online processing to gain a deeper understanding of speech recognition.

Topic Areas: Speech Perception, Phonology

## Rapid auditory and linguistic processing requires the left planum temporale

***Poster E79*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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After bilateral acoustic processing, speech and language processing is left-lateralized. The reason for this remains an open question. One prominent hypothesis (Asymmetric Sampling in Time) proposes different biases in the left and right hemispheres for processing auditory information in short (25ms) versus long (250ms) temporal windows, respectively. Here we investigated this hypothesis in a sample of adults with left hemisphere stroke (LHS) with respect to both auditory and linguistic processing. We first asked: Do adults with LHS perform worse on rapid auditory judgments than healthy controls, and is there a certain lesion location that predicts worse performance on these judgments? Fifty LHS participants (18 female, 20 African American, ages ranging 39.4-81.4 years with a mean of 60.0 years, time since stroke ranging from 0.12-16.7 years with a mean of 3.9 years) and 61 healthy controls (34 female, 20 African American, ages ranging 30.7-83.8 years with a mean of 61.0 years) performed a frequency-modulated (FM) sweeps judgment task involving short (25ms) and long (250ms) sweeps. Mean accuracies for each participant were calculated across all short-sweep and long-sweep trials respectively. Performance was significantly lower for patients than controls, and for short sweeps than long sweeps. We then performed support vector regression lesion-symptom mapping (SVR-LSM) using manually traced lesions warped to MNI space. Lesion volume was included as a covariate in the behavioral measures and voxelwise lesion data, and maps were thresholded using continuous family-wise error correction based on permutation analyses. The SVR-LSM results revealed that a stroke to the planum temporale (PT) predicted worse performance on short sweeps, controlling for performance on long sweeps. We then asked: Do adults with a stroke to the PT perform worse on linguistic judgments that rely on these short time windows? We separated patients into subgroups of “PT lesion” or “No PT lesion,” and examined their performance on a categorical phoneme identification (CP ID) task in which they identified a phoneme as either /ba/ or /da/. Importantly, the spectrograms for /ba/ versus /da/ differ in the initial 25ms segment of the second formant. We examined two measures of CP ID accuracy: categorization slope, measured as the steepness of the transition between the two mid-point stimuli, and end-point accuracies, measured as the

difference between the accuracies on the two end-point stimuli (i.e., the most “/ba/-like” and the most “/da/-like” stimuli). To calculate categorization slope, we first sigmoid-fit each participant’s raw response data using a nonlinear least squares approach. Controls performed significantly better than LHS participants on both measures of CP ID accuracy. Additionally, the PT lesion group performed significantly worse than the No PT lesion group on correctly identifying the end-point stimuli. An SVR-LSM analysis revealed that worse performance on both measures of CP ID proficiency related to strokes to the PT. We conclude that the left PT is an essential region for processing auditory information in short temporal windows, and it may also be an essential transfer point in auditory-to-linguistic processing.

Topic Areas: Speech Perception, Phonology

## To what extent do French listeners perceive word accentuation? An EEG investigation

***Poster E80*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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It is now well established that French listeners have difficulties to detect a change in word accentuation when the accentual contrast under investigation does not exist in the native language. Nonetheless, in all the behavioral studies examining the ability of French listeners to process non-native accentual contrasts, French listeners performed rather well, above the chance level and around 85% of correct responses. In this study, we provided a more in-depth examination of the ability of French listeners to perceive word accentual information, and compared the time-course of the discrimination of native and non-native accentual contrasts. To do it, Event-Related-Potentials (ERPs) were recorded while participants performed a same-different task. They first heard four stimuli that were strictly identical in respect to both their phonemic and accentual patterns, but were produced by four different female speakers (e.g., /ʒy'ʁi/-/ʒy'ʁi/-/ʒy'ʁi/-/ʒy'ʁi/), and then heard a fifth stimulus, the target, which was always produced by a male speaker. The target was either the same as (identical condition; e.g., /ʒy'ʁi/), or different from the first four stimuli (deviant conditions). In the deviant conditions, the target stimulus differed from the first four stimuli, either in the phonemic pattern (phonemic deviant condition; e.g., / ʒy'ʁɔ̃/) or in the accentual pattern (accentual deviant condition; e.g., /ʒyʁi/ for the native contrast or /'ʒyʁi/ for the non-native contrast). We measured the precise moment at which phonemic and accentual discrimination occurs by comparing the ERPs in the standard vs. deviant conditions. ERPs results indicated that a change in word accentuation for the native contrast (e.g., /ʒy'ʁi /-/ʒyʁi/) was detected in a time-windows between 370 and 500 ms after target onset, and that this discrimination occurs in the same-time window as phoneme (e.g., /ʒy'ʁi/-/ ʒy'ʁɔ̃/) discrimination. In contrast, while behavioral performance reached 90 % of correct responses, ERPs results indicated that a change in word accentuation was never detected for the non-native accentual contrast (/ʒy'ʁi/-/'ʒyʁi/). We conclude that the good performances observed in behavioral experiments for non-native accentual contrasts are due to attentional/decisional processes linked to the discrimination tasks, and not to automatic and unconscious processes involved in word accentuation processing.

Topic Areas: Speech Perception, Prosody

## The temporal and spatial dynamics of prosodic processing - an MEG study with French listeners

***Poster E81*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In speech, any given target utterance can be realized through many different physical manifestations that depend on factors like linguistic intentions or speaker-related characteristics. At the same, it is well-known that listeners use prosody – acoustic-phonetic modulations – to make linguistic inferences, for example, about an utterance's lexical segmentation or syntactic structure. This suggests that prosody is an important part of the linguistic system and functions as a useful source of information for speech processing. However, these observations raise the question of how listeners navigate phonetic variability to extract a dependable and generalizable cue. One frequent source of phonetic variability stems from sentence types – for example, statements and polar questions – and the distinctions between them. The prosodic feature responsible for conveying this distinction is fundamental frequency (f0). Polar questions are reliably produced with a final rise in terminal f0 while statements are marked by a falling terminal f0. For speech perception to be efficient and successful in such a case, a listener must, on the one hand, perform a fine-grained analysis of the physical prosodic contour and, on the other hand, form an abstract prosodic representation that allows a categorization regarding sentence type. A broad network, especially in the right hemisphere, has been implicated in the analysis and transformation of prosodic information including the superior temporal gyrus (STG) and sulcus (STS), inferior frontal gyrus, as well as premotor cortex. However, what is missing from these mainly fMRI-based findings is a characterization of how the brain captures meaningful phonetic variability and the temporal and spatial dynamics of associated processing stages. To fill this gap, we are currently running an MEG study with French-speaking young adults. Participants listen to and categorize French words intoned either as a question or a statement. To create controlled phonetic variability, we synthesized a continuum between two prototypes by manipulating f0 in 6 equidistant steps. The psychometric identification function stemming from a behavioral pilot study confirms that these stimuli are perceived categorically. On a neural level, we expect to see an initially continuous physical representation of phonetic variability in early auditory processing regions especially in right posterior STS. Progressing in space (towards anterior STS) and time, we expect to find a categorical representation of prosodic cues. Given previous research, we hypothesize the premotor cortex to be involved in the transformation from continuous to categorical representations. From a broader perspective, this study is valuable insofar as prosody is generally an understudied phenomenon in the cognitive neuroscience of speech: Studies usually control for prosodic cues as an undesired confounding source. This is surprising considering the fundamental role prosody plays in language acquisition in infants as well as speech processing in adults. Therefore, the insights generated from this experiment will contribute to a more encompassing understanding of speech processing in the brain. Additionally, since comparisons between the human brain and more complex computational models of language are getting increased attention, an integration of prosodic information into these architectures will better capture the naturalistic aspects of how we communicate.

Topic Areas: Speech Perception, Prosody

# Do the eyes retune the ears? MEG evidence that sign language knowledge affects how we process spoken language.

***Poster E82*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Neural tracking of the speech envelope seems to support spoken language processing and comprehension. Linguistic information is not limited to the auditory domain and may also be transmitted and perceived through the visual modality, either accompanying the speech signal (visual information on the face and mouth, as well as co-speech gestures) or as an autonomous language code (signed languages). In a previous study we showed that signers' neural activity tracks the visual linguistic signal during sign language processing, although it is qualitatively and quantitatively different from entrainment to spoken language. In that study, we compared cortical tracking to signed and spoken languages. To characterise the temporal regularities of the visual linguistic signal we used markerless motion tracking. A custom-built Kinect setup allowed us to record the three-dimensional motion information of different points on the body, including the hands, the head and the torso. This Kinect set up was used to record videos of native speakers/signers producing narratives in four different languages (Spanish, Russian, Spanish Sign Language - LSE and Russian Sign Language), and these videos served as stimuli for the experiment. Two groups of hearing participants – 15 proficient LSE signers and 15 matched controls with no knowledge of sign language – watched videos in all four languages while we recorded their neural activity using magnetoencephaolography (MEG). We calculated coherence between the preprocessed MEG data and the linguistic signal (the speech envelope in spoken languages and the speed vector of the right hand in signed languages) and used cluster-based permutation tests to assess statistical differences across experimental conditions. Unexpectedly, when comparing bimodal bilinguals and sign-naive controls the former group showed stronger entrainment to spoken language (mainly in the theta frequency band). Both groups had similar spoken language experience (all participants were native Spanish speakers and had no knowledge of Russian), suggesting that signers' familiarity with a visual language is impacting how they process spoken language. We plan to explore two possible explanations for this result with a follow-up analyses. In our study the spoken language stimuli included visual information: participants could see the speaker's facial movements and co-speech gestures. Sign language knowledge may aid (hearing) signers in picking up and synchronising to the visual information available while attending to speech, supporting the tracking of body articulators or facial information (or both). To test this hypothesis we will use the data previously collected and analyse coherence between hands and mouth movements during speech with MEG data, and examine the coherence between the auditory speech signal and the different visual articulators. Based on the results for neural tracking of sign language, we expect signers to show higher coherence to the right hand compared to sign-naive controls; furthermore, since signers showed more coherence to speech in the theta band, we anticipate greater coherence with mouth movements. This result may provide evidence for a cross-modal transfer effect between sign and spoken language: knowing a sign language may change how

you perceive and comprehend spoken language.

Topic Areas: Speech Perception, Signed Language and Gesture

## Comprehension and neuronal tracking of speeded speech - contributions of preferred rates and auditory-motor synchronization

***Poster E83*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Acoustic speech signals are tracked along the auditory pathway, presumably facilitating speech segmentation and decoding of speech information. Humans listeners understand speech effortlessly within an optimal range of syllabic rates, however, comprehension deteriorates at fast speech rates. Thus, speech comprehension is suggested to be limited by the temporal constraints of the auditory system. Here we ask whether these temporal constraints are shaped by individual differences in temporal characteristics of the auditory and motor systems, and the auditory-motor coupling strength. In a combined behavioral and MEG experiment, we characterize individual differences in the comprehension of naturalistic speech as a function of the synchronization between the auditory and motor systems and the preferred frequencies of the systems. Furthermore, we investigate how different levels in the auditory processing hierarchy are affected by accelerated speech. More specifically, do increased speech rates lead to poorer early auditory speech tracking and/or are higher-level representations of linguistic information impaired? In the behavioral data we observed that speech comprehension declined at higher speech rates. Importantly, both auditory-motor synchronization and spontaneous speech motor production rates were predictive of better speech-comprehension performance, with higher synchronization and rates related to better performance. Furthermore, performance increased with higher working memory capacity (Digit Span). The MEG data analysis is ongoing, however, we expect that as the syllabic rate increases, both speech tracking in auditory cortex and the amplitude of the TRF400 (indicating linguistic representation) decrease. The behavioral data provide evidence for a model of speech comprehension in which individual flexibility of the motor system and auditory-motor synchronization may play a modulatory role.

Topic Areas: Speech Perception, Speech Motor Control

## Intracranial EEG investigation of the neural processing of speech in light of its multiscale dynamics

***Poster E84*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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To obtain a comprehensive understanding of speech perception, it is crucial to expand beyond the dominant "dual-stream" model that primarily focuses on functional neuroanatomy. In addition to this neuroanatomical

perspective, achieving a more holistic comprehension of speech perception becomes imperative. This requires integrating a neurophysiological model, capturing local and global oscillatory neural dynamics, as well as an informational model that elucidates cognitive algorithms and representational inference processes. This is particularly important because speech, as a temporal signal, possesses a hierarchical linguistic structure encompassing notably phonemes, syllables, words, and phrases. Exploring how information is analyzed across these timescales and understanding how they hierarchically combine through network dynamics is essential for unraveling how the human brain links intricate acoustic signals to semantic representations. To explore these dynamics, we collected stereo-electroencephalography (sEEG) data from pharmaco-resistant epileptic patients while they were listening to a 10-minute story in French. We then trained transformer neural networks to predict upcoming words, syllables, or phonemes, and investigated the neural correlates of continuous entropy and surprise values at these three linguistic timescales. We performed a multivariate Temporal Response Function (mTRF) analysis, to investigate the neural frequencies encoding each linguistic feature and to explore dynamic and spatial characteristics of these representations. We anticipate revealing a spatio-temporal gradient mapping, exemplifying the shift from low-level local to high-level distributed linguistic predictive features. Moreover, we expect different linguistic features to be encoded by complementary neural frequencies. Finally, we are considering future work involving functional connectivity analysis, which would provide additional insights into the dynamic functional hierarchy linking the different linguistic processing stages. Importantly, this work serves important theoretical goals by offering a critical test to determine the extent to which neural oscillations play a fundamental role in the computational processes of speech processing. It has the potential to define the intricate mapping between speech and neural timescales, shedding light on how information is transferred and combined across the linguistic computational processing hierarchy.

Topic Areas: Speech Perception, Speech-Language Treatment

## Does the Closure Positive Shift Consist of Phase-Locked Delta-Band Oscillations?

***Poster E85*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The Closure Positive Shift (CPS) is an event-related brain potential associated with the termination of prosodic phrases as well as larger syntactic units, such as clauses. The likelihood of a CPS increases with the duration of the terminated unit. In addition, the CPS exhibits an endogenous period of about 2.7 seconds; that is, the occurrence of a CPS is more likely when the terminated unit is 2.7 seconds long. Recently, we and others have hypothesized that the CPS might consist of underlying neural oscillations, with increases in amplitude arising from phase-locking across trials. This is based on the observation that the phase of neural activity < 4 Hertz (i.e., delta-band oscillations) predicts the segmentation of sentences, specifically when segment duration is 2.7 seconds. To test this hypothesis, our auditory magnetoencephalography (MEG) study used sentences containing globally ambiguous relative clauses (e.g., Mrs. Groß called the nurse of the pensioner who always joked.), where the relative clause (i.e., who always joked) can be attached to either of two preceding noun phrases (i.e., NP1 the nurse or NP2 the pensioner). Prior work has found that attachment is influenced by clause duration, with long relative clauses triggering NP1-attachment. This could reflect an endogenous limit on segment duration—such as the period of delta-band oscillations. Accordingly, our design manipulated the duration of the main clause in seven levels ranging from ~2–4 seconds in order to parametrically increase the likelihood of clause termination, a CPS, and delta-band phase-locking. Preliminary results indicate that CPS amplitude increases with clause duration. Likewise, we show that the delta-band phase before the offset of the main clause correlates with clause duration. Critically, the phase of the delta band was related to the single trial CPS amplitude. In conclusion, we tentatively suggest that the CPS may reflect the time-domain equivalent of phase-locked oscillatory cycles at delta-band frequency.

Topic Areas: Speech Perception,

## Behavioral and neural mechanisms for accommodating different forms of non-canonical speech

***Poster E86*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Whether due to novel words or unfamiliar accents, speech can diverge from listeners' existing knowledge in many ways. A range of adaptive mechanisms enable accommodation of non-canonical speech. For instance, new lexical information is made meaningful via word learning, and non-canonical phonetic input—like accents—becomes comprehensible through perceptual learning (Norris et al., 2003). Neural representations of non-canonical speech also change as listeners adapt; pseudowords become more word-like with time (Bakker-Marshall et al., 2018), and responses to acoustically ambiguous segments resemble unambiguous phonemes as phonetic boundaries shift (Luthra et al., 2020). Studies of non-canonical speech often focus on just one adaptation mechanism. We propose to investigate behavioral and neural responses to multiple forms of non-canonical speech presented concurrently. Re-analysis of existing MEG data will provide insight into how neural responses to semantic violations differ depending on whether speech contradicts immediate context and/or longer-term lexico-semantic knowledge. Listeners (n=18) completed various tasks while hearing either isolated or word-primed items from word-word-pseudoword triplets ending in /t/, /p/, and /k/ (e.g., lake, late, lape). Comparing unexpected words (swan-late) with pseudowords (swan-lape), relative to expected words (swan-lake), will tell us about the impact of longer-term lexico-semantic knowledge violations when listeners have also generated semantic predictions based on immediate context. We will also compare responses to isolated (lape) and word-primed pseudowords (swan-lape), relative to differences between isolated (late) and word-primed words (swan-late). This will inform our understanding of how existing lexicalized knowledge affects the impact of semantic predictions on neural activity. Multivariate decoding will assess how syllable final segment identification is modulated by short-term semantic context versus longer-term lexico-semantic knowledge. We also present a planned MEG study exploring the consequences of semantic and phonetic prediction violations on two adaptive processes—namely perceptual learning and word learning. Participants will read pairs of sentence stems predicting the same final word ("The students couldn't keep still during…"), followed by spoken presentation of either the predicted word or a pseudoword ("class"/"paboose"). Critically, half the speech stimuli are pronounced canonically ("class"/"paboose"), while the other half are pronounced in an artificial accent encouraging perceptual learning ("claff"/"paboof"). Listeners may thus engage in word learning, perceptual learning, or both on a given trial depending on whether a violation is interpreted as semantic (pseudoword) and/or phonetic (accented). Pilot behavioral data (n = 34) suggests that listeners uniquely correct for trained accents but not unfamiliar ones in word report, while also performing above chance on pseudoword memory. Listeners can thus flexibly engage in both perceptual and word learning within a single set of trials to extract the most probable explanation for why speech differed from expectations. We will compare neural responses to early and late presentations of pseudowords to assess word learning effects, and also contrast presentations in trained and untrained accents to evaluate whether encoding is episodic. Multivariate decoding of final segment will gauge the relative impacts of accent training and lexicality on neural representations for non-canonical phonemes. The above studies will thus untangle how listeners simultaneously navigate multiple types of speech prediction violations.

Topic Areas: Speech Perception,

## A detailed functional characterization of cerebellar language-responsive brain areas

***Poster E87*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Complementing early research on the cerebellum's contributions to motor control, evidence has been accumulating for a role of the cerebellum in human cognition, including language (Stoodley & Schmahmann 2009; 2010; Mariën et al., 2014; Guell et al., 2018). Moreover, recent 'deep neuroscience' approaches where large amounts of naturalistic-cognition data are collected from each individual have uncovered a complex mosaic whereby many distinct areas tile the cerebellum, each exhibiting a distinct pattern of functional correlations with cortical networks (Habas et al., 2009; Buckner et al., 2011). Here, we first leveraged a large dataset of individuals (n=806 participants) performing an extensively validated language 'localizer' task—based on a contrast between reading or listening to sentences vs. a perceptually similar but meaningless control condition (nonwords or speech in a foreign language) (Fedorenko et al., 2010)— to search for language-responsive areas within the cerebellum. Three such areas were discovered in the right cerebellum (localized to lobule VI/Crus I, Crus I/Crus II, and lobule VIII), all showing strong and highly replicable responses during language processing. Next, using data from n=82 diverse fMRI experiments (343 experimental conditions encompassing an array of perceptual, motor, cognitive, and social tasks) conducted on subsets of these 800+ individuals, we richly characterize the functional profiles of these right-cerebellar language-responsive areas, and their left-cerebellar homotopic areas, for completeness. These experiments include both non-linguistic tasks (n=114 conditions) and linguistic manipulations (n=223 conditions), allowing us to probe both selectivity for language and sensitivity to particular aspects of language. We find that all three areas show strong responses to language—across both auditory and visual modalities—relative to diverse perceptual, motor, and cognitive non-linguistic tasks, ruling out numerous hypotheses about the nature of these areas' contributions to language. Further, all three areas show robust sensitivity to linguistic combinatorial processing, exhibiting stronger responses during sentence processing compared to the processing of word lists, mirroring the functional profile of the cortical language areas. In tandem, these results suggest that the right cerebellum contains three areas that functionally resemble the fronto-temporal cortical language network in both selectivity for language and sensitivity to combinatorial linguistic processing. These cerebellar language components work in concert with the cortical language network to support our linguistic ability.

Topic Areas: Speech Perception,

## Time-course of neural computations supporting perception and misperception of degraded speech

***Poster E88*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Humans utilize prior expectations to comprehend speech, but overreliance on these expectations can induce perceptual illusions if they mismatch with incoming sensory information. These misperceptions are especially likely in noisy acoustic environments or when there is partial overlap between expectations and sensory signals, which explains why misheard song lyrics are so common. Perceptual misperceptions may be explained by different theories: sharpening schemes in which neural representations matching prior knowledge are enhanced, and prediction error theories in which neural representations encode the difference between prior knowledge and sensory signals (Aitchison & Lengyel 2017). A previous fMRI study supported representations of prediction errors during perception of degraded speech (Blank et al. 2018). Our study aims to extend these findings using MEG/EEG to understand the time course of these computations during speech perception. Presentations of written words were used to manipulate prior knowledge while behavioural and neural (MEG/EEG) responses to noise-vocoded spoken words were recorded from 29 normal hearing listeners. The stimuli consisted of 32 monosyllabic words combined into four conditions: match (written “kip”, spoken “kip”), total mismatch (written “kip”, spoken “bath”), onset partial mismatch (written “kip”, spoken “pip”) and offset partial mismatch (written “kip”, spoken “kick”). Each trial started with the presentation of the written word for 500 ms, followed by a noise-vocoded spoken word. Participants indicated after each trial weather they perceived the written and spoken words as the same or different, as well as their confidence in their judgement (i.e., “definitely same”, "possibly same", "possibly different", "definitely different"). For the analyses presented below, responses were pooled over confidence levels within “same” and “different” judgements. As expected, participants correctly perceived word pairs in the match condition as “same” (P(same) = 0.909) and pairs in the total mismatch condition as “different” (P(same) = 0.005). However, perception in partial mismatch trials was more variable, with participants displaying frequent misperceptions (P(same) = 0.468 and 0.254 for onset and offset mismatch, respectively). Furthermore, the rate of misperceptions of particular partial mismatch word pairs (e.g., kit-pit) were better predicted by other word pairs sharing the deviating sounds (i.e., kip-pip, kitsch-pitch, kick-pick) than pairs sharing the matching sounds (i.e., pit-kit, wit-writ and writ-wit), pointing towards a prediction error mechanism (Blank et al. 2018). Preliminary MEG/EEG analyses in sensor space replicated previous findings that matching compared to totally mismatching text is associated with a reduction of evoked responses for magnetometers and gradiometers and an enhancement for EEG sensors (Sohoglu et al. 2012). Further univariate analyses in source space and multivariate representational similarity analyses are ongoing with the latter enabling specific conclusions concerning the timing, oscillatory correlates and perceptual contribution of sharpening and prediction error computations.

Topic Areas: Speech Perception,

## When Age Tips The Balance: a Dual Mechanism Affecting Hemispheric Specialization for Language

***Poster E89*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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As people age, there is a decline in the specificity, selectivity, and lateralization of functional brain responses. Language-related neural networks are predominantly left-lateralized in healthy adults, and there have been reports of significant changes in these networks with age. However, the evolution of hemispheric specialization for language with aging, the underlying mechanisms, and their effects on cognition remain to be further clarified. Cognitive and MRI data from 759 healthy adults (18 to 88yo) were included. We preprocessed T1w and resting state data using fMRIprep. We extracted the normalized volume (vol_norm) and the main functional gradient values (G1), revealing the ability of brain regions to process high-order information, for each ROI defined in the Language-and-Memory network [LMN; 10 Language Cores (LCORE); 27 Language-verbal Memory (LM)]. We modeled the asymmetry of G1 across ages by applying the Generalized Additive Mixed Models method. ROIs with a significant FDR-corrected hemisphere*age interaction were selected and then classified (k-medoids) according to their asymmetry profile (left minus right hemisphere). We assessed the relationship between brain variables and cognitive language performance using partial Canonical Correlation Analyses (CCA). Brain variables were first reduced using a Principal Component Analysis (PC). We identified correlations between CCA modes and tested their significance. 25/37 LMN regions showed an asymmetry change in G1 with aging ($p<0.02$, FDR corrected). Changes occurred gradually, according to a dual mechanism described by two main clusters, with a switch at 53 years old. The first cluster (C1) included 14 regions whose gradient asymmetry evolved from a left-sided specialization to a tendency towards bilateralization. Left hemisphere G1 capacity remained stable across ages, but right hemisphere heteromodality increased sharply. In the second cluster (C2), G1 asymmetry evolved from bilateral towards a left hemisphere dominance with age through increased left hemisphere heteromodal specialization, while the right hemisphere remains stable. 86% of the LCORE regions that showed G1 disruption with age followed the C1 pattern. LM regions, on the other hand, showed both types of patterns (45% C1; 55% C2). Regarding behavior, language production was more strongly impacted by age than comprehension and decreased around the switching point of G1. Multimodal CCA revealed that the dual mechanism of asymmetry changes was significantly related to language production ($r=.28$, $p<.001$ for C1 and C2). Good language performance was characterized by: for C1, a leftward asymmetry of the volume of the dorsal pathway (PC1) and the

heteromodality of the ventral pathway (PC2); and for C2, both heteromodal (LM regions; PC2) and volumic (lateral regions; PC1) bilateralization. As the opposite scheme was observed with advancing age, the closer older adults maintained a brain pattern to that of younger adults, the better their language production. Functional asymmetry in integrating high-level information helps optimize the functioning of neural processes involved in language. Changes in asymmetries are related to the difficulties in language production often reported in typical aging. Our results support and expand on previous research on interhemispheric reorganization, providing a comprehensive, multimodal, and dynamic view of brain plasticity during healthy aging.

Topic Areas: Language Development/Acquisition, Computational Approaches

## Thalamic changes in gray- and white-matter over the lifespan related to language development

***Poster E90*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Language development is a complex phenomenon shaped by a confluence of neurobiological, cognitive, and environmental factors (Pulvermüller & Schumann, 1994; Romeo, 2019). Language undergoes dynamic changes across an individual's lifespan, leading to the organization and specialization of its constituent systems within the brain. For instance, language acquisition initially involves bilateral engagement before transitioning to a state of left-hemisphere dominance (Olulade et al., 2020). A wealth of research findings have consistently highlighted the preferential involvement of left-hemispheric regions in language processing, but emerging evidence suggests that thalamic asymmetry may also contribute to language functions and lateralization (Hebb & Ojemann, 2013). Understanding age-related changes in thalamic organization is crucial as modern accounts emphasize the role of the thalamus in modulating information flow in higher-order cognitive processes, including language (Klostermann et al., 2013). However, investigations into the volumetric changes of thalamic nuclei and the development of thalamocortical bundles across the lifespan are limited. Here, we sought to characterize changes in both thalamic nuclei volume and thalamocortical white-matter tracts over the lifespan. Our cohort consists of 348 healthy right-handed individuals spanning from middle childhood to senescence (age range: 6.4 to 81.6, mean age: 39.21 ± 23.9 years; 194 females, 154 males). T1-weighted (T1w) images were processed with the Freesurfer software package, and thalamic segmentation was refined by the first probabilistic atlas of the human thalamic nuclei combining ex vivo MRI and histology (Iglesias et al., 2018). Diffusion-weighted images (DWI) were denoised, corrected for anatomical distortions, and registered to T1w images, using the preprocessing pipeline provided in the Reproducible Tract Profiles 2 (RTP2) (Lerma-Usabiaga et al., 2023). Finally, white-matter thalamocortical tracts were reconstructed and measured using the RTP2-pipeline for both first-order and higher-order human thalamic nuclei (Liu et al., 2022), ensuring neuroanatomical reproducibility and data provenance. Our findings demonstrate that almost all thalamic nuclei exhibited a shrinking trajectory over the lifespan. Remarkably, the trajectories of asymmetry indices reflected a rightward volumetric lateralization that persists over the lifetime, with the right thalamus following different shrinking developmental profiles with respect to the left thalamus. Notably, higher-order nuclei tend to exhibit an increasing rightward asymmetry from childhood to adulthood which reverts in the posterior years, while first-order nuclei show subtle or no interhemispheric differences across the lifespan, possibly influenced by the strong bilateral dependency of sensory and motor functions. These results, combined with micro and macro-structural measures of thalamocortical white-matter projections (Mean Diffusivity, Fractional Anisotropy, Apparent Fiber Density, and DICE), suggest a heightened level of remodeling within the left thalamus. This phenomenon is likely attributed to the influence of cognitive functions that are strongly left-lateralized and remain relatively intact in healthy aging, such as language. For the first time, our work provides a comprehensive view of structural developmental patterns of the human thalamic nuclei and thalamocortical tracts and discusses their developmental trajectories in relation to language.

Topic Areas: Language Development/Acquisition, Computational Approaches

## Neural Prediction of Early Language Development is Language Independent: Evidence from Neural Speech Encoding

***Poster E91*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Early development of neural speech encoding, as reflected by the early-latency EEG responses (e.g., the frequency following responses [FFR]), has been found to be independent of the nativeness of the speech signal (Novitskiy et al., 2022). This differs from long-latency cortical responses which are sensitive to the infant's native language experiences starting from mid-infancy (Kuhl, 2010). These findings support a model that postulates a two-stage developmental process of speech, with the two stages corresponding to early- and long-latency neural responses. While infants' subcortical structures contribute to the faithful neural encoding of the incoming speech signal regardless of its native status, cortical structures are developed to attend to native speech. The current study seeks to obtain converging evidence for this model by examining whether neural speech encoding predicts early language development regardless of whether the speech stimuli are native or non-native to the child's immediate language environment. To test this hypothesis, we recruited 300 medically healthy infants (157 males) from Cantonese-speaking families and evaluated their speech encoding of Cantonese tones 2 and 4 (native) and Mandarin tone 3 (non-native) using EEG. We quantified neuronal phase-locking to the speech stimulus frequencies by extracting FFRs from the EEG. As the fundamental frequencies of all tones were above 120 Hz, the neural generator of the FFRs was likely (though not exclusively) below the cortex (Bidelman, 2018). Each infant underwent an EEG procedure while naturally sleeping (0.75–24 months, M=5.67 SD=4.41). The MacArthur-Bates Communicative Development Inventories (MCDI)-Cantonese version was used to evaluate language and communication outcomes up to 26 months (0–26.86 months, M=12.06, SD=6.88) after EEG testing. Random Forest with out-of-bag validation was used to construct a binary prediction model whereas children were classified as below or above 1 SD (~16th percentile) of the mean on the MCDI (n=300). Neural predictive models were constructed separately for Cantonese (native) and Mandarin (non-native) stimuli. An external validation procedure was also implemented by dividing the sample into separate sub-samples (n=204, 102 children acted as the unseen data). FFR

encoding accurately predicted future language outcomes. The out-of-bag validation and validation with unseen data had sensitivity values of at least 0.8. Other model performance indexes such as diagnostic accuracy and area under the curve are similarly high. The sensitivity of the neural predictive models constructed using the native stimuli of tone 2 and tone 4 were .83±0.018 and .86±0.018 respectively, and .84±0.015 for the non-native Mandarin tone 3. The predictive performance of these models did not significantly differ from each other. (tone 2/4 vs tone 3, all p values of performance indexes were > 0.05). These results support our hypothesis that FFR encoding of speech predicts early language development independent of the languages that these infants learned and perceived. Our findings speak to a potentially auditory-general rather than a language-dependent speech encoding process of early spoken language development. Future research will examine the contribution of cortical processes in the neural prediction of language development as well as whether these findings can generalize to non-tone-learning infants.

Topic Areas: Language Development/Acquisition, Computational Approaches

## Neural speech encoding predicts language outcome in preterm infants: a comparative study of synchronicity and gross-power measures

***Poster E92*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Nikolay Novitskiy[1], Shaoqi Pan[1], Ching Man Lai[1], Peggy Hiu Ying Chan[1], Patrick Wong[1]; [1]Brain and Mind Institute, The Chinese University of Hong Kong

Infants born preterm are more likely to have language developmental problems detected from preschool years (Zimmerman 2018). Infants born preterm are also more likely to show neuroanatomical deficits, particularly those associated with white matter processes (Dibble et al. 2021). A recent study has also found neural functional differences between term and preterm infants (Novitskiy et al. 2023). Using EEG to measure neural encoding of speech, term and preterm infants were found to differ mainly on synchronicity measures of the frequency-following response (FFR), as opposed to gross-power measures. These two types of measures are hypothesized to reflect white and grey matter processes, respectively. In the present study, we ask whether neural encoding of speech measured in infancy can forecast language development in preterm infants as observed in term-born infants (Wong et al. 2021). We further investigate whether synchronicity measures are more predictive of future language development than gross-power measures in preterm infants, due to a higher likelihood of synchronicity measures being disrupted by prematurity. Fifty-five preterm children born before 37 weeks of gestation (32.52±3.57 weeks) participated in the study. Their EEG was recorded during natural sleep at corrected age 6.97±4.02 months while they were passively listening to a sequence of three different Chinese tone syllables via the headphones. The children's parents provided MacArthur-Bates Communicative Development Inventories (MCDI)-Cantonese version scores on average 7.69 months after the EEG recording, that is at the corrected age of 13.24±3.96 months. Three cross-validated support-vector machine (SVM) binary classification models were constructed: (1) with six FFR synchronicity features, including Pitch Strength, Response Consistency, FFR Signal-to-Noise Ratio (SNR), maximal inter-trial phase coherence (ITPC) and ITPC in mid- and low-frequency ranges, (2) with five FFR gross-power measures including Noise Root-Mean Square (RMS), Power in mid- and low-frequency ranges as well as the ratio of the Power in low- and mid-frequency ranges to the Power in the high-frequency range and (3) with all 11 measures included. The target class for binary classification were the children with vocabulary comprehension score in the lower 16th percentile of the population norm. Statistical significance was assessed with permutation and bootstrapping. Model 1 (with synchronicity features only) showed 0.799±0.060 in accuracy, 0.784±0.094 in sensitivity, 0.801±0.091 in specificity and 0.871±0.064 in area under the receiver-operator curve (AUC). Model 2 (gross-power features only) showed 0.768±0.067 in accuracy, 0.775±0.103 in sensitivity, 0.744±0.107 in specificity and 0.826±0.074 in AUC. Model 3 (all features) yielded 0.773±0.0628 in accuracy, 0.767±0.0994 in sensitivity, 0.762±0.102 in specificity, and 0.89±0.05 in AUC. All three models performed significantly better than chance in a permutation test ($p<0.05$). Bootstrapping test demonstrated no significant differences for any combination between synchronicity, gross-power and combined-measures models. Neural encoding of speech measured during infancy can predict language outcome in preterm infants. Despite our earlier findings that only synchronicity but not gross-power measures differ between term and preterm infants, both synchronicity and gross-power measures are equally predictive of preterm infants' language outcome. References: Dibble et al.2021, J.Pediatr.232:48-58.e3.; Novitskiy et al.2023, Dev.Cogn.Neurosci. in press.; Wong et al.2021, Am.J.Speech-Language.Pathol.30(5):2241–50.; Zimmerman 2018, J.Speech.Lang.Hear.Res.61(1):53–65.

Topic Areas: Language Development/Acquisition, Computational Approaches

## Preoperative Neural Networks Predict Children's Speech and Language Improvement 24 Months After Cochlear Implantation

***Poster E93*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A previous study found that the preoperative neural features of 37 pediatric cochlear implant (CI) users predicted the variability of their speech perception development six months after surgery. Additionally, the neuroanatomical network unaffected by auditory deficit produced more precise predictions than the affected network. Given the experience-dependent plasticity of the human brain, the neuroanatomical network supporting speech and language development in children with CI may dynamically change across different linguistic developmental stages. It is hypothesized that children using CI for six months undergo an acclimatization process, involving higher-level brain regions (unaffected network) that invoke global attention to speech. Consequently, after this acclimatization period, children's speech and language abilities may extend from the auditory to the phonological stage, where the affected network also contributes to predicting long-term post-CI outcomes. This study aims to address this issue by utilizing preoperative neuroanatomical features to predict speech and language development in children using CI for 24 months. The study included forty-two children with sensorineural hearing loss who were CI candidates. The multivoxel pattern similarity of gray matter (GM) density was calculated in children with sensorineural hearing loss, in comparison with age-matched typical-hearing children. The GM similarity was used to predict speech and language improvement from pre-CI to 24 months post-CI. Separate machine-learning models were constructed for the whole-brain, affected, and unaffected brain networks. The nested k-fold cross-validation procedure and support vector classification (SVC) were employed. The classification accuracy, sensitivity, and specificity were calculated using a bootstrapping and permutation test. The results showed that speech and language improvement could be predicted by the whole brain GM similarity (accuracy: 69%; sensitivity: 68%; specificity: 67%). The unaffected network exhibited significantly higher accuracy than the affected network for 24-month improvement after surgery (affected: accuracy = 67%; unaffected: accuracy = 69%; $p < 0.001$). Furthermore, the accuracy of the model using non-neural features (household income, gender, prematurity) to predict postoperative improvement is 56%. Our results demonstrated that an extensive network including areas affected and unaffected by hearing loss contributes to the long-term speech and language development in pediatric CI users, despite slight but significant advantage of unaffected areas. This study suggests that there is a dynamic speech and language development supported by different preoperative brain networks in children with CI. Further studies are needed to delve into the relationship between neuroanatomical networks and the various linguistic components in children with CI.

Topic Areas: Language Development/Acquisition, Computational Approaches

## Neural Mechanisms Linking Rapid Automatized Naming (RAN) with Reading and Arithmetic in Typically Developing Children: Insights from Intrinsic Functional Connectivity of Thalamus

***Poster E94*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Background. Rapid automatized naming (RAN) refers to the rate of access to phonological information stored in long-term memory. While it is well established that RAN is a common factor influencing both reading and arithmetic skills in children, the neural mechanisms underlying RAN and its associations with academic abilities are not fully understood. Recent studies suggest that intrinsic functional connectivity (iFC) may play a role as either a mediating factor, or provide joint support for the RAN-reading/arithmetic association. In this study, we aimed to investigate two potential mediation models: (1) iFC –> RAN –> reading/arithmetic, which suggests that iFC serves as a foundation for cognitive performance, or (2) RAN –> iFC –> reading/arithmetic, highlighting the role of RAN development in brain plasticity and the neural mediating effects. Methods. A total of 34 typically developing children (mean age = 11.82, SD = 1.13, 23 boys) took part in the study. They underwent resting-state MRI scanning, along with behavioral assessments measuring RAN, reading fluency, and arithmetic abilities. Firstly, the correlations between RAN, reading fluency, and arithmetic were calculated after controlling for age and sex. Secondly, to conduct fMRI analysis, we constructed individual functional connectivity maps using Power et al.'s (2011) template. The edges showing stably positive or negative correlations with RAN were selected and averaged at the network level. Finally, the within or between network connectivity was used to test two possible mediation models in reading and arithmetic respectively. Results. After adjusting for age and sex, we observed significant positive correlations between RAN and reading ($r = 0.63$, $p = 0.003$), as well as between RAN and arithmetic ($r = 0.56$, $p = 0.011$) at the behavioral level. Network analysis revealed that 21 connections were positively correlated with RAN ($r = 0.69$ and R2 = 0.48), and most of the connections (85.7%, n = 18) included the thalamus. Among these connections, 38.1% (n = 8) were associated with the visual network. In the first mediation model (between/within network connectivity -> RAN

-> reading/arithmetic), we identified two network connections that were shared by both reading and arithmetic: the connection between visual regions and the thalamus, and the connectivity within the thalamus. Surprisingly, two connections were specifically related to the RAN-reading relationship: the connection between the dorsal attention network and the thalamus, and the connection between the sensory somatomotor network and the thalamus. In the reverse model (RAN -> between/within network connectivity -> reading/arithmetic), none of the connections reached significance. The additional results supported our expectation that the contribution was not dominated by only one edge. Summary. Our study provides compelling evidence that RAN is a common predictor of both reading and arithmetic abilities at the neural level, underscoring the significance of RAN to reading and arithmetic and the role of thalamus-cortical connection in the association between RAN and academic performances. While the relationship between reading and arithmetic involves multiple levels such as intelligence and executive function, our findings have revealed a fundamental shared factor between the two domains, even during the resting state.

Topic Areas: Language Development/Acquisition, Reading

## Longitudinal analysis of letter and speech sound association

***Poster E95*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The first and critical step for reading development is learning letter-speech sound (LS) association. LS integration was extensively studied in adults and children using cross-sectional designs, with a consensus that the left superior temporal cortex is the integration site (Blau et al. 2009). Relatively little is known about the development of LS integration in children on both behavioral and neuronal levels, which constitutes my research's goal. On a behavioral level, Polish children from kindergarten to 8th grade participated in an experiment with a computer-based letter and speech sound discrimination task in which they had to judge whether letters match phonemes. Results showed that children learned accurate LS association within one year of reading instruction. Still, they needed more time (around three years) to automate this ability, as reflected by decreasing reaction times. On the neuronal level, using a simple fMRI task (four experimental conditions: letters, speech sounds, congruent, and incongruent LS pairs), we measured LS integration on two levels: lower, more fundamental sensory aspects were examined by looking at the super-additive effect, and higher, orthographic and phonological aspects by the congruency effect. In the longitudinal fMRI study (N = 67), we found significant changes in the pattern of brain activation during the first two years of formal education. While the brain activity in sensory areas decreased in response to unimodally presented speech sounds and letters, it increased when children processed multimodal LS pairs. Namely, sub-additive effects reverse into super-additive effects in superior temporal areas. We did not observe changes in time for the congruency effect. Thirty children returned for an additional scan in the 8th grade of primary school (third-time point). I will present the pattern of brain activation in children who have already automatized LS integration and higher levels of LS integration. We did not observe the time effect in the congruence effect. We speculate if the results are more connected to the developmental step or that our paradigm can not track differences in such small units as letters in children in transparent orthographies, such as Polish.

Topic Areas: Language Development/Acquisition, Reading

# Fetal development of an articulatory motor pattern for native language production

***Poster E96*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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By 20 weeks gestational age, fetuses perceive the auditory environment outside the womb, a capability that substantially increases in sophistication during the third trimester of pregnancy. Numerous studies have demonstrated that the prenatal linguistic environment influences postnatal language comprehension, such as the discrimination of speech in the mother tongue from that in a foreign language or variations in pitch. Recent findings reveal that infants a few days after birth produce accented cries. Specifically, cries in native French and German newborns are marked by a distinct pitch contour that reflects the typically pitch accent of the environmental language. This suggests that articulatory patterns influenced by the auditory environment start to develop in utero, well before the production of any vocalisations. We hypothesize that in utero auditory experience contributes to the tuning of future articulatory-motor patterns, that may even support early articulatory skills. Fetal magnetic resonance imaging (MRI) is a second line clinical tool for prenatal diagnostics after prenatal ultrasonography, and has become widely accepted as a safe tool for in utero assessment of brain development. More recent works have demonstrated the viability of fetal MRI for detecting brain activation for auditory stimuli as well as revealed how brain networks develop, offering a more direct assessment of prenatal language processing. The main objective of our study is therefore to directly map the fetal response to speech stimuli and characterize the auditory and sensorimotor coupling. Up to 25 expectant mothers carrying healthy singleton pregnancies will be recruited to participate in a study to examine fetal brain responses to auditory stimuli. Each mother's voice will be recorded articulating trisyllabic nonsense words which will undergo manipulation to produce falling, rising and flat pitch contours, and will be transposed in pitch to have a fundamental frequency resembling a male voice. A set of non-speech control stimuli (harmonic complexes with the fundamental frequency and pitch contours of the speech stimuli) and null events will be presented in a pseudo random order using a rapid event-related design (three five-minute blocks). Audio stimuli are presented transabdominally to the fetus via MR-compatible headphones. Fetal cerebral response will be recorded using EPI imaging at 3T. Fetal brain responses will be tested for differential responses to speech vs non-speech, maternal vs non-maternal speech and to different pitch contour. Further, functional connectivity of key areas in both hemispheres for expressive (inferior frontal) and receptive (superior temporal) language processing will be tested for differential connectivity during stimulus processing. Graph network analysis will allow to further interpret properties of network architecture related to fetal language processing. This study is a first step in refining our understanding of the developmental trajectory of cerebral language networks and to precise the role of auditory and sensorimotor interactions for the establishment of native accents and later language acquisition. We are currently piloting in adult participants to validate our task and optimize imaging parameters. The recruitment of pregnant women starts this summer, and we aim to have preliminary fetal data by fall 2023.

Topic Areas: Language Development/Acquisition, Speech Motor Control

## The role of prosodic and statistical cues for speech segmentation during the first year of life

***Poster E98*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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One of the earliest problems infants face in language learning is breaking the continuous speech input into words, which is a necessary step in language acquisition. Statistical and prosodic cues are crucial information in the speech signal that contributes to solving this speech segmentation problem. Understanding how prosodic processing may constrain and interact with statistical learning during early infancy for the development of speech segmentation remains unclear. Importantly, previous electrophysiological studies in adults suggest that brain oscillations are sensitive to different hierarchical complexity levels of the input, making them a plausible neural substrate for speech parsing. Specifically, successful speech segmentation might be associated with a peak at both syllable and word frequencies during exposure to statistically structured streams. In this poster, we show the results of a longitudinal study in which electrophysiological data were collected in the same infants at birth, at 6, and at 10 months during statistical learning of flat contour and melodically enriched speech streams. Frequency-tagging analyses were performed on the EEG data and show (i) enhanced brain responses to melodically enriched compared to flat speech streams across the three ages and (ii) increased word frequency power through development. These results illustrate the developmental brain dynamics associated with the gradual weighting of prosodic and statistical cues for speech segmentation during the first year of life.

Topic Areas: Language Development/Acquisition, Speech Perception

## Development of cortical and subcortical responses to speech sounds during infancy

***Poster E99*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The two first years of human life constitute a critical period for the emergence of robust speech encoding.

Event-related brain potentials as well as the Frequency Following Response can be used to decipher how speech sounds are encoded along the auditory pathway at the cortical and subcortical levels. Previous electrophysiological studies have shown that experience can trigger neural plasticity within these two structures resulting in increased quality of speech sound encoding. However, the sensitivity to plastic experience-dependant mechanisms of each structure during early infancy remain largely unknown. Here, we gathered simultaneous cortical and subcortical brain responses to synthetic speech sounds in 6- to 24 months-old infants. We developed an innovative experimental paradigm that allowed to analyze both ERPs and FFRs in young infants and thus offering a new tool to obtain comprehensive developmental auditory profiles. Our results show how cortical and subcortical responses to speech sounds interact during early human development. We expect these findings to session pave the way for an integrative view of early developmental plasticity mechanisms taking place along the human auditory pathway and accounting for the gradual emergence of native speech sound encoding abilities.

Topic Areas: Language Development/Acquisition, Speech Perception

## Do visual speech cues facilitate infants' neural tracking of speech?

***Poster E100*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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In face-to-face interactions with their caregivers, infants receive multimodal language input from both the auditory speech signal as well as the visual speech signal on the speaker's face. Previous research has shown that visual speech cues (i.e., the rhythmic movements of the lips, mouth and jaw) can modify speech perception in adults and infants (Crosse et al., 2015; Tan et al., 2022; Teinonen et al., 2008). Infants between 6-12 months may be especially sensitive to these cues as they attend more to the mouth of a talking face than the eyes (Lewkowicz & Hansen-Tift, 2012). One mechanism argued to play a key role in speech processing in both adult and infant listeners is neural tracking of speech. This refers to the phase-locking of cortical oscillations to the amplitude envelope of the speech signal at multiple frequencies, such as the rate of stressed, syllable or phrasal units. Importantly, visual speech cues can provide additional information about the amplitude envelope of the speech signal, given the close temporal correspondence between the opening and closing of the lips and the acoustic envelope, specifically at the syllable frequency range (Chandrasekaran et al., 2009). Thus, exposure to the visual and auditory input simultaneously during speech perception may aid speech processing by enhancing neural tracking of speech, particularly at the syllable rate (Peelle & Sommers, 2015). The current study investigated whether visual speech cues facilitate infants' speech processing, indexed by their neural tracking of speech. 32-channel EEG data was recorded from 10-month-old Dutch-learning infants while they watched videos of a native Dutch speaker reciting passages in infant-directed speech. Half of the videos displayed the speaker's full face (Audiovisual [AV] condition), while in the other half, the speaker's mouth and jaw were masked with a static block, obstructing the visual speech cues (AV-Block condition). We analysed infants' neural speech tracking, measured by speech-brain coherence at the stress and syllable rates (1-1.75 and 2.5-3.5 Hz respectively in our stimuli). To investigate whether infants show neural tracking of speech, cluster-based permutation analyses were performed at the stress and syllable rates by comparing real speech-brain coherence to shuffled data, created by randomly pairing the speech envelope with the EEG data. Then, differences in infants' speech-brain coherence in the AV and Block conditions were tested with cluster-based permutation at the frequencies of interest. Our results (N = 32) indicate that infants show neural tracking at both the stress and syllable rates at all electrode sites (cluster p's = .002). However, we identified no significant differences in speech-brain coherence between the fully audio-visual vs. block conditions, meaning that infants likely tracked the speech envelope equally well when visual speech cues were present or masked (p's > .05). These results have important implications for our understanding of both speech processing and language development, as they suggest that neural speech tracking is a robust phenomenon already present in infancy and that infants' speech processing is not necessarily impaired when visual speech cues are occluded, such as when listening to a speaker wearing a facemask.

Topic Areas: Language Development/Acquisition, Speech Perception

## THETA AND BETA OSCILLATIONS REVEAL LANGUAGE SPECIFIC INFLUENCES IN INFANTS' STRESS CUE-WEIGHTING

***Poster E101*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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From segmenting words to tracking hierarchical structures in natural speech, sensitivity to rhythmic patterns in speech facilitates language acquisition (see Barajas et al., 2021 for a review). While rhythm perception is modulated by listeners' prior linguistic knowledge, the extent to which it is modulated by acoustic or phonological processes, as well as the neural underpinnings of this developmental process, is not well understood. Most studies on this topic investigated the Event-related potentials (ERPs), in particular mis-math negativity (MMN), yielding mixed findings and interpretations on the polarity and strength of the responses (Friedrich et al., 2007; Kidd et al., 2018; Kooijman et al., 2009; Ragó et al., 2021; Weber et al., 2004; Werwach et al., 2022). The limited number of studies on the neural oscillations in infants suggest that power at different frequency bands can provide indication of neural phonological sensitivity. Theta oscillations have been reported as an index for perceptual narrowing of non-native phonetic segments (Bosseler et al., 2014). Moreover, oscillatory power becomes more prominent at higher bands with development (Barajas et al., 2021). Beta synchronisation is relevant to auditory prediction in an oddball paradigm (Chang et al., 2008). Using a multi-feature mismatch negativity paradigm, the current study investigated the event-related time-frequency responses of the weighting of pitch, intensity and duration cues signalling stress, in speech and (acoustically matched) non-speech (see stimuli and paradigm in Zeng et al., 2022) in English and Mandarin infants at 7-8 and 10-11 months (15-17 per subgroup, between-group design). The two developmental stages were set to explore potential perceptual narrowing of lexical stress cues (Skorupa et al 2009; 2013). Infants' time-frequency responses at theta and beta bands revealed striking cross-linguistic differences in the speech domain. English infants used all three cues at both ages, whereas Mandarin infants showed sensitivity to pitch and intensity only in the younger age and diminished sensitivity to all three stress cues when older. These results are in line with the perceptual narrowing process, providing strong evidence suggesting that the infant phonological system is heavily involved in the processing of acoustic changes in stress cues, even when these cues are not strictly categorical. When listening to the non-speech cues, both English and Mandarin infants showed increased sensitivity to cues with age. No obvious perceptual narrowing comparable to that in the speech domain was observed. Nonetheless, there was limited cross-linguistic difference, such that English infants and Mandarin infants showed sensitivity to differing cues at the younger age. English infants focused on intensity and duration at 7-8 months. Meanwhile, age-matched Mandarin infants tended to pitch and intensity. Moreover, English infants' sensitivity to pitch cues are shown at 10-11 months but not 7-8 months, so is Mandarin infants' sensitivity to duration cues, reflecting late sensitivity for these cues. These results suggest that attunement to differing cues may point to the level of familiarity with the cues employed in phonological processing, which may mildly modulate the acoustic processing in a neighbouring auditory domain.

Topic Areas: Language Development/Acquisition, Speech Perception

## Tracking the neural coding shift from low-level linguistic features to sensorimotor control signals.

***Poster E102*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Human linguistic intelligence allows us to appropriately follow verbal instructions we have never encountered before, an ability known as "zero-shot learning". At least three processing stages are required: the linguistic analysis of the instructions, the extraction of their meaning, and the sensorimotor implementation of the required behaviour. To investigate language's ability to scaffold sensorimotor representations to achieve zero-shot learning, we will leverage a recent artificial model put forward by Riveland and Pouget (2022). In this ongoing functional magnetic resonance study, we will aim at elucidating the nature of the underlying computations and representations by comparing those inferred from neural and behavioural human data to those observed in an artificial model trained to perform a similar task (Schrimpf et al., 2020). We will recruit young adults with no history of neurological or psychiatric disorders and scan them while they perform a judgement task: they will see two pictures and be asked to perform a simple choice based on verbal instructions. The instructions will reflect two conditions: judgement on the size or colour of the images. To study meaning-related changes in the representations while controlling for other linguistic factors, the sentences (12 in total; 6 per condition) will have similar meanings, but vary in terms of syntactic complexity (i.e., passive, negative, relative), such as "Choose the image with the most colours" versus "The image with the most colours must be chosen". Finally, to track the effect of the selective attentional focus the verbal instructions bring about, the pictures will belong to categories known to elicit activity in specific patches of the ventral visual path (cars, fruits/vegetables, animals) and the instructions will be displayed either at the start of the trial, or between the two pictures. The resulting acquisitions will be analysed using multivariate pattern analysis, both in regions of interest (ROIs) and through a searchlight approach. The following regions will be included in our ROIs: the primary visual cortex, a region known to be involved in lower-level visual processing

(Harrison & Tong, 2009); the anterior temporal lobe and the angular gyrus, regions associated with semantic processing (Farahibozorg et al., 2022); the supplementary motor area and the premotor cortex, known to be associated with behavioural implementation (Konoike et al., 2015). We will use representational similarity analysis to determine the level of similarity between the different trials and between the results observed in humans versus computational models (Kriegeskorte et al., 2008). Our results, describing the representational shift required to perform task-appropriate behaviours following minimal verbal instruction, will pave the way to the answer to a key question: what computational advantage do language representations offer?

Topic Areas: Control, Selection, and Executive Processes, Computational Approaches

## Neural correlates of linguistic and non-linguistic demand in the visual and auditory modalities

***Poster E103*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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A major challenge in interpreting functional imaging studies of language processing in clinical populations is the difficulty of matching processing effort across groups (e.g., individuals with aphasia compared to controls) and across tasks (e.g., linguistic versus non-linguistic) [1,2]. Processing effort strongly modulates neural activity in many brain regions, but how specific brain regions respond to different kinds of effort in different contexts remains poorly understood. To address this gap, we investigated the neural correlates of task difficulty as a function of task domain (linguistic, non-linguistic) and stimulus modality (visual, auditory) [3,4]. Thirty-nine neurologically normal individuals were scanned with fMRI (age 28–40 years; 34/5 female/male; all left-lateralized for language). Stimulus modality was a between-subjects variable: 20 participants performed tasks in the visual modality and 19 in the auditory modality. In a block design, participants performed easy and difficult linguistic tasks (deciding if two words were semantically related) and easy and difficult non-linguistic tasks: identifying matches between pairs of symbol strings (visual), or pairs of melodies (auditory). Behavioral data showed that our manipulations of difficulty yielded expected effects on accuracy and reaction time, which were generally well matched across domains and modalities. The functional imaging data were analyzed using standard methods. Whole brain analyses were subject to a cluster-defining threshold of $p<.005$ and corrected for multiple comparisons at $p<.05$ based on permutation analysis of cluster extent. We also carried out a parallel analysis using functionally defined regions of interest in individual participants [5]. We found that linguistic demand modulated left hemisphere language regions—the IFG and the STS—as well as the right IFG to a lesser extent, in both the visual and auditory modalities. Linguistic demand also modulated the “multiple demand” (MD) network, but surprisingly, only in the visual modality, not in the auditory modality. Non-linguistic demand did not modulate language regions in either modality. The regions modulated by non-linguistic demand were strikingly different in the two modalities investigated: in the visual modality, non-linguistic demand strongly modulated the MD network, while in the auditory modality, only the right anterior insula was modulated. Our findings have implications for the interpretation of clinical studies. The language network is modulated by linguistic demand irrespective of modality, implying that between-groups differences in language regions should be interpreted carefully, because they may reflect differences in linguistic demand.

In contrast, it appears that the MD network is not obligatorily recruited for effortful language processing, since its modulation was modality-dependent in our data, and other studies have suggested that this network is minimally involved in natural language processing [6,7]. Activation of the MD network apparently depends on task details that are not well understood, so differences between clinical groups within the MD network should be approached with caution [1,2]. References: [1] Geranmayeh et al. Brain 2014;137:2632–2648; [2] Wilson & Schneck. Neurobiol Lang 2021;2:22–82. [3] Quillen et al. Neurobiol Lang 2021;2:202–225. [4] Philips et al. Neurobiol Lang 2023; in press. [5] Fedorenko et al. J Neurophysiol 2010;104:1177–1194. [6] Wehbe et al. Cerebral Cortex 2021;31:4006–4023. [7] Shain et al. J Neurosci 2022;42:7412–7430.

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

## Robust dissociation between the language and Multiple Demand networks in aging and after a stroke

***Poster E104*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The human brain consists of functionally distinct large-scale networks (e.g., Yeo et al., 2011). A subset of these networks support high-level cognition and include the language network (Fedorenko et al., 2011) and the Multiple Demand (MD) network (Duncan, 2010). These two networks robustly dissociate in young adults (Fedorenko & Blank, 2020). However, some have argued that functional networks become less segregated with age (e.g., Chan et al., 2014) or after a brain injury (e.g., Siegel et al., 2016). We tested this hypothesis with respect to the language and MD networks for healthy older adults and adults with post-stroke aphasia, relative to young adults. 43 healthy older adults (age range:44-85), 24 adults with post-stroke aphasia (age range:18-81), and 568 young adults (age range:19-39) completed structural and functional MRI scans. The functional tasks included i) a language comprehension task (reading sentences vs. nonword lists), which reliably identifies the language-selective network (Fedorenko et al., 2010) and ii) a demanding non-linguistic task (a spatial working memory or an arithmetic addition task, including hard and easy conditions), which reliably identifies the Multiple Demand network (Fedorenko et al., 2013). Language and MD functional regions of interest (fROIs) were defined in each participant using a group-constrained subject-specific approach (Fedorenko et al., 2010). Within each parcel derived from probabilistic activation maps for the same contrasts in independent participants, a subject-specific fROI was defined as the 10% of voxels with the highest t-value for the relevant contrast. The magnitudes of response to the four conditions (Sentences, Nonwords, Hard, and Easy) were estimated in each fROI with a split-half approach to ensure independence of the data. The response magnitudes were examined using paired samples t-tests with FDR correction and compared among the three groups using linear mixed-effects models. The three groups exhibit some differences in the overall magnitude of response (patients show lower responses to language in the language network, and both older adults and patients show lower responses to MD tasks in the MD network). However, similar to previously reported findings in young adults (e.g., Mineroff et al., 2018) and replicated here, older adults and adults with aphasia show a robust dissociation between the language and the MD networks. In particular, the language fROIs show a language-selective profile with strong and reliable responses to the language task and little or no response to the MD tasks, whereas the MD fROIs show a strong and reliable response to the MD task (Hard>Easy), and most MD fROIs respond to the language task in the opposite way from the language network (nonword lists>sentences). The language-selective and the MD networks are robustly dissociated in their functional profiles not only in young adults, but also in older adults and adults with post-stroke aphasia. Identifying these networks in individual participants using extensively validated localizer tasks may be critical for uncovering these dissociations, as traditional group-averaging fMRI analyses do not take into account inter-individual variability in the precise locations of functional areas (and such variability may be even greater in aging or after brain damage).

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

## Look, listen, look & listen – all alike? Modality-modulated attentional impairments in patients with and without aphasia after left hemisphere stroke

***Poster E105*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Attentional impairments are a common consequence of brain lesions but neuropsychological research on attention usually focuses on patients with right hemisphere lesions and deficits in (visuo)spatial attention allocation. However, patients with left hemisphere lesions (and aphasia) also show difficulties in this cognitive domain and we previously reported that a high proportion of patients with chronic post-stroke aphasia had impaired performance in complex attention tasks involving auditory stimuli [1]. What remained unclear is to what extent this poor performance might be attributable to differences in task difficulty or other task characteristics that are confounded with sensory modality. The present study thus investigated left hemisphere stroke patients' auditory and visual attentional performance in a range of tasks carefully matched for task demands across modalities. To this end, experimental attentional tasks of increasing complexity were administered, assessing participants' alertness, selective attention, and divided attention. The tasks were available in auditory, visual and combined versions. Reaction times as well as error types (omissions, false alarms) were recorded. The sample consisted of forty stroke patients (around three quarters with aphasia) and an age-matched control group. Group-level analyses revealed significant main effects and interactions of all three factors (task, modality, group). Reaction times to auditory stimuli were generally faster than to visual stimuli but this difference was not found in patients for the more complex tasks, thus pointing to a disproportionate slowing of their reactions to auditory stimuli when task demands increased. More pronounced difficulties with the auditory stimuli were also apparent in the error patterns as omissions and false alarms occurred significantly more often in auditory tasks. Depending on the task and measure, up to forty percent of the patients performed outside normal range and this was most pronounced for the patients with aphasia. In fact, a notable minority of the patients with aphasia showed remarkable difficulties in correctly selecting the target sound among three perceptually very different sounds, indicating potential

impairments in lower-level auditory processing. Taken together, these investigations extend our previous findings in patients with post-stroke aphasia. The high number of patients with impairments in more complex attention tasks and, in particular, with auditory stimuli underscores not only the importance of assessing this cognitive domain in all stroke patients but also the necessity of further investigating auditory processing difficulties in this patient group. 1. Schumacher, R., Halai, A. D., & Lambon Ralph, M. A. (2022). Attention to attention in aphasia - elucidating impairment patterns, modality differences and neural correlates. Neuropsychologia, 177, 108413. doi:10.1016/j.neuropsychologia.2022.108413

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

## Cursing Feedback Control, Attentional Capture, and Physiological Arousal: A Combined Eye Tracking and Electrocardiography Study

***Poster E106*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: Cursing occurs across virtually all natural languages, yet our understanding of the neurobiology of cursing remains limited. Many neurological disorders are characterized by non-volitional or uncontrolled cursing, known as neurogenic cursing. Hughlings-Jackson (1878) distinguished between two types of neurogenic cursing. Non-propositional cursing includes interjections following sudden dismay or excitement (Shit!), while propositional cursing is embedded within controlled, intentional constructions (That smells like shit). We hypothesize a feedback control loop between arousal and both types of cursing. The pathway begins at a low-arousal baseline. Next, an intrinsic or extrinsic trigger evokes physiological arousal, the speed and intensity of which mediate two potential outcomes. Non-propositional cursing results from a rapid spike in phasic arousal causing an individual to immediately exit the loop and curse. Slower changes in arousal lead to an intermediate deliberation stage, allowing for emotion regulation. An individual may then choose to curse or instead modulate their output to avoid conflict. We examined the effects of exposure to cursing on physiological (i.e., heart rate, gaze) and cognitive (i.e., memory, attention) indicators of arousal to elucidate the operation of feedback within this loop. We predict increased heart rate and greater visual attention to curse words during reading and poorer recall of passages containing curse words. Method: Participants (N=5, data collection ongoing) read didactic passages as we continuously monitored eyegaze (Eyelink 1000) and heart rate (HR; BIOPAC MP150). After each passage, participants were cued to recall as much detail as possible. Passages (N=6) were roughly matched in complexity (Flesch-Kincaid level) and length (M=230 words). Half the passages contained taboo words; the remainder included pragmatically unexpected words. We defined rectangular regions of interest (RoIs) surrounding target words and acquired baseline HR during one-minute rest intervals preceding each story. We conducted the following contrasts: a) HR(taboo_RoI) > HR(control_RoI), b) HR(taboo_RoI) > HR(baseline), c) Dwell Time(taboo_RoIs) > Dwell Time(control_RoIs), d) N Facts Recalled(taboo_passages) > N Facts Recalled(control_passages) Results: Average HR over 2-second intervals after gaze entered taboo RoIs (M=80.09, SD=15.58) was not significantly different from control RoIs (M=85.37, SD=13.87), t(4)=1.17, p=.15, or baseline (M=89.01, SD=19.92), t(4)=1.18, p=.15. Gaze dwell time was significantly longer on taboo (M=943.25, SD=174.87) than control words (M=1580.29, SD=380.69), t(4)=-3.4, p<.01. A Wilcoxon Signed-Rank test indicated participants recalled more facts after reading control versus taboo passages (Z=-2.22, p=.01). Discussion: We did not observe physiological effects of exposure to cursing, possibly due to sample size. Cognitive effects, however, were significant; participants had better recall for control than curse passages and spent more time looking at curse than control words. It is unlikely that these effects are simply due to distraction or surprise, since control passages contained unexpected words. These preliminary results partially support a feedback control loop between arousal and cursing. Understanding the physiological underpinnings of neurogenic cursing is the first step toward developing treatments for this socially impairing condition. Next steps include exploring the physiological and cognitive effects of curse word production in a planned sister experiment as well as investigating arousal and cursing in naturalistic language settings.

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

## Executive functions and propositional language: Verbal initiation, selection, strategy, and inhibition in acute stroke

***Poster E108*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Stroke frequently results in cognitive difficulties including executive dysfunction, which can persist longer-term. Currently, brief screening measures that can detect subtle and focal cognitive changes, especially in executive functions, are lacking. The Brief Executive Language Screening Tool (BELS) is a recently developed executive function and language measure. First, we examined the reliability and validity of the BELS sentence completion (SC) subtest (BELS-SC), which measures executive function components within a semantic context in an acute stroke population. Second, we investigated acute stroke performance on Propositional Language and Executive Function subtests (Spontaneous Speech and SC), relative to healthy controls. Eighty-seven left and right hemisphere stroke patients completed the BELS and other neuropsychological measures within seven weeks of a stroke (acute phase). Ninety-two age- and gender-matched healthy control participants completed the same neuropsychological battery. The BELS-SC showed good construct validity and inter-rater reliability. The acute stroke patients were significantly more impaired on the BELS-SC measures (initiation, suppression, selection, strategy use) and Spontaneous Speech subtests compared to the healthy controls. Specifically, acute stroke patients were selectively impaired on Low (compared to High) Constraint SC Initiation Items (number correct), which place higher demands on selection processes. Stroke patients were also significantly slower on SC Initiation items, impaired on SC Inhibition items, and they employed fewer strategies than healthy controls. Further, 30-44% of patients were impaired (<5th percentile) on Spontaneous Speech subtests, demonstrating significantly reduced connected speech. Stroke patients were intact on Single Word Comprehension and Repetition, and largely unimpaired on Articulation (26% <5th percentile) and Nominal Language (29% <5th percentile) subsections; however, 72% of patients were impaired (<5th percentile) on the Propositional Language and Executive Function subsection. Findings highlight that acute stroke patients can have largely well-preserved nominal language functions, with impaired propositional language and executive functions (i.e., initiation, selection, inhibition and strategy). This study provides new insight into the assessment of executive functioning and propositional language in acute stroke and a novel finding in strategy

generation. The BELS-SC subtest in particular is a valid and clinically useful tool for assessing executive functions in acute stroke, with implications for long-term functional outcomes post-stroke.

Topic Areas: Control, Selection, and Executive Processes, Language Production

## The influence of atypical lateralization of language on cognitive processing

***Poster E109*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Cristina Cano Melle[1], María Baena Pérez[1], Esteban Rodriguez Villar[1], Lidón Marín Marín[1], César Ávila[1]; [1]Jaume I University

INTRODUCTION: For many years, extensive research has consistently proved that specific cognitive functions can be predominantly sustained by either one of the two hemispheres, while other functions are shared by both hemispheres when processing information. Language function, one of the most explored, is mainly left-lateralized in the brain. However, some individuals (mostly left-handers) have an atypical organization of language. We have known for years that atypical lateralization may be a risk for neurodevelopmental disorders suggesting the existence of cognitive deficits. One of the proposed mechanisms to these deficits is need for a greater hemispheric transfer via corpus callosum, that slows the cognitive processing. Here, we will employ lateralized tasks (visuospatial and language) and tasks requiring high processing speed to investigate performance of left-handed individuals with typical and atypical lateralization of language. Additionally, we will correlate performance of these tasks with the volume of the corpus callosum. METHOD: Seven ty left-handed participants initially completed the verb generation task in an MRI scanner. We classified participants into two groups by calculating Laterality Index (LI) in the inferior frontal gyrus (IFG) using the bootstrap in LI-toolbox for SPM12, resulting in 40 typically-lateralized and 30 atypically-lateralized subjects. These individual also completed the cognitive tasks: reading words and pseudo-words and detection to second phoneme, n-back task, Paced Auditory Serial Addition Test (PASAT), stop-signal task, Stroop Test and mental rotation task. In addition to that, we calculated the volume of corpus callosum and then we correlated with each cognitive performance ($P < 0.05$). RESULTS: Significant differences between typically and atypically lateralized arose only in language and visuo-spatial functions. Our results revealed that atypical group performed worse in reading short in unfamiliar words and pseudowords, as well as long in familiar and unfamiliar words ($F (2,63) = 7.02$, $P = 0.002$) and in both condition to phoneme detection task ($F (1,64) = 7.18$, $P = 0.009$). However, atypical participants showed a better performance in mental rotation task in comparison to typical lateralization group ($F = 2.87$, $P = 0.043$). No differences were found for N-Back, PASAT, Stop and Stroop tasks. The volume of the corpus callosum correlated significantly with better performance in working memory (N-Back3 and PASAT) and language (reading short familiar words and long pseudowords) tasks. However, the volume of the corpus callosum correlated negatively with performance of those tasks lateralized in the right hemisphere, that is SSRT and mental rotation. CONCLUSION: Our results demonstrated that the typical and atypical lateralization of language is associated with a better performance in task performance lateralized in one of two hemispheres: language tasks in left handers with a typical lateralization of language and visuospatial tasks in those with an atypical lateralization of language. In the case of corpus callosum, the results showed a better performance in tasks requiring bilateral and (mainly) left lateralized control, but a worse performance in (mainly) right-lateralized tasks. Future studies with larger sample size should determine the interaction of both factors.

Topic Areas: Control, Selection, and Executive Processes, Language Production

## The neural architecture of compositional generalization in language: how do we infer the meaning of “un-reject-able-ish”

***Poster E110** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The ability to generalize previously learned knowledge to novel situations is essential for adaptive behavior. For example, when encountering the word “un-reject-able-ish” for the first time, one can easily infer its meaning by integrating knowledge of its constituent parts based on abstract structural rules (such as the sequential order of word parts). To investigate the neural mechanisms involved in inferring novel compositional word meanings, we developed a behavioral paradigm to probe compositional inference in language. In a pre-registered fMRI study, we trained 43 participants on the meanings of compositional words made up of known stems (“good”) and novel affixes (“kla”) from an artificial language. The meaning of the compositional words depended on the position of the novel affix (“goodkla = bad”, “klahorse = pony”). We then asked them to infer the meaning of novel compositional words (“whitekla =?”, “klacat =?”) that were either congruent or incongruent with the established rule (“klawhite” is incongruent because a small version of “white” does not exist). In the scanner, participants performed a semantic priming task in which the novel words served as either congruent or incongruent primes (“whitekla”) and their synonyms (“black”) served as targets. After the scanning session, they were asked to indicate whether these novel words they had been presented held any meaning and, if so, to provide their interpretation. Our results demonstrated that participants were able to generate novel compositional meanings on the fly, successfully inferring meanings of congruent versus incongruent words. Univariate analysis of fMRI data at target words revealed a greater repetition suppression effect when primed with congruent than incongruent words in the left inferior frontal gyrus, which suggests that novel meanings are derived at this linguistic “building” hub. Further analysis of congruent versus incongruent prime-related activity revealed a broad frontal-parietal network, including the hippocampus, a brain area commonly associated with the generalization process of structural relationships. Furthermore, we employed multivariate representational similarity analysis to demonstrate structural rule and word meaning representations in hippocampus and left-lateralized core language areas. Together, these findings suggest that compositional generalization in language recruits a domain-general network shared with action planning, compositional vision and constructive relational memory, while newly inferred meanings are represented in more language-specific regions.

Topic Areas: Control, Selection, and Executive Processes, Meaning: Lexical Semantics

## When I budge but you don’t: Inter player theta power coupling forecasts future joint action outcome

***Poster E111*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Roksana Markiewicz[1], Katrien Segaert[1], Ali Mazaheri[1]; [1]University of Birmingham

Communication between people can be considered a joint action and a key aspect of successful cooperation is effective use of feedback. Here, we examine joint adjustment in response to feedback in a two-player game while recording electroencephalography (EEG). Sixty young adults (i.e. 30 pairs) participated in a cooperation task in which they had to synchronise a button press with one another. Each trial was deemed successful if the pair pressed buttons within 250ms of each other. There was an auditory cue (a high, medium or low pitch tone) at the beginning of each trial to indicate the length of time (either 'short', 'medium', or 'long') participants had to wait before pressing the button. Without communication, they had to synchronise with their partner. They could use the feedback at the end of each trial to adjust their responses: they received a 'Well done' feedback after successful trials, and detailed negative feedback indicating who pressed the button first and the elapsed time between the button presses after unsuccessful trials. EEG was recorded from both participants simultaneously using 32 channel Waveguard caps. We used non-parametric cluster based permutation tests to examine condition differences in the inter player power coupling. We focused our analysis on the incorrect trials, which were further divided into two conditions: forecasting successful and failed cooperation. In line with previous reports, we found a significant increase in frontal midline theta activity after negative feedback. A positive correlation in theta power between players was associated with a significantly greater likelihood of an error in the next trial. On the other hand, a negative correlation in theta power between players was associated with successful subsequent trial. The current view of feedback induced theta activity is that it reflects network changes underlying behavioural adjustment. Our results suggest that the synchronization of these networks between cooperative players can have a maladaptive joint action outcomes.

Topic Areas: Control, Selection, and Executive Processes, Methods

## Beyond the brain: A multimodal approach to describing the relationship between brain oscillations, heart rate, and involuntarily eye movements during auditory processing

***Poster E112*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction. Most theories describe higher-level cognition based on observing the human brain, while the role of the autonomic nervous system (ANS) is often overlooked (Porges & Furman, 2011). Here, we jointly recorded the electroencephalogram (EEG), heart rate, and involuntary eye movements when participants performed linguistic and nonlinguistic auditory tasks that varied by cognitive load. Specifically, we compared neurophysiological differences in (a) alpha-band brain oscillatory power, (b) mean heart rate and interbeat interval, and (c) microsaccade rate between linguistic (familiar vs. unfamiliar languages) and nonlinguistic (simple vs. complex musical sounds) processing, and explored the association between these attentional measures. A multimodal approach will shed light on the interactions between the neural and peripheral nervous systems to ultimately modulate behavior related to auditory processing. Methods. 70 English-speaking young adults (age range: 18–25; 35 female) completed two active listening tasks: linguistic and nonlinguistic, with 18 trials (around 15 minutes) each. During the linguistic task, participants listened to short passages spoken in a familiar (English—low cognitive load) or unfamiliar (Hebrew—high cognitive load) language while watching a video on display. They were asked to respond by button pressing whether they heard a target word. During the nonlinguistic task, participants listened to sequences of musical tones that were either simple (fewer instrument varieties—low cognitive load) or complex (more instrument varieties—high cognitive load) while watching the video and were asked to respond whether they heard a target instrument sound. For data acquisition, 32-channel EEG and heart rate were recorded with an actiCHamp Plus amplifier (Brain Products, GmbH). Eye movements were collected via an EyeLink 1000 Plus eye tracker (SR Research, Canada). Oscillatory power in the alpha frequency band was estimated using the BrainVision Analyzer software. Mean heart rate and interbeat interval were calculated using the EEG-Beats toolbox (Thanapaisal et al., 2020), and microsaccades were detected using the Microsaccade Toolbox for R (Engbert et al., 2015). Outcome Interpretation and Significance. In this study, we observe neural and physiological responses in tandem to understand the human nervous system activities more fully during auditory processing. We anticipate identifying distinct patterns linked to linguistic and nonlinguistic processing influenced by cognitive load. The multimodal approach we employed can advance theories on auditory processing that include the involvement of the ANS. Moreover, the possible associations between EEG, heart rate and eye movement data can expand the techniques of choice when addressing auditory cognition.

Topic Areas: Control, Selection, and Executive Processes, Methods

## cneuromod-triplets: enabling deep lexico-semantic phenotyping through a large and freely available dataset

***Poster E113*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Existing neurocognitive models of lexico-semantic processing describe a broad, bilateral fronto-temporal network. However, the role of individual variability has often been overlooked and can be best examined through deep phenotyping (Gratton & Braga, 2021): the collection, within subject, of behavioral and neuroimaging responses to stimuli spanning a wide range of variables during tasks that require different levels of semantic processing. We present the cneuromod-triplets dataset from the Courtois Project on Neural Modelling (cneuromod, https://www.cneuromod.ca/): a large-scale, freely available and multimodal dataset that covers a wide range of neuroimaging and behavioral tasks in a small sample of subjects. The dataset includes two tasks that enable 1) the isolation of neural activity associated to single word processing and its modulation by perceptual and conceptual features of words and 2) the investigation of semantic processing of those same words within a minimal context. The first task was a familiarity judgment task in which subjects were visually presented with a single word and were asked to rate their subjective familiarity (Fernandino et al., 2022). The second task was a three-term task (3TT) in which participants were presented with three words (i.e., a "triplet") and asked to select the unrelated word from the set. The stimuli, drawn from a large, publicly available and human-annotated dataset (Borghesani et al., 2023), comprised 1,588 unique words spanning a large range of lexico-semantic and psycholinguistic features, arranged into 709 triplets. Four right-handed, English-French bilingual participants (2 female, age: 44±4.3 years; education: 20±3.6 years) performed these two tasks in a 3T fMRI scanner over multiple sessions, for a total of approximately seven hours. To highlight the quality of this dataset, we ran parametric modulation analyses for each subject to examine fMRI-BOLD response covariation with low-level visual (i.e., word length), lexical (i.e., frequency, orthographic complexity) and semantic (i.e., concreteness, sensorimotor features) aspects of the presented single words, as well as the effect of response time (a proxy for task difficulty) during the 3TT. Lexico-semantic features of single words differentially modulated neural activity across the cortex, with frequency and sensorimotor features of the words showing the greatest and most heterogeneous modulatory pattern. Our results highlight the quality of this freely available dataset, which enables further investigation of the organization of lexico-semantic processing at the individual level. For instance, we will leverage multivariate methods to assess whether the subject-specific trial-by-trial decision on the 3TT can be predicted by the pattern of activation of the three words when presented individually during the familiarity task (Wu et al., 2022).

Topic Areas: Development of Resources, Software, Educational Materials, etc., Meaning: Lexical Semantics

## Measuring language exposure during social media interaction and its application as a reliable metric of individual differences during comprehension

***Poster E114*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Shannon McKnight[1]; [1]Fort Lewis College

It is estimated that nearly two-thirds of the population interacts with social media with nearly 90% of college-aged students interacting at least once per day (Pew Research Center, 2021). While many social media platforms support different forms of posting including photo, text, and video; users will encounter more or less verbal material depending on the platform. For example, Twitter users are more likely to spend time scrolling through text than users of TikTok or Instagram. However, there is not yet a consistent method for measuring language exposure online. As a field, there is a growing need for a reliable way to measure how social media based language interactions (including subtitles, video content, text posts, etc.) contribute to our overall experience with and mastery of language and how that shapes comprehension. Author recognition tests (ARTs) combine popular author names with reasonable foils (Stanovich & West, 1989; Acheson et al 2008) as an indirect measure of print exposure and reliably correlate with vocabulary size (West and Stanovich, 1991; Martin-Chang & Gould, 2008) and reading comprehension (Mol & Bus, 2011). Language experience measured at least in part through ARTs have also been shown to predict the P600 event-related potential (ERP) response to syntactic errors (Pakulak & Neville, 2010; McKnight et al., 2016) as well as eye-movements during comprehension (Moore & Gordon, 2015). While they continue to reflect vocabulary and word knowledge in predominantly WEIRD samples, they need to be periodically updated to accurately reflect knowledge from this sample (see Acheson et al 2008). Furthermore, they can be specialized to better capture individual differences among unique populations, including for readers of English in the United Kingdom (Masterson & Hayes, 2007), Canada (Chateau & Jared, 200), and children (eg. Ricketts et al., 2007). However, social media algorithms and the sheer volume of online creators poses a problem for a social media specialized ART. Nevertheless, questionnaires can be administered and psychometrically evaluated to capture language exposure on social media. Based on the original Reading and Media Habits Questionnaire (Stanovich & West, 1989) and Reading Habits Questionnaire (Acheson et al, 2008), the Social Media Interactions and Language Exposure scale (SMILE) includes measurements of how often (in hours) individuals spend on social media, the platforms they prefer to use, "activeness" on social media (passively scrolling versus actively commenting on posts), as well as how often they view subtitles on social media posts, while watching TV or movies, and in online classroom settings. The goal for this work in progress is twofold: the first stage involves the development of a reliable SMILE scale and appropriate psychometric testing. The second stage is to determine the relatedness of SMILE to standard individual differences measures (such as ARTs, vocabulary, comprehension tests, and author naming tasks) as well as during error monitoring tasks. Overall, this Sandbox Series presentation will present psychometric data for the SMILE scale and preliminary data to address the scale's utility in capturing a realistic snapshot of an individual's language experience.

Topic Areas: Development of Resources, Software, Educational Materials, etc., Reading

## Action comprehension assessment during intraoperative mapping in patients with right hemisphere gliomas.

***Poster E115*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The Action Observation Network (AON) plays a critical role in our ability to understand the "why" of other people's actions, allowing us to interact with our conspecifics in a flexible and appropriate fashion. At the neuroanatomical level, the AON involves fronto-parietal regions subcortically interconnected through the superior longitudinal fasciculus (SLF), which has recently been identified as the main association tract in this network. Damage to this system can result in maladaptive social behavior, highlighting the need for its preservation during intraoperative mapping for glioma resection. However, no team has yet developed a cognitive task that allows mapping the AON during awake brain surgery. Here, we used fMRI to validate an action observation task requiring participants to watch incomplete ongoing actions performed by others and infer the underlying motor intention. In healthy individuals, the task accurately mapped bilateral AON regions dorsally (z-score ~ 7). We further applied this task to patients with gliomas in frontal and parietal regions prior to surgery, and observed significant activation in the AON and regions surrounding the tumor, proving valuable for presurgical planning. During the surgical procedure, the direct electrical stimulation (DES) technique was employed to map the hubs of the AON enabling real-time structure-function causal evidence and shedding light in the involvement of white matter tracts in this cognitive process. The combination of this task with DES, successfully identified positive sites at cortical (e.g., IFG) and subcortical levels (e.g., SLF). Overall, our findings demonstrate that this task is highly sensitive and specific for detecting AON activity in both neurotypical individuals and patients diagnosed with right glioma tumors. They also show that, although challenging, developing tools to map social cognition in the right hemisphere can enhance the precision of awake brain surgery, potentially reducing postoperative deficits in social comprehension abilities.

Topic Areas: Development of Resources, Software, Educational Materials, etc.,

## Sleep Quality and Hippocampal Resting State Functional Connectivity to the Language Network in the Aging Population

***Poster E116*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The hippocampus is not widely studied within the neurobiology of language. However, growing evidence implicates hippocampus as a critical neural substrate of language processing, including in lexical-phonological processes[1], relational binding[2], and word learning[3]. Blank et al.[4] identified language-specialized subregions of healthy adult hippocampi that activated exclusively for language-based cognitive tasks, and which were functionally connected at rest to putative cortical language areas. Yet the functional connectivity between hippocampus and the language network remains underexplored. Increased age is known to influence resting state functional connectivity (RSFC) between hippocampus and neocortical networks, including the Default Mode Network (DMN)[5]. Despite abundant evidence that hippocampus is part of the language network, age-related changes in hippocampal-language network RSFC have not been systematically studied (Aim 1). In addition to age, sleep quality may moderate hippocampal-neocortical RSFC. Sleep quality decreases with age, which may negatively impact consolidation, a neurobiological process that relies on hippocampal-neocortical connectivity and supports hippocampus-dependent language functions [3]. It is unknown if sleep quality influences hippocampal-neocortical connectivity (Aim 2). We used minimally preprocessed archival Lifespan Human Connectome Project Aging T1-weighted structural and resting state functional data. A subset (n=176) of a larger planned sample (N=631) were examined. Participants were 35-100 years old, right-hand dominant, and had no history of stroke. Participants provided self-ratings of sleep quality using the Pittsburgh Sleep Quality Index (PSQI). We used the CONN toolbox for preprocessing and analysis. First level analyses applied structural segmentation, functional artifact detection, functional smoothing (4mm kernel), CompCor-based denoising, and band-pass filtering (0.01-1.0 Hz). Seed Regions of Interest (ROIs) were defined using the Tian et al.[6] subcortical atlas, which delineates 4 hippocampal subregions per hemisphere. Second level multiple regression models examined the influence of age, PSQI, and their interaction on hippocampal-language network connectivity. We further examined hippocampal-DMN connectivity as a control. Preliminary findings suggest that increasing age significantly decreases RSFC between hippocampal subregions and multiple regions comprising the DMN, including bilateral medial prefrontal cortex and post-cingulate cortex. Age also reduces RSFC between hippocampus and several language network areas, though less robustly compared to DMN, including aspects of bilateral inferior frontal and superior temporal gyri, and left angular gyrus. PSQI score has less of an effect on hippocampal RSFC, with modest findings involving bilateral angular gyri, right superior temporal gyrus, and right middle and inferior frontal gyri. The interaction between PSQI and age had no moderating effects. By the time of this Sandbox presentation, results for the full sample will be available. We will examine resting state functional connectivity between individual hippocampal ROIS and the language network compared to the DMN, both networks which will be defined using demarcations from established atlases. The moderating effects of age, PSQI, and their interaction will be explored. 1. Hula et al., Brain 143(8), 2532-2544 (2020). 2. Covington & Duff, Trends Cognitive Science 20(12), 869-870 (2016). 3. Schimke et al. Psychonomic Bulletin Review 28(6), 1811-1838 (2021). 4. Blank et al. BioRxiv 091900, (2016). 5. Salami et al., PNAS 111(49), 17654-17659 (2014). 6. Tian et al., Nature Neuroscience 23(11), 1421-1432 (2020).

Topic Areas: History of the Neurobiology of Language,

## Using deep neural networks and adaptive stimulus presentation for automated investigation of natural sound representations in auditory cortex

***Poster E117** in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Humans can efficiently and rapidly digest auditory scenes, segregating and sorting a single stream of superimposed sounds into separate categories. However, the neural processes underlying this transformation from acoustic signals to semantic categories remain poorly understood. To investigate this, researchers often record neural responses while subjects listen to a stimulus set of natural sounds and then build encoding models to relate neural responses to stimulus features, such as spectrotemporal measures and category-level representations. One intriguing approach involves using deep neural networks (DNNs) trained to categorize sounds; if an encoding model that uses DNN hidden layer activations as input features (i.e., a DNN-derived encoding model) can predict neural responses accurately, this suggests similar representations between the machine learning model and human auditory cortex. A cortical site that is most accurately predicted by a shallow DNN layer would suggest low-level acoustic representations, while deeper layers correspond to abstract category-level representations. In spite of the success of these approaches, one major limitation involves the risk of undersampling the stimulus space when using a fixed set of stimuli. To address this, we propose a two-stage approach: in stage one (S1), we collect neural responses to a standard natural sounds stimulus set using stereoelectroencephalography (sEEG) and build DNN-derived encoding models across all DNN layers. For a given channel, the most accurate model is then applied to a very large (hundreds of thousands) stimulus library, producing a stimulus space of predicted neural responses across this library. During stage two (S2), Bayesian optimization is used to adaptively select and present stimuli from this library, with neural responses analyzed in real time. By prioritizing exploration over exploitation, we can force the model to sample across the stimulus space and investigate regions of high uncertainty, e.g., where observed neural responses differ from those predicted by the S1 encoding model. Here we show a proof of concept for this approach in one subject. After completing S1, three auditory cortex channels were selected for S2. The first channel, located in left posteromedial Heschl's gyrus, was revealed to encode features of the modulation power spectrum (MPS), namely fast temporal and low spectral modulations. An MPS encoding model built from S2 data performed better than S1, suggesting the S2 stimuli were better tuned to explore this feature encoding. The second channel, located in left superior temporal sulcus (STS), was speech-selective, with S2 providing additional corroborating stimuli. Lastly, a site in right STS provides the most compelling evidence for the utility of our approach. The S1 encoding model suggested speech selectivity, with large neural responses predicted for both singing and speech. However, S2 data revealed song selectivity, with observed responses to singing exceeding both speech and instrumental music. Without having to design and run separate experiments, our method automatically picked stimuli to elucidate MPS encoding, speech selectivity, and song selectivity in three separate channels. These preliminary results suggest that this is a powerful method to interrogate a channel's feature encoding in an automated way.

Topic Areas: Methods, Speech Perception

## Systematic Review: Electrophysiological Markers of Language in Neurodegenerative Diseases

***Poster E118*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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An early and accurate diagnosis enables optimal care of patients with neurodegenerative diseases. Electroencephalography (EEG) shows advantages in terms of availability, comfort, cost and time-effectiveness compared to routinely used diagnostic tools such as e.g. neuropsychological testing or the collection of cerebrospinal fluid. This systematic review aims to evaluate the diagnostic utility of electrophysiological markers in Alzheimer's disease (AD), Frontotemporal Dementia (FTD) including Primary Progressive Aphasia (PPA), and Lewy Body Dementia (LBD). Considering the variable prevalence of language deficits in the three populations, we opted to scope the literature related to semantic processing separately. The review was registered with PROSPERO (ID: CRD42023392253). We systematically searched databases Pubmed, Cochrane, Web of Science, and Scopus for articles published from 2000 to January 2023. Our complete search string defined a total of 12010 studies, 714 papers were eligible for full-text screening after removal of duplicates and screening of the abstracts by 2 blinded reviewers. Additionally, three eligible articles were added. For the language sub-review, only articles including a semantic event-related (ERP) paradigm were selected. Sixteen articles were selected for full-text screening, of which 12 were included. Regarding participant characteristics, eight studies included individuals diagnosed with AD, while four studies studied differences in PPA subtypes. Interestingly, one study compared AD to semantic variant PPA (svPPA). Notably, no study included LBD participants. Our findings highlight the N400 component, elicited by a semantically unexpected stimulus, as the most prominent ERP-marker across populations. Alterations in amplitude, latency or topography of the N400 were reported in all included studies. In AD, the N400 amplitude was consistently reduced (less negative) in seven out of eight studies. Furthermore, one study comparing individuals with symptomatic AD, presymptomatic AD and familial non-carriers of the E280A presenilin 1 mutation causative of AD, suggested that topographic disruptions in N400 generators precede a decrease in N400 amplitude. Similarly, PPA patients exhibited significant alterations in the N400 response to semantic violations compared to healthy

controls. More specifically, N400 responses were hardly detectable in semantic PPA (svPPA), delayed in logopenic (lvPPA), and showed mixed results in nonfluent PPA (nfvPPA). Moreover, alterations in N400 topography showed prominent disturbances in svPPA. Additionally, one paper argued that not only the N400 but also the P600 holds potential for discriminating nfvPPA from lvPPA. Likewise, one AD study stated that combining the N400 and P600 increases diagnostic accuracy in mild AD. In conclusion, our review supports the diagnostic and differential diagnostic value of electrophysiological markers, and in particular the N400. Nonetheless, alterations in this component were not limited to PPA and AD, but were also observed in healthy elderly controls in all three studies including younger and older healthy controls. Therefore, further comprehensive research should include larger study populations and direct comparisons between neurodegenerative diseases and healthy controls as similar effects in healthy ageing and interindividual differences complicate interpretation. Additionally, standardization of used paradigms, stimuli, modalities and outcome measures could increase the value of reported results.

Topic Areas: Methods,

## Cortical Organization of Shared Neural Computations for Reading and Auditory Speech Perception

***Poster E119*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Terri L. Scott[1], Matthew K. Leonard[1], Edward F. Chang[1]; [1]UCSF

Reading is a skill that does not naturally develop; it must be acquired by learning to associate novel visual input with neural systems previously devoted to auditory speech comprehension. Behavioral studies have shown that reading automatically activates some knowledge of the sound of a word, even in adult readers; however, it is unknown what types of functions the auditory speech perception system supports during proficient, naturalistic reading. Here, we used intracranial electrocorticography (ECoG) to investigate not only the spatial overlap of cortical activation during reading and listening to speech, but also the temporal properties of neural activity in these shared regions. Eleven participants undergoing clinical monitoring for intractable epilepsy listened to and read naturalistic sentences while ECoG signals were recorded from high-density electrode grids. We found electrodes with significant high-gamma amplitude (HGA) responses to both speech and reading across several frontotemporal brain areas, with the largest proportion localized to the superior temporal gyrus (STG). Individual subject analyses revealed that shared speech and reading responsive electrodes are consistently observed in posterior STG. We used non-negative matrix factorization to cluster common temporal features of HGA timecourses during reading and found that a key dynamical feature that distinguishes shared reading responses from modality-specific reading responses across brain areas is an increase in high-gamma activity over the course of the sentence. We found similar dynamics in these same electrodes during speech perception. Speech responses in shared electrodes show more gradual build-up of HGA over time compared to the larger population of electrodes with modality-specific speech responses. Furthermore, feature-based temporal receptive field modeling of HGA during speech perception revealed that shared electrodes, when compared to those with modality-specific responses, are less sensitive to stimulus driven features such as sentence onset and auditory envelope and more sensitive to word-level features such as lexical frequency and surprisal. Taken together, these results suggest that neural computations active during speech perception and reading occupy a space in the processing hierarchies of both tasks that has access to word-level and sentence-level representations. The most robustly and consistently identified area showing this effect was posterior STG, thus this work sheds new light on how sentence context may shape the dynamics of speech perception as well as the functional role auditory speech systems play during proficient reading.

Topic Areas: Reading, Speech Perception

## Language model predictability and word frequency effects on fixation-related N400s during Chinese natural article reading

***Poster E120*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Word predictability and frequency effects on N400s have been used to indicate top-down contextual prediction and bottom-up lexical retrieval processes during reading comprehension. Previous fixation-related potential (FRP) studies have revealed their interaction effects on N400s in the natural sentence and article reading. The decreasing N400 amplitude with augmenting predictability only occurred in infrequent words. These findings suggested that a highly predictive context benefits word identification. Word predictability is commonly quantified using cloze probability (CP), which refers to the proportion of people offering a particular continuation to complete its preceding context. However, the subjective cloze procedure is laborious, and CPs are hardly generalized to other new materials. For expediting testing processes and validating CPs across contexts, recent studies trained language models (LMs) to automatically derive words' probability from natural language corpora. The LM-based CPs can explain above half of the change in human CPs. Therefore, this study aimed to examine whether LM predictions well account for N400 responses as human predictions in natural reading by simultaneously recording eye movement and fixation-related potential (EMFRP). The EMFRP data were collected from forty-seven participants while reading 2504 words of twenty-two articles in traditional Chinese from the Academia Sinica Article Corpus. The word predictability was estimated from a cloze test completed by 32 readers and the BERT language model. The word frequency was computed as occurrences per million in log-transformed format from the Academia Sinica Corpus of Contemporary Taiwan Mandarin (ASCCTM). We applied linear mixed-effects models (LMMs) to examine the effects of word frequency and predictability from human and BERT-based CPs on N400s. The LMMs for single-trial FRPs with two-character content words were performed on the mean N400 amplitudes between 375-475 ms. The LMMs include the participants, article numbers, and word items as random effects and the word stroke, launch site, position, frequency, predictability, and frequency-predictability interaction as fixed effects. Pearson correlation revealed that BERT-based CPs were significantly positively related to human CPs ($r = 0.63$, $p < 0.0001$). Moreover, the facilitative impacts of BERT-based CPs on N400s with central-parietal distribution are comparable to human CPs. Specifically, both LMM results of human and BERT-based CPs showed a significant predictability-frequency interaction effect (Human $t = -2.907$; BERT: $t = -2.322$), a significant word

predictability effect (Human: t = 4.195; BERT: t = 3.216) and a null effect of word frequency (Human: t = 1.057; BERT: t = 0.457). A greater N400 reduction with human and BERT-based CP was restricted to low-frequency words. That is, low-frequency words had enormous benefits from contextual clues. These findings suggest that BERT-estimated probabilities are a good substitute for human-generated CPs due to their strong correlation and analogous brain responses.

Topic Areas: Reading,

## Effect of Working Memory Load in Resolving Filler-Gap Dependency in Natural Sentence Reading- evidence from the simultaneous recording of Eye Movements and Fixation-Related Potentials

***Poster E121*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The filler-gap dependency within Relative Clause (RC) structure provides detailed information about the specific person or thing, but resolving the filler-gap dependency can impose large demands on working memory (WM). Prior event-related potential (ERPs) studies have demonstrated the effect of WM load imposed by the filler-gap dependency on sustained negativity or P600 in the word-by-word sentence reading with a fixed presentation rate. This study aims to investigate the effect of WM load in natural reading with the simultaneous recording of Eye-Movement (EM) and Fixation-Related potentials (FRPs), which provides complementary EM and ERPs measures to capture the cognitive operations in natural reading. Three levels of WM load are determined by the varying distance between filler and gap. The Low WM load (LWM) condition comprises the sentences with the simplest Chinese Subjective Relative Clause (SRC) ( [FILLER] RC verb (協助/help) + RC noun (居民/resident) + 的(DE) + Head noun [GAP] (志工/volunteer) ). As for the medium and high WM load conditions, one constituent- adverbial modifier (ex: 熱心/enthusiastically) and two constituents- a locative preposition and an adverbial modifier (ex: (在社區/in the community)+(熱心/enthusiastically)) were added prior to the RC verb, respectively. Thirty-six native Chinese speakers were invited to read 81 sentences at their own pace while their EMFRPs were simultaneously recorded. The improved masking empirical mode decomposition (iMEMD) method was applied to correct the oculomotor artifacts introduced by ocular motion. Additionally, the overlapping correction analysis was used to deconstruct the temporal overlap of FRPs signals elicited by the successive fixations. The result shows the effect of WM load on EM and FRPs. The EM patterns and FRPs on Head Noun where the ambiguity is resolved were compared among three conditions. EM indices include early (e.g., First-Fixation-Duration, Gaze Duration...etc.) and late measures (e.g., go-past time, regression). ERP components such as N100, P200, N400 and sustained negativity were examined as to their amplitude, latency, and topographical distribution. Compared to the LWM load, sentences with HWM load exhibited longer First-Fixation-Duration and Gaze Duration on Head Noun. The cluster-based permutation test shows that they also exhibited an increased N100 ( $p = 0.004$) and a reduced P200 amplitude ($p = 0.009$). These findings indicate the effect of WM load on the early stages of information processing. Readers are more

attentive as the WM load increases. Moreover, sentences with HWM showed longer go-past time, higher regression-in rate, and greater negativity of N400 ( (p = 0.006) on the head noun. These findings suggest the need for reanalysis and processing difficulty in resolving the longer filler-gap dependency. Sentences with MWM showed similar EM and FRPs patterns to the sentences with HWM load, indicating that both types of WM load might impose similar amount of demand on readers. In sum, EMFRPs yield more complete evidence for the effect of WM load on natural reading from the early stages of information processing, sentence integration and reanalysis.

Topic Areas: Reading,

## Intracerebral electrical stimulation of the left word-selective temporal cortex induces pure alexia

***Poster E123*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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The ability to read relies on the rapid mapping of perceived visual letters and their combinations (i.e., visual word forms) to phonology and meaning. The central role of the left ventral occipito-temporal cortex (VOTC) in processing letter strings, initially suggested by pure alexia in lesion studies, is now widely accepted. While this region has been intensely studied with functional MRI, direct electrical stimulation (DES) has rarely been used, although it allows a more direct assessment of causality between region(s) and function(s). Moreover, the few DES case studies reported did not provide stringent evaluation of the stimulation effect on reading performance. Here we report a comprehensive case of pure alexia during DES of the left VOTC (subject LV, female, 38 y.o, implanted with SEEG electrodes for refractory epilepsy). During DES of the left posterior occipito-temporal sulcus, but not of other sites, LV was transiently impaired at reading single words (performance on paper without time constraint: 99% correct before and after stimulation vs. 71% during stimulation) but was still able to slowly read letter-by-letter. LV was also impaired at making lexical decision on written words/pseudo-words (performance on paper: 100% vs. 75%; on computer screen: 92% vs. 72%), showing that she had impaired access to the lexico-semantic representation of the words. By contrast, performance was intact during stimulation for oral naming, auditory naming, reading numbers, writing, auditory lexical decision or semantic matching of pictures. Independent functional mapping using a frequency-tagging approach in SEEG showed that the stimulated site was located in a highly word-selective region. Altogether, our results show that DES of the word-selective left VOTC induced pure alexia remarkably selective to words reading.

Topic Areas: Reading,

# Frontoparietal interactions underlay visuospatial orthographic processes in Chinese reading

***Poster E124*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Previous neuroimaging research has started to unveil the neural correlates of orthographic, phonological, and semantic processing of Chinese reading. As a logographic writing system, Chinese reading encompasses processing visuospatial orthographic properties. To date, most of the neuroimaing research in processing Chinese characters have focused on phonological and semantic aspects rather than on visuospatial orthographic processes. Here, we sought to investigate the functional correlates supporting visuospatial orthographic processes relative to semantic and phonological processes in Chinese reading. We conducted a functional MRI single-character reading study in Chinese, in which 35 right-handed native Chinese young adults were asked to make orthographic judgments (i.e., whether the orthography of a character contains a radical "又", such as a target "对"), phonological judgments (i.e., whether the phonology of a character contains the vowel of "ong", such as "红, /hong2/"), and semantic judgments (i.e., whether the meaning of a character is an animal, such as "狗, dog"). Stimuli were visually presented in separate task-specific (orthographic, phonological, semantic) activation blocks of 11-13 s, that were alternated with rest-fixation blocks of 12 s. Conjunction analyses at the whole-brain level revealed that single-character reading across the three tasks recruited a frontal-parietal-temporal network in the left hemisphere and ventral occipitotemporal cortex (vOTC) bilaterally. Whole-brain contrasts between the three tasks showed that the brain activation for orthographic processing, compared to semantic processing, was mainly right lateralized. Also, activations associated with semantic processing occurred bilaterally but was more left lateralized for semantic versus phonological processing. Regions of interest (ROIs) analyses based on previous meta-analyses in Chinese reading revealed similar engagement profile across areas with stronger activation for semantic and orthographic processing than phonological processing. Of interest, among the regions examined, only the left pars triangularis (Tri) showed stronger engagement for semantic processing relative to orthographic and phonological processing. Time-course analysis conducted to examine temporal differences in the profile of activation among three tasks revealed a Task X Time-window interaction for left superior parietal gyrus (SPG), with initial activation being stronger for semantic than orthographic and phonological processing, and a significant increase for later activation in the orthographic processing of this region that reaches up to the same extent of the semantic processing but goes up higher than phonological processing. Both pairwise and whole-brain functional connectivity (FC) revealed that the MFG-SPG and vOTC-SPG FC was stronger in orthographic processing than semantic processing. In addition, stronger vOTC-SPG FC was associated with weaker vOTC activation and SPG-MFG FC was also associated with weaker MFG engagement. In sum, our study revealed that visuospatial orthographic processes in Chinese reading involves stronger right hemisphere engagement, including right vOTC, as well as a left-lateralized dorsal frontoparietal network that interacts with vOTC to orthographically process Chinese characters. Stronger connectivity in this left vOTC-

SPG-MFG network is associated with reduced regional engagement, which suggest that processing visuospatial orthographic processes in Chinese rely on functional interactions among regions rather than of local processes taking place in each of them.

Topic Areas: Reading,

## An fMRI study of phonological decoding: Learning to read in an artificial script

***Poster E125*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Anna Chrabaszcz[1], Kailee M Lear[1], Corrine Durisko[1], Julie A Fiez[1]; [1]University of Pittsburgh

Introduction. Skilled reading is characterized by fast and efficient visual word recognition and relies on an extensive network of dorsal fronto-temporo-parietal and ventral occipito-temporal brain regions, supporting phonology-based and orthography-based processes, respectively[1-4]. In contrast, emergent reading is characterized by heavy reliance on phonological decoding, or the process of transforming letters into speech sounds[5-6]. We used an artificial grapheme-phoneme training paradigm to emulate the initial stage of reading acquisition to characterize the brain network that supports this process in novice reading. Methods. Thirty-two neurotypical participants (M age=26, 9M/21F/2Other) learned a rune-like artificial alphabet consisting of 24 letters that mapped onto English language sounds. Each of the 10 consonant sounds was represented by 2 homophonous letters (like K and C can be both pronounced as /k/ in English). After 10 sessions of training to decode words written in the artificial script (160 words per session), participants completed an fMRI scan during which they read target words (not seen during training) (16 targets x 16 runs) interspersed with visual patterns (control condition). They were instructed to first decode the word silently and name it after the button press. Participants' memory of target words was tested on the next day with the spelling, word recognition and lexical decision tasks. Imaging data were processed and analyzed in the AFNI software. Brain areas showing significant activation were compared to the canonical reading network generated via the Neurosynth. Additionally, all participants completed a standardized assessment of their reading-related and general cognitive functions. Results. Analysis of behavioral training effects showed improvement in word decoding accuracy and reading speed which generalized to novel words (92% accuracy). Participants also demonstrated orthographic learning of the target words in that they responded to them faster than to homophonous spellings of the same words ($p = 0.006$) in the word recognition task and the LDT ($p = 0.0016$). Analysis of imaging data showed that regions with significant activation during decoding of the target words vs. visual patterns largely overlapped with the Neurosynth's reading network, including left SMA, bilateral clusters in the Middle/Inferior Occipital gyrus, Inferior/Superior Parietal lobule, fusiform area, and clusters in the right cerebellum (Lobules VI, VIII, Crus 1 and 2). Distinct brain activations not present in the Neurosynth's reading network were found in the left cerebellum (Lobules VI, IX, X, Crus 1) and bilateral calcarine sulci (which correlated with the WAIS vocabulary measure and passage reading performance). Despite existing literature implicating fronto-temporal areas in phonological processes and letter-to-sound conversion[2,3,7] and in contrast with the Neurosynth's reading network, we observed activation only in superior, but not inferior, portions of the left IFG (p.triangularis and p.opercularis) and no significant activation in p.orbitalis or in any of the temporal areas. Conclusion. Our findings highlight differences in the brain networks supporting skilled reading vs. novice reading and are consistent with the ideas that the nature of decoding changes over reading development[6]. Thus, the lack of significant activation in the frontal and the temporal areas may be indicative of decoding that has not yet become lexicalized.

Topic Areas: Reading,

## Specific rather than a general neural adaptation deficit in children with dyslexia when processing print

***Poster E126*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

Sarah Di Pietro[1,2,3], Alexandra Brem[1], David Tanner[1], Silvia Brem[1,2,3]; [1]Department of Child and Adolescent Psychiatry and Psychotherapy, University Hospital of Psychiatry Zurich, University of Zurich, Switzerland, [2]Neuroscience Center Zurich, University of Zurich and ETH Zurich, Switzerland, [3]URPP Adaptive Brain Circuits in Development and Learning (AdaBD), University of Zurich, Switzerland

Repeated stimulus presentation leads to reduced neural activity, also called adaptation effect, in brain regions involved in processing the presented information (Grill-Spector et al., 2006). Neural adaptation (NA) paradigms can thus be used to assess the magnitude and spatial location of selective neural processing in specific cortical networks. In written word processing, this effect is expected to be specific to areas within the reading network, for example the ventral occipitotemporal cortex (vOTC) including the visual word form area, and its electrophysiological correlate, the occipitotemporal N1 event-related potential (ERP) (Price, 2012; Maurer et al., 2005). Neural adaptation to objects is expected to occur in posterior occipital object processing regions. A recent study showed a general deficit in NA to speech, print and object processing in adults with developmental dyslexia, suggesting dysfunctional adaptation as a core impairment in dyslexia (Perrachione et al., 2016). We aimed to investigate whether this NA effect for written words occurs in children and sought to clarify its association with reading skills. A group of 85 fifth grade children with varying reading skills (11.4 ± .4 years) performed a visual adaptation paradigm during simultaneous high-density EEG-fMRI, consisting of block-wise presentation of repeated and non-repeated words, objects and pseudowords. To derive adaptation effects, we performed one-sample t-tests on a whole-brain level for fMRI data. For EEG data, we computed the ERPs for each condition (repeated, non-repeated) and part (words, pseudowords, objects) and extracted the mean amplitudes of the left visual occipitotemporal negativity N1 (170-230 ms) and the subsequent occipitotemporal positivity P2 (290-350 ms). These ERP amplitudes were then entered in linear mixed models with factors condition (repeated, non-repeated) and hemisphere (left, right) for each part separately. Children’s reading skills were added as a covariate in the fMRI and ERP analyses. Our fMRI results reveal NA effects to words, objects and pseudowords in bilateral vOTC, to words in the superior temporal cortex, and to pseudowords in the precentral gyrus. These results were paralleled by NA effects in the N1 and the P2 ERPs. For pseudowords, poor reading skills were associated with reduced NA BOLD signal in the left vOTC and in the frontal cortex. No association between reading skills and NA was found for words or objects. Reading skills also modulated the NA effect in the P2 ERP during pseudoword and object processing, with stronger NA effects in children with better reading skills. As expected, we found an NA effect for all parts in the occipitotemporal cortex and additionally some effects in other areas of the reading network for words and pseudowords, confirming the feasibility of measuring the neural adaptation effect with this paradigm.

Contrary to previous findings (Perrachione et al., 2016), however, our results speak against a general neural adaptation deficit as a cause for dyslexia in children because a consistent reduction in the NA effect in fMRI and ERPs in poor readers was only detected when processing pseudowords. Rather, our data suggest a specific NA deficit in the visual domain when children with dyslexia process phonologically demanding pseudowords.

Topic Areas: Reading,

## Title: Differential Eye Movement Patterns in Processing Phrasal Verbs and Verb-Preposition Combinations

***Poster E127*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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Introduction: The cognitive processing of language is a complex phenomenon that involves various neural mechanisms. One aspect of language processing that has garnered significant attention is the comprehension and integration of verb-particle combinations, such as phrasal verbs and verb-preposition combinations. These constructions pose unique challenges due to their complex valency patterns, requiring readers to efficiently process the lexical verb and its associated adverbial or prepositional particle. The eye-tracking methodology offers valuable insights into the cognitive processes involved in reading, as it allows for the examination of eye movement patterns during language tasks. In this study, we investigate the differences in eye movement patterns when native English speakers engage with phrasal verbs and verb-preposition combinations. Methods: The study utilized the "Provo" corpus of eye-tracking data of Native American English speakers (n=84) reading written passages. The target regions of interest (ROIs) were extracted, specifically verb-particle combinations containing phrasal verbs (n=13) and verb-preposition combinations (n=11). The eye-tracking measurements analyzed included fixation and saccadic eye movements. In order to assess the effect of external factors, such as frequency and predictability, on these eye movements, we conducted a frequency analysis using the Corpus of Contemporary American English (COCA), followed by a predictability assessment of the construction components using the fill mask task from BERT neural language model. Results: Analysis of the eye-tracking data revealed interesting differences in the eye movement patterns between phrasal verbs and verb-preposition combinations. While fixation durations did not significantly differ between the two constructions, differences were observed in other eye movement parameters, the sequence and number of fixations differed. In addition to saccadic measures, where native speakers alternated greater times and effort moving eyes around the ROIs in verb-preposition combinations more than phrasal verbs. Furthermore, neither category of object verbs manifested any statistically significant probabilities in prediction. Moreover, the frequency of use did not significantly impact eye movement patterns for either construction type. Discussion and Conclusion: These findings suggest that readers allocate attention differently during reading phrasal verbs and verb-preposition combinations. Notably, readers exhibited more efficient processing of phrasal verbs, as evidenced by a more direct visual path to the target words. These results indicate that the distinction between these constructions is due to their linguistic nature as it was not influenced by external factors such as the frequency or predictability of the verb-particle combinations. This study provides valuable insights into the cognitive processing of phrasal verbs and verb-preposition combinations during reading. The differential eye movement patterns observed between these constructions highlight the distinct cognitive processes involved in comprehending and integrating these constructions. These findings contribute to the understanding of language processing and can be considered experimental proof of theoretical linguistic claims on the semantic unity of phrasal verbs and the syntactic complexity of verb-preposition combinations.

Topic Areas: Reading,

## Left lateralization of N170 component in grapheme processing in Brazilian 8th graders and university students.

***Poster E128*** *in Poster Session E, Thursday, October 26, 10:15 am - 12:00 pm CEST, Espace Vieux-Port*

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This study zooms in on the specialization of visual processing that underlies grapheme and word form processing, and presents an ERP study comparing neurophysiological responses of 8th graders in a public state elementary school to those of university students. Participants engaged in a repetition detection task with four types of visual stimuli: words, pseudowords, false fonts and line drawings, whilst EEG signals were recorded. Of special interest was the N170 component, a neurophysiological signature sensitive to grapheme and word form processing (MAURER & McBRIDE, 2018; C, HASKO et al., 2013). Mean amplitudes from two main regions of interest (ROIs): left hemisphere occipital region (O1, PO3, PO7) and right hemisphere occipital region (O2, PO4, PO6) were analyzed applying mixed effect models with two factors (hemisphere and stimuli type). The test results indicated that, in the group of 20 young teengagers (13 to 14 y.o., fem=13) there was a clear left lateralization of print sensitive N170 responses, with significantly higher amplitudes for words and pseudowords compared to figures and false font. This results is in line with the Phonological Mapping Hypothesis according to which left lateralization occurs due to the strengthening of connections between phonological, lexical and orthographic representations stored in occipito-temporal regions, the reading process (MAURER & MCCANDLISS, 2008). Also it confirms that language with more transparent and fine grained grapheme to phoneme correspondences elicit left lateralized responses for both words and pseudowords. We also looked at individual performance of participants: stronger readers presented the highest difference between word and figure amplitudes, strongly left lateralized, whereas weaker readers did not present any difference. The varying levels of intensity and lateralization of the neurophysiological response indicate that a large portion of the participants remain in the process of obtaining reading fluency long after having started to learn how to read. Currently, data of 17 university students have been collected and analyses are underway. We expect N170 components for these putatively highly proficient readers to show the effects of lexical frequency, with higher sensitivity for words than for pseudowords, as well as a strong left lateralization of the print sensitivity. Also less variability is predicted. Overall, it seems that the qualitative correlation between performance and the degree of lateralization of the N170 component, as a reflection of the degree of specialization in grapheme processing, adequately describes and predicts reading acquisition stages, including when children are supposedly literate but still very variable in the automatization of grapheme perception. References: HASKO, S. et al. The time course of reading processes in children with

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Topic Areas: Reading,

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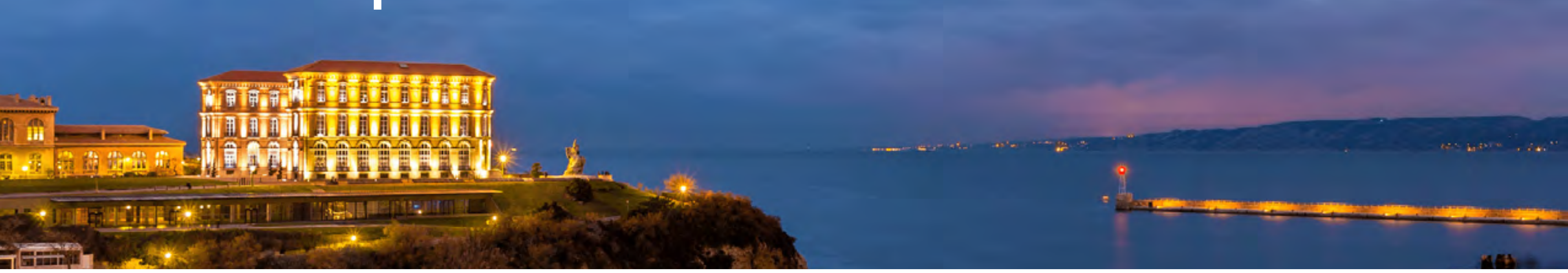

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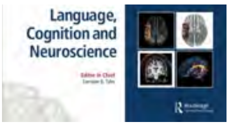


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