SNL 2016

Abstracts

Are you running Psychology, Neuroscience or Vision experiments using a computer?

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TIMING ERROR MEANS YOUR STUDY MAY NOT BE WORKING AS YOU INTENDED CAUSING SPURIOUS RESULTS. GUARANTEE YOUR ABILITY TO REPLICATE: QUICKLY AND EASILY CHECK YOUR OWN ACCURACY. WORKS WITH ANY COMPUTER-BASED STUDY, EEG, FMRI OR EYE TRACKER.

1. WHAT – If you are a psychologist, neuroscientist or vision researcher who reports timing accuracy in units of a millisecond, then it's likely your timings are wrong! This can lead to replication failure, spurious results and questionable conclusions. The Black Box ToolKit lets you quickly and easily check your own timing accuracy in terms of stimulus presentation; synchronization with other equipment; and RT accuracy.

2. WHY – Modern hardware may be faster but millisecond timing accuracy is becoming harder to achieve: 'millisecond precision' does not equal 'millisecond accuracy'. Precision simply means timings are reported in units of a millisecond, not that they are accurate! Whatever experiment generator you use, it only knows when it requested a stimulus be shown and not the time when it physically appeared.

3. HOW – Currently self-validation of timing accuracy can only be done quickly and easily with a Black Box ToolKit. This acts as a programmable virtual human that can detect and respond to stimulus events with sub-millisecond accuracy. It enables you to check the accuracy of your own paradigm whilst running in-situ on your own equipment by using external sensors, TTL I/O and your own response devices.

To improve replication and enhance credibility all researchers should self-validate, or self-certify, their own studies in terms of millisecond presentation, synchronization and response timing accuracy.

Not ready for a Black Box ToolKit just yet. Our range of standalone USB response pads, voice keys and USB TTL event marking modules can all help improve your timing in any experiment generator!

To find out more about how we could help you improve your research please visit our website, www.blackboxtoolkit.com.

Serious about science: Serious about timing

The Black Box ToolKit

Measurement & Calibration Tools for Professionals

Welcome to the 8th Annual Meeting of the Society for the Neurobiology of Language

On behalf of the Board and the local organizers, I welcome you to London, the United Kingdom's largest and most cosmopolitan city. Our society is defined by a collective commitment to understand the neurobiological mechanisms of language. This commitment began with the aphasiologists of the 19th century and continues into the modern age with all its technological advantages.

This year, our meeting program spans both ancient and modern eras. It begins with a reception in the British Museum, with an expert introduction to the history of the Rosetta Stone. The Stone is probably the most iconic historical artefact specifically related to language. This is a perfect historical backdrop to our featured debate on a contemporary 'hot topic' in the field of neurobiology of language: the cognitive and neural consequences of bilingualism.

The keynote topics we have arranged for this year are diverse, encompassing the energetic design of the brain, the coupling of cortical oscillations with speech, and the neural adaptations necessitated by deafness and sign language. The major features of our meeting, the slide and poster presentations by members, continue to occupy pride of place. Acknowledging feedback from our members, we have organised poster sessions to allow more space for active discussion of presented work. In addition to the reception, we have arranged three social events, including a Science Showoff in nearby Bloomsbury and two Social Hours: one during an evening poster session and another in a conservatory and private garden. Aside from providing a respite from the scientific program, these events should provide ample opportunity to mingle and connect with colleagues from around the world.

As an indication that our Society and its Meetings continue to mature, we are proud to be able to offer childcare this year, and hope to make it a regular feature. I would like to express my thanks to colleagues on the Organizing Committee: Joe Devlin, Jonathan Peelle, and Lolly Tyler, and to our meeting planner Shauney Wilson and her colleague Shawna Lampkin, for helping organize this year's meeting. A special thank you goes to Steve Small who continues to successfully apply for NIH funding to support meetings of the Society he helped create. Thanks also go to all of our abstract reviewers who always ensure the excellent quality of our presentations.

I look forward to seeing you all at this year's meeting.

Greig de Zubicaray
Chair, Society for the Neurobiology of Language

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2016 Meeting

AUGUST 17-20, 2016

20 Bedford Way
UCL Institute of Education, London

Future Meetings

SNL 2017

Baltimore, Maryland, USA

SNL 2018

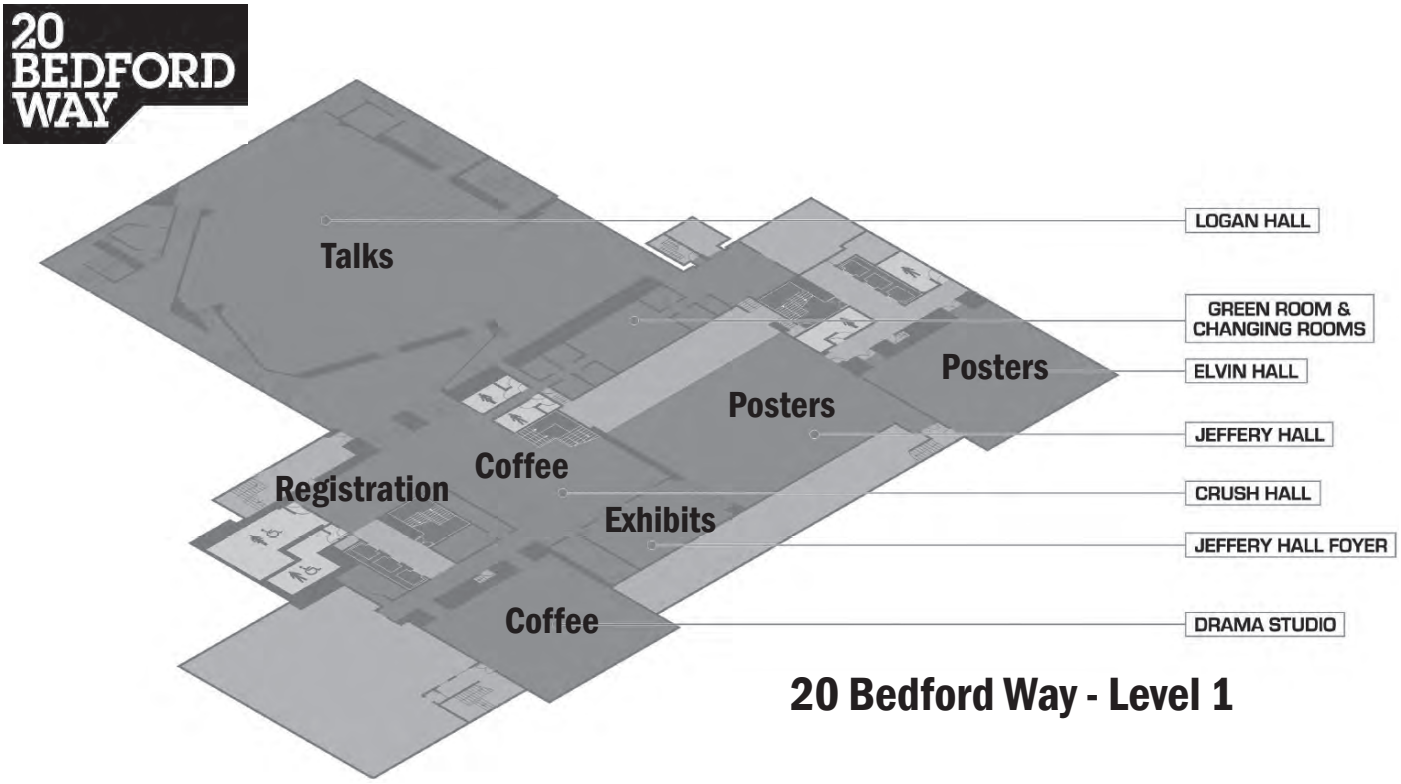
Québec City, Canada

Area Map

The 2016 meeting of the Society for the Neurobiology of Language is being held August 17-20, 2016, at 20 Bedford Way, UCL Institute of Education, London.

Venue Map

The entrance to 20 Bedford Way is on Level 2. SNL registration, talk sessions and posters are on Level 1 (see map below). Childcare (Committee Room 1), live streaming of talks (Committee Room 2), and overflow coffee break seating (Nunn Hall) are on Level 4.



Schedule of Events

Wednesday, August 17th

10:00 am – 5:30 pm	British Museum open to the public *Come early and enjoy the museum before the SNL Welcome Reception*
5:30 – 8:00 pm	Welcome Reception *Offsite, British Museum* *Museum gates close at 6:00 pm. No entrance to Welcome Reception after 6:00 pm.*
7:00 – 7:30 pm	Rosetta Stone Talk *At the SNL Welcome Reception, British Museum*

Thursday, August 18th

7:30 am – 6:00 pm	Meeting Registration *Crush Hall*
8:00 – 8:45 am	Coffee and Danish *Crush Hall, Drama Studio and Nunn Hall*
8:45 – 9:00 am	Opening Remarks: Greig de Zubicaray, Chair *Logan Hall*
9:00 – 10:00 am	**Keynote Lecture:** **Mairéad MacSweeney** Insights into the neurobiology of language processing from deafness and sign language *Logan Hall*
10:00 – 10:30 am	Coffee Break *Crush Hall, Drama Studio and Nunn Hall*
10:00 am – 12:00 pm	Poster Session A *Jeffery Hall and Elvin Hall*
12:00 – 1:30 pm	Lunch (on your own)
1:30 – 3:00 pm	**Debate: Ellen Bialystok and Manuel Carreiras** The consequences of bilingualism for cognitive and neural function *Logan Hall*
3:00 – 3:30 pm	Coffee Break *Crush Hall, Drama Studio and Nunn Hall*
3:00 – 5:00 pm	Poster Session B *Jeffery Hall and Elvin Hall*
5:10 – 6:30 pm	Slide Session A: Reading and Comprehension *Logan Hall*
6:30 pm	Social Hour *Offsite, Grange White Hall Hotel*
7:30 pm	Science Showoff: Brains and Language Special *Offsite, Bloomsbury Studio*

Friday, August 19th

8:00 am – 7:00 pm	Meeting Registration *Crush Hall*
8:00 – 8:45 am	Coffee and Danish *Crush Hall, Drama Studio and Nunn Hall*
8:45 – 9:00 am	Announcements *Logan Hall*
9:00 – 10:00 am	**Keynote Lecture: David Attwell** The energetic design of the brain *Logan Hall*
10:00 – 10:30 am	Coffee Break *Crush Hall, Drama Studio and Nunn Hall*
10:00 am – 12:00 pm	Poster Session C *Jeffery Hall and Elvin Hall*
12:00 – 1:30 pm	Lunch (on your own)
1:30 – 3:30 pm	Poster Session D *Jeffery Hall and Elvin Hall*
3:00 – 3:30 pm	Coffee Break *Crush Hall, Drama Studio and Nunn Hall*
3:40 – 4:00 pm	Business Meeting *Logan Hall*
4:00 – 5:20 pm	Slide Session B: Speech Perception and Prediction *Logan Hall*
5:30 – 7:30 pm	Poster Session E and Social Hour *Jeffery Hall and Elvin Hall*

Saturday, August 20th

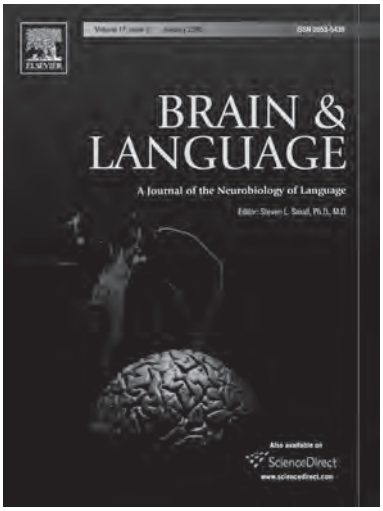
8:00 am – 1:40 pm	Meeting Registration *Crush Hall*
8:00 – 8:45 am	Coffee and Danish *Crush Hall, Drama Studio and Nunn Hall*
8:45 – 9:00 am	Announcements *Logan Hall*
9:00 – 10:00 am	**Keynote Lecture:** **Anne-Lise Giraud** Modelling neuronal oscillations to understand language neurodevelopmental disorders *Logan Hall*
10:00 – 10:30 am	Coffee Break *Crush Hall, Drama Studio and Nunn Hall*
10:00 am – 12:00 pm	Poster Session F *Jeffery Hall and Elvin Hall*
12:10 – 1:30 pm	Slide Session C: Language Disorders and Therapy *Logan Hall*
1:30 – 1:40 pm	Closing Remarks: Lorraine K. Tyler, Chair Elect *Logan Hall*

Sponsors

The Society for the Neurobiology of Language thanks the following sponsors for their support of our 2016 meeting.

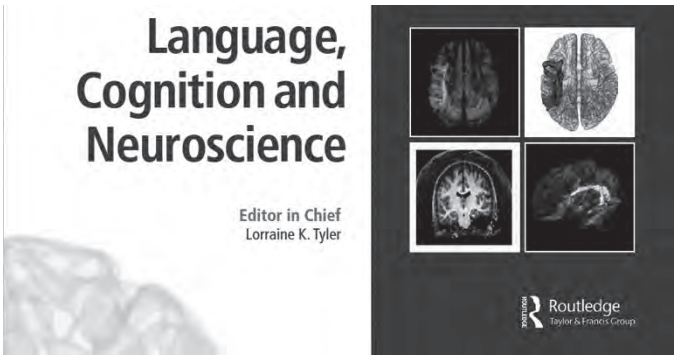
Brain & Language (Elsevier) Gold Sponsor

An interdisciplinary journal, Brain and Language focuses on the neurobiological mechanisms underlying human language. The journal covers the large variety of modern techniques in cognitive neuroscience, including lesion-based approaches as well as functional and structural brain imaging, electrophysiology, cellular and molecular neurobiology, genetics, and computational modeling. All articles must relate to human language and be relevant to an elaboration of its neurobiological basis. Along with an emphasis on neurobiology, journal articles are expected to take into account relevant data and theoretical perspectives from psychology and linguistics.



Language, Cognition & Neuroscience (Routledge) Silver Sponsor

Language, Cognition & Neuroscience publishes high-quality papers taking an interdisciplinary approach to the study of brain and language, and promotes studies that integrate cognitive theoretical accounts of language and its neural bases. The Journal publishes both high quality, theoretically-motivated cognitive behavioural studies of language function, and papers which integrate cognitive theoretical accounts of language with its neurobiological foundations.



Exhibitors

The Society for the Neurobiology of Language thanks the following SNL 2016 exhibitors. Please visit our exhibitors in Jeffery Hall Foyer.

Brain & Language (Elsevier) Gold Sponsor

See description under Sponsors.

Language, Cognition & Neuroscience (Routledge) Silver Sponsor

See description under Sponsors.

Brain Products

Brain Products dedicates itself to the research and understanding of the human brain and nervous system. The focus on positively impacting neuroscience made Brain Products the worldwide leading manufacturer of hard and software solutions for neurophysiological research. Our solutions cover the fields of: ERP, BCI, EEG/fMRI, EEG/TMS, as well as sports, sleep, behavioural sciences and similar disciplines. Since for us at Brain Products a solution is only solution if it covers all the researcher´s needs, we also provide caps, sensors, easily integrated stimulation software and much more.

Optoacoustics

Optoacoustics is the leader in high performance optical fiber-based sound and measurement solutions for functional, interventional and clinical MRI and MEG. Optoacoustics MR-safe microphones and headphones provide crisp, clear two-way communications. Our FOMRI-III noise cancelling microphone is today's standard for recording speech in fMRI. We've recently introduced OptoACTIVE slim headphones that actively/passively reduce >95% of EPI gradient noise and deliver high fidelity audio, enabling MR research that could not be done before.

Rogue Resolutions

At Rogue Resolutions, we specialize in bringing together and combining technologies, techniques and services for neuroscience and in doing so, help our customers to conduct robust, credible, replicable and cutting edge research. We achieve this by offering state of the art equipment combined with unrivalled service and support from our experienced team of product and application specialists.

Social Events

Welcome Reception and Rosetta Stone Talk

Wednesday, August 17
Reception: 5:30 – 8:00 pm, Talk: 7:00 - 7:30 pm
Clore Education Centre, British Museum

The museum closes to the public at 5:30 pm. The museum gates close at 6:00 pm. You must arrive before 6:00 pm to attend the SNL Welcome Reception.

SNL invites you to our Welcome Reception on Wednesday, August 17, 5:30 pm at the spectacular British Museum, just steps away from this year's meeting venue. Join your colleagues for an elegant evening of food, drinks and stimulating conversation at one of the world's oldest museums (established in 1753).

The museum us Britain's largest and is widely considered to be one of the world's greatest. The permanent collection comprises over 8 million objects spanning the history of the world's cultures from the stone tools of early man to twentieth century prints. The collection includes controversial items including the Elgin Marbles from the Parthenon in Greece and the Rosetta Stone from Egypt.

Don't miss this occasion to experience one of the world's greatest museums and an opportunity to socialize with colleagues and friends before the meeting commences. The British Museum is open from 10:00 am to 5:30 pm. Plan to spend the day or even just an hour before heading downstairs to the East and West Foyers beneath the Great Court in the Clore Education Centre. There is no admission fee for the museum.

The Rosetta Stone: Greek or Egyptian? Or both?

7:00 – 7:30 pm, During the SNL Welcome Reception

Speaker: Dr. Ilona Regulski

Dr. Ilona Regulski will discuss the role of the Rosetta Stone in understanding both ancient cultures, but also ancient writing systems and their relation to language. Dr. Regulski is the curator for the Rosetta Stone and the Egyptian papyrus collection at the British Museum. Her research focuses on the written culture of Ancient Egypt with concentration on inscribed material culture first-hand, an approach that materialized in a palaeographic study of early writing in Egypt. She is interested in how ancient writing systems came into existence independently in very different cultures and how their trajectories from pictographic to phonological representations developed.

Thursday Social Hour

Thursday, August 18, 6:30 pm
Offsite, Grange White Hall Hotel, Conservatory and Garden, 2-5 Montague Street

Join your colleagues for Social Hour after the meeting on Thursday evening at the charming Grange White Hall Hotel. The Conservatory and Garden will be reserved for SNL attendees only. Complimentary welcome drinks will be offered for the first 200 people.

The Grange White Hall Hotel is a six-minute walk from the meeting venue. To get to the hotel, turn right on Bedford Way; right at Russell Square; left at Montague St. The Grange White Hall Hotel will be on your right at 2-5 Montague Street.

Science Showoff: Brains and Language Special

Thursday, August 18, 7:30 pm
Bloomsbury Studio

Join eight brain experts for a night of chaotic science cabaret, hosted by comedian and celebrity nerd, Steve Cross. Expect to learn things, laugh at things and like things as our specially-chosen neuroscience and psychology brainboxes entertain you in any style they see fit for nine minutes each!

Performers to include Sophie Scott (UCL), Matt Davis (MRC CBU), Kathy Rastle (Royal Holloway), Jenni Rodd (UCL), Carolyn McGettigan (Royal Holloway), Zarinah Agnew (UCSF), Nadine Lavan (Royal Holloway) and Alex Billig (University of Western Ontario).

Admission: £6 in advance with promotion code, £8 at the door on the night of the event. Purchase tickets at https://www.thebloomsbury.com/event/run/16003. The SNL promotion code is "broca".

All profits from the ticket sales will go to local charities.

Bloomsbury Studio is a small theatre located on the UCL campus at 15 Gordon Street; a five block, 6-8 minute walk from the SNL meeting location. The theatre has room for only 70 people, so get there early if you want a seat.

Friday Social Hour

Friday, August 19, 5:30 – 7:30 pm
Crush Hall, Drama Studio and Nunn Hall

Friday evening's poster session will feature light snacks and a bar. Your first drink is on us. You'll find a drink ticket in the back of your badge.

Abstract Merit Awards

The Society for the Neurobiology of Language Abstract Merit Awards are given to the students and postdocs who submitted the highest ranked abstracts.

Graduate Student Merit Award Winners

Caroline Beelen, Parenting and Special Education, Faculty of Psychology and Educational Sciences, KU Leuven, Belgium

Dave Kleinschmidt, University of Rochester, USA

Post Doctoral Merit Award Winners

Anne Kosem, Donders Institute for Brain, Cognition, and Behaviour, Radboud University, Netherlands

Matthew Nelson, Institut National de la Santé et de la Recherche Médicale (INSERM) U992, and NeuroSpin Research Center, France

Travel Awards

This year, the Society for the Neurobiology of Language granted 25 Travel Awards. The awards, funded by the National Institutes of Health (NIH), help to cover travel and registration costs for the 2016 Society for the Neurobiology of Language Meeting in London.

Through the travel awards, SNL aims to encourage and foster the participation of junior scientists who are members of underrepresented groups.

The 2016 Travel Awards were given to:

Florencia Assaneo, New York University, USA

Elena Barbieri, Northwestern University, USA

Alexander Billig, Western University, Canada

Richard Binney, Temple University, USA

Idan Blank, Massachusetts Institute of Technology, USA

Faith Chiu, University College London, UK

Dawoon Choi, University of British Columbia, Canada

Shruti Dave, University of California, Davis, USA

Junhua Ding, Beijing Normal University, China

Laura Gwilliams, New York University, USA

Viviana Haase, Ruhr University of Bochum, Germany

Paul Hoffman, University of Edinburgh, Scotland

Lela Ivaz, BCBL, Spain

Sladjana Lukic, Northwestern University, USA

Barbara Marebwa, University of South Carolina, USA

Anne Mickan, Radboud University, Netherlands

Maxime Montembeault, University of Montreal, Canada

Lorelei Phillip, University of South Carolina, USA

Amy Price, University of Pennsylvania, USA

Katarzyna Rączy, Jagiellonian University, Poland

Miguel Santos, University of California, San Francisco, USA

Brielle Stark, University of South Carolina, USA

Yingying Tan, Max Planck Institute for Psycholinguistics, Netherlands

David Thornton, The University of Tennessee Health Science Center, USA

Maya Yablonski, Bar-Ilan University, Israel

Keynote Lecture: Mairéad MacSweeney

Mairéad MacSweeney
University College London

Dr. Mairéad MacSweeney is a Wellcome Trust Senior Research Fellow at the University College London Institute of Cognitive Neuroscience where she leads the Visual Communication group. She is also a Co-Director of the UCL Deafness, Cognition and Language Research Centre. She explores how the brain processes language through primarily visual means including reading, gesture, lipreading and sign language. Much of her research focusses on people who were born profoundly deaf.

INSIGHTS INTO THE NEUROBIOLOGY OF LANGUAGE PROCESSING FROM DEAFNESS AND SIGN LANGUAGE

Thursday, August 18, 2016, 9:00 – 10:00 am, Logan Hall

Chair: Greig de Zubicaray, Queensland University of Technology

The study of the neurobiology of language has, until recently, focussed primarily on auditory speech. In this talk I will consider how research with people born deaf can provide a unique perspective into the neural basis of language processing.

First, signed languages can be used as tools to determine the neural systems involved in processing language, regardless of whether it is seen or heard. I will review the current literature which suggests that the neural systems supporting signed and spoken language are very similar, both involving a predominantly left-lateralised perisylvian network. Yet they are not identical. Many recent studies highlight subtle differences between sign and speech processing. These findings have consequences for developing models of language processing that can be applied to all languages.

Second, examining how spoken languages, and representations of spoken languages, are processed in the absence of auditory input (e.g., lipreading/reading) provides unique insights into the influence of altered sensory experience on language processing. This research can help establish, for example, the role of auditory information in learning to read and may inform models of reading development.

Findings from this field further our understanding of how the brain processes language under conditions of altered sensory experience. Importantly however, it also encourages and stimulates the application of a wider, multimodal view of language and communication to the broader hearing population.

Debate: Ellen Bialystok & Manuel Carreiras

THE CONSEQUENCES OF BILINGUALISM FOR COGNITIVE AND NEURAL FUNCTION

Thursday, August 18, 2016, 1:30 – 3:00 pm, Logan Hall

Chair: Jonathan Peelle, Washington University in St. Louis

Ellen Bialystok

Distinguished Research Professor of Psychology at York University and Associate Scientist at the Rotman Research Institute of the Baycrest Centre for Geriatric Care

Ellen Bialystok is a Distinguished Research Professor of Psychology and Walter Gordon York Research Chair of Lifespan Cognitive Development at York University. She is also an Associate Scientist at the Rotman Research Institute of the Baycrest Centre for Geriatric Care. Her research uses both behavioral and neuroimaging methods to examine the effect of experience on cognitive processes across the lifespan, with most attention on the effect of bilingualism. Participants in these studies include children, younger and older adults, and patients, in an attempt to identify the mechanism by which experience modifies cognitive systems. She has published extensively in the form of books, scientific articles, and book chapters. She is a fellow of the Royal Society of Canada, Society for Experimental Psychology, American Psychological Society, and other professional organizations. Among her awards are the Canadian Society for Brain Behaviour and Cognitive Science Hebb Award (2011), Killam Prize for the Social Sciences (2010), York University President's Research Award of Merit (2009), Donald T. Stuss Award for Research Excellence at the Baycrest Geriatric Centre (2005), Dean's Award for Outstanding Research (2002), Killam Research Fellowship (2001), and the Walter Gordon Research Fellowship (1999). In 2016, she was named an Officer of the Order of Canada for her contributions to our understanding bilingualism and for opening up new avenues of research in her field.

Manuel Carreiras

Scientific Director of the BCBL (Basque Center on Cognition, Brain and Language), Donostia-San Sebastián, Spain

Manuel Carreiras is the Scientific Director of the BCBL (Basque Center on Cognition, Brain and Language, Donostia-San Sebastián, Spain) that has been recently awarded the "Severo Ochoa" label of excellence. He is also IKERBASQUE research professor, Honorary Professor of the UCL, and visiting professor of the UPV/EHU. His research focuses on reading, bilingualism and second language learning. He is the editor in chief of Frontiers in Language Sciences, and associated editor of Language, Cognition, and Neuroscience. He has published more than 200 papers in high impact journals in the field. His research has been funded by different research agencies. He was the coordinator of the Consolider-Ingenio2010 grant entitled COEDUCA, recipient of the ERC advanced grant entitled Bi-Literacy, recipient of the Euskadi Research Prize 2015, and others.

Talk Summary for Ellen Bialystok

There is now substantial evidence supporting the notion of lifelong neuroplasticity from intense experience, a situation that can lead to "cognitive reserve" in older age. The present proposal is that bilingualism is one such experience. Therefore, along with factors like formal education, aerobic exercise, and musical training, bilingualism has systematic consequences for both cognitive function and brain systems that benefit some aspects of cognitive performance and protect against cognitive decline in older age. The proposed mechanism by which these modifications occur will be explained, along with a summary of the evidence showing changes in cognitive and brain function across the lifespan that can be attributed to bilingualism. Following this, specific areas of the research that may appear to be inconsistent with this overall interpretation will be examined in more detail. The conclusion is that the body of evidence obtained from these studies of bilingualism and the underlying mechanism proposed to be responsible are consistent with the notion of lifelong neuroplasticity from bilingualism that lead to measurable changes in cognitive and brain function.

Talk Summary for Manuel Carreiras

Bilingualism and second language learning are interesting cases for understanding (1) whether effects of long term training generalize to other cognitive domains, and (2) brain plasticity. I will argue that, as documented in other cognitive domains, transfer of training effects are minimal. In particular, I will argue that bilinguals do not exhibit enhanced executive control as compared to monolinguals in several behavioral tasks when using tight controls and large samples. The so called "bilingual advantage" is non-existent or may stem from poorly matched samples or other uncontrolled factors. On the other hand, I will argue that the learning and daily use of two languages modulates structural and functional brain connectivity. However, the specific neural consequences of dealing with two languages are still a matter of debate since current findings are quite variable. In any case, it is important to note that differences between bilinguals and monolinguals in structural and functional brain connectivity cannot be used to argue against or in favor of the so called "bilingual advantage".

Keynote Lecture: David Attwell

David Attwell

Jodrell Professor of Physiology, University College London

David Attwell studied as an undergraduate in Oxford, first in physics and then in physiology. He subsequently did a PhD with Julian Jack, again in Oxford, studying the electrical properties of nerve and muscle cells, before moving to Berkeley to work on the retina in Frank Werblin's lab. On returning to the UK from California, he obtained a lectureship at UCL where he has been ever since, being appointed Jodrell Professor of Physiology in 1995 and made a Fellow of the Royal Society in 2001.

His research career has spanned a wide range of interests, including cardiac electrophysiology, visual information processing, synaptic channels and transporters, glial cells, and brain energy use and supply. He pioneered the use of patch-clamp methods to study how reversal of glutamate transporters causes neurotoxic glutamate release in stroke and related conditions, and (with Simon Laughlin) produced the first "energy budget" assessing the subcellular processes on which the brain uses energy. He has demonstrated that control of cerebral energy supply occurs, not only at the arteriole level, but also at the capillary level mediated by pericytes.

THE ENERGETIC DESIGN OF THE BRAIN

Friday, August 19, 2016, 9:00 – 10:00 am, Logan Hall

Chair: Joe Devlin, University College London

A universal constraint on the evolution of brains is that the nervous system's computational power is limited by its energy supply. By describing an energy budget for the grey matter of the mammalian CNS, I will explain how key design features of the brain are determined by the energy supply the brain receives as oxygen and glucose, and how matching of brain energy supply to brain energy use underpins BOLD functional magnetic resonance imaging. I will examine why the brain's white matter uses less energy than the grey matter, and whether myelination really saves energy. By examining how information flow along axons and through synapses relates to the energy used on these processes, I will show that a key concept in brain design is optimisation of information transfer per energy used. Finally, I will demonstrate that the primary locus of control of the brain's energy supply, and hence of the generation of BOLD fMRI signals, is in capillaries rather than arterioles, outline how dysfunction of this regulatory system occurs after stroke, and highlight the therapeutic opportunities this offers.

Keynote Lecture: Anne-Lise Giraud

Anne-Lise Giraud

Director, Auditory Language Group, Université de Genève

Anne-Lise was born in Lyon and lived there until she obtained her PhD in Neuroscience in 1997 on peripheral auditory neurophysiology. She did a post-doc at the Functional Imaging Lab in London between 1997 and 1999, where she studied the plasticity of auditory and visual systems during deafness and after cochlear implantation, using mainly positron emission tomography (PET) and fMRI. In 2001, Anne-Lise founded the Auditory Language Group, at the Brain Imaging Center in Frankfurt/Main Germany, where she worked on multisensory integration in speech processing.

The group survived a first move in 2004 to the Cognitive Neuroscience Lab of the DEC at Ecole Normale Supérieure Paris, where Anne-Lise took a CNRS research director's position, and a second one in 2012 to the Department of Neuroscience of the University of Geneva, where she is being appointed Director of Neuroscience. Anne-Lise is interested in the transformations of the neural code between cochlear speech encoding and access to meaning. She is particularly dedicated to using basic science to understand the causes of speech and language disorders.

MODELLING NEURONAL OSCILLATIONS TO UNDERSTAND LANGUAGE NEURODEVELOPMENTAL DISORDERS

August 20, 2016, 9:00 – 10:00 am, Logan Hall

Chair: Lorraine K. Tyler, University of Cambridge

Perception of connected speech relies on accurate syllabic segmentation and phonemic encoding. These processes are essential because they determine the building blocks that we can manipulate mentally to understand and produce speech. Segmentation and encoding might be underpinned by specific interactions between the acoustic rhythms of speech and coupled neural oscillations in the theta and low-gamma band. To address how neural oscillations interact with speech, we used a neurocomputational model of speech processing generating biophysically plausible coupled theta and gamma oscillations. We show that speech could be well decoded from the artificial network's low-gamma activity, when the phase of theta activity was taken into account. Based on this model we then asked what could happen to speech perception if different parts of the network were disrupted. We postulated that if low-gamma oscillations were shifted in frequency speech perception would still be possible, but phonemic units within syllables would have different format. Phonemic format anomalies could thus cause difficulties to map idiosyncratic phonemic representations, with universal ones, as those we are taught to become aware of when learning to read. A disruption of the auditory gamma oscillation could hence account for some aspects of the phonological deficit in dyslexia. Using MEG, and EEG combined with fMRI, we observed that dyslexia was associated with faster gamma activity in auditory cortex, and we found that this anomaly could explain several facets of the dyslexia phenotype. We also found that the theta/gamma coupling was preserved despite abnormal gamma frequency. Using a similar approach we reasoned that a disruption of the theta auditory network would likely cause more serious speech perception difficulties, such as perhaps those observed in autism spectrum disorders, as syllabic segmentation would also be altered. Using EEG combined with fMRI, we found that both theta activity and the coupling of auditory and gamma oscillations was profoundly abnormal in autism; this anomaly selectively predicted the severity of verbal impairment in autism. These data suggest that speech and language difficulties in dyslexia and autism can be brought together in a common theoretical framework involving the functional coupling between neural oscillations.

Attendee Resources

ATM

The closest ATM is located across the street in the Royal National Hotel lobby.

Abstracts

The full text of poster, slide, and symposium abstracts can be found in the SNL 2016 Abstracts book, which can downloaded in PDF format from www.neurolang.org.

Audio-Visual

An LCD projector (e.g., for PowerPoint presentations) will be provided in Logan Hall; 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. The stage is set with two lecturns which can be used for alternating between speakers. A switch box is provided to switch the projector display between lecturns. To avoid setup problems affecting your presentation, presenters are strongly encouraged to arrive at their scheduled room a minimum of 30 minutes before their talk.

Baggage Check

A secure space will be allocated for luggage on the last day of the meeting. All items will need to be picked up no later 2:00 pm. Although the space will be secure, items are left at your own risk.

Certificate of Attendance

A signed and dated Certificate of Attendance is on the back of your badge. If you require something additional, we will be happy to email or mail a copy after the meeting. Contact us at info@neurolang.org.

Childcare

Thanks to the funding from the National Institutes of Health, SNL is pleased to be able to offer onsite childcare at this year's meeting in London. We have contracted with Relief Creche Care, a mobile creche company based in London.

Childcare will be offered free of charge, on a first-come first-served basis, for children 0-10 years of age. Drop-ins may be accommodated onsite if room allows, but cannot be guaranteed. Childcare is in Committee Room 1 on Level 4 of 20 Bedford Way.

All Relief Creche Care staff are first aid qualified and DBS cleared with recognized childcare qualifications including NNEBs, NVQs, Degrees, PGCE & Nursing qualifications.

For questions, contact SNL staff at info@neurolang.org or Relief Creche Care at info@reliefcrechecare.co.uk.

Childcare Schedule

Thursday, August 18, 9:00 am – 1:15 pm, 1:30 – 6:30 pm
Friday, August 19, 9:00 am – 1:15 pm, 1:30 – 6:30 pm
Saturday, August 20, 9:00 am – 1:30 pm

Contact Us

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

Copying, Printing and Office Supplies

Liquid Imaging (23a Tavistock Place; http://www.liquidimaging.co.uk/) is a 5-minute walk from and offers copying and printing services, including large format printing (posters). Basic office supplies can be purchased from the store in the Student Union (same building as the meeting). A larger office supply store, Rymans, is located inside Waterstones Bookstore on the corner of Gower Street and Tavistock Road (5-minute walk).

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.

Coffee Service

Complimentary coffee and tea service is available to all registered attendees at the times shown below. Coffee service is in Crush Hall with overflow seating in Drama Studio and Nunn Hall (Level 4).

Thursday

Coffee and Danish, 8:00 - 8:45 am
Crush Hall, Drama Studio and Nunn Hall

Coffee Break, 10:00 - 10:30 am
Crush Hall, Drama Studio and Nunn Hall

Afternoon Coffee, 3:00 – 3:30 pm
Crush Hall, Drama Studio and Nunn Hall

Friday

Coffee and Danish, 8:00 - 8:45 am
Crush Hall, Drama Studio and Nunn Hall

Coffee Break, 10:00 - 10:30 am
Crush Hall, Drama Studio and Nunn Hall

Afternoon Coffee, 3:00 – 3:30 pm
Crush Hall, Drama Studio and Nunn Hall

Saturday

Coffee and Danish, 8:00 - 8:45 am
Crush Hall, Drama Studio and Nunn Hall

Coffee Break, 10:00 - 10:30 am
Crush Hall, Drama Studio and Nunn Hall

Future Meetings

SNL 2017 will be held in Baltimore, Maryland, USA

SNL 2018 will be held in Québec City, Canada

Internet

Internet access is complimentary:

1. Connect to the UCLGuest wireless network.
2. Go to any web page and you will be redirected to the UCLGuest Welcome page.
3. Click Self Service.
4. Complete the form to create an account. For the Event code, enter SNL2016.
5. Click Login and enter your username and password.
6. Click Accept.

Go directly to the Login page for subsequent connections.

Live Streaming of Talks

Live streaming of the talks in Logan Hall will be provided in Committee Room 2 on Level 4.

Local Dining

For a Google map of local coffee shops, restaurants and pubs, go to http://tinyurl.com/snl2016map.

Lost & Found

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

Meeting Rooms

All general sessions (Keynotes, Debate, and Slides) will be held in Logan Hall.

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 badges 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.

Onsite Meeting Registration

The SNL Registration Desk is located in Crush Hall, on the lower level of 20 Bedford Way at the UCL Institute of Education. The Registration Desk hours are:

Thursday, August 18, 7:30 am – 6:00 pm
Friday, August 19, 8:00 am – 7:00 pm
Saturday, August 20, 8:00 am - 1:40 pm

Parking

There is no parking available onsite. On-street parking in the neighborhood is available and managed by Camden Council. Private parking is offered within a few minutes' walk by National Car Parks (NCP).

Photography, Video and Recording

Photography, video and audio recording for personal use is permitted. Attendees are encouraged to tweet about the meeting using the hashtag #snlmtg16.

Poster Sessions

Posters are located in the Jeffery and Elvin Halls. See page 18 for the Poster Schedule.

Social Events

See page 7 for details on the SNL Social Events.

Social Media

Attendees are encouraged to tweet about the meeting using the hashtag #snlmtg16.

Smoking

Smoking is not permitted at 20 Bedford Way. A smoking area is provided outside the main entrance.

Speakers

Please ensure that you are available at least thirty minutes before the start of the session. See "Audiovisual" for technical information.

Transportation

SNL 2016 will be held at 20 Bedford Way, at the UCL Institute of Education. To reach us:

Traveling by Bus - Bus stops, within a 5 to 15-minute walk, are located on Euston Road, Gower Street, Tottenham Court Road, Woburn Place and Southampton Row. The closest are on Woburn Place and Southampton Row.

Traveling by Tube (underground)

The closest tube station to the venue is Russell Square which is a 5- minute walk, but there are six more within a 5 to 15-minute walk, including: Euston, Euston Square, Goodge Street, Tottenham Court Road, Holborn and Warren Street, providing excellent access to most parts of the city via the Northern, Piccadilly, Victoria, and Central Lines.

Traveling by Train

The closest station to the venue is Euston which is a 10-minute walk or a short taxi ride away. Kings Cross and St Pancras stations are less than a mile away and provide access to national and international rail links.

Traveling by Bicycle

There is a cycle-hire docking station on the east side of the main building, on Bedford Way. It is managed by Transport for London. Visitors arriving on their own bikes may lock them to the perimeter railing of the concourse, on the west side of the main building.

Slide Sessions

Slide Session A

Thursday, August 18, 5:10 – 6:30 pm, Logan Hall

Reading and Comprehension

Chair: Liina Pylkkänen

Speakers: Matthew Nelson, Caroline Beelen, Shruti Dave, Ina Bornkessel-Schlesewsky

5:10 pm

A1 Neurophysiological dynamics of phrase structure building during sentence reading *Matthew Nelson[1,2], Imen El Karoui[3,4,5,6], Kristof Giber[7], Laurent Cohen[3,4,5,6,8], Sydney Cash[7], Josef Parvizi[9], Lionel Naccache[3,4,5,6,8], John Hale[10], Christophe Pallier[1,2,11], Stanislas Dehaene[1,2,11,12]; [1]Institut National de la Santé et de la Recherche Médicale (INSERM) U992, [2]NeuroSpin Research Center, [3]Institut National de la Santé et de la Recherche Médicale (INSERM) U1127, [4]Centre National de la Recherche Scientifique (CNRS) UMR7225, [5]Université Paris 6, [6]Institut du Cerveau et de la Moelle Épinière Research Center (ICM), [7]Massachusetts General Hospital, [8]AP-HP Groupe hospitalier Pitié-Salpêtrière, [9]Stanford University, [10]Cornell University, [11]Université Paris 11, [12]Collège de France*

Although sentences unfold one word at a time, most linguistic theories agree that the proper description of language structures is not a linear sequence of words, but a tree structure of nested phrases. Yet this description remains a theoretical construct with neurophysiological underpinnings that have never been directly observed. Here we demonstrate intracranial neurophysiological evidence for the construction of such structures in the left hemisphere language network. Epileptic patients implanted with electrodes volunteered to perform a meaning-matching task of sentence pairs presented word-by-word using Rapid Serial Visual Presentation. Sentences of 3 to 10 words in length were automatically generated with a range of varied syntactic structures across sentences. Patients were asked to compare the meaning of the sentence to a second sentence presented after a 2-second delay. We analyzed the time-dependent broadband high gamma power (70 to 150 Hz), which is considered to be a reliable marker of the overall activation rate of the local neuronal population near the recording site. For electrodes located in key parts of the left hemisphere language network, particularly the left temporal pole (TP) and anterior superior temporal sulcus (aSTS), broadband high gamma power gradually builds-up with each successive word in the sentence. This built-up activity then collapses following moments when these words can be unified into a constituent phrase, and then builds-up again with the presentation of additional words in the next phrase of the sentence. This activity corresponds to the number of open nodes of a syntactic tree that could be built to represent the sentence, which we propose is reflected in this activity. Simultaneously, when the constituent unification events occur, electrodes in the left inferior frontal gyrus (IFG) and posterior superior temporal sulcus (pSTS) show a unique transient activation whose magnitude increases with the number of nodes being closed, and may reflect constituent structure building operations associated with the closing of the open nodes in the tree structure. We compare the data to precise computational linguistic models and find that the data most closely matches the operations of models of bottom-up parsing that can be implemented using push-down automata to parse incoming language into syntactic trees. We suggest that neural activity in the left-hemisphere language network reflects the sequence of steps leading to the formation of phrasal structures in this manner.

5:30 pm

A2 Pre-reading neuroanatomical anomalies related to developmental dyslexia *Caroline Beelen[1], Jolijn Vanderauwera[1,2], Maaike Vandermosten[1,2], Jan Wouters[2], Pol Ghesquière[1]; [1]Parenting and Special Education, Faculty of Psychology and Educational Sciences, KU Leuven, Belgium, [2]Research Group ExpORL, Department of Neurosciences, KU Leuven, Belgium*

Developmental dyslexia is a learning disability characterized by persistent reading and/or spelling impairments despite adequate intellectual and sensory abilities. This learning disability is considered a multifactorial deficit, caused by a complex interplay of genes, environment and cognitive abilities, expressed at the neural level. In the present study we investigated whether anatomical differences in specific reading-related regions are already present prior to reading and spelling instruction onset in children who develop dyslexia later on. For this purpose, we investigated cortical thickness and surface area sizes of specific brain regions derived from meta-analyses of Richlan et al. (Human Brain Mapping, 2009; Neuroimage, 2011), i.e. the fusiform, the left inferior, middle and superior temporal cortex, the left inferior parietal lobule (IPL) and the pars opercularis of the left inferior frontal gyrus (IFG). Since past research suggested that individuals with dyslexia rely more strongly on both hemispheres during reading-related tasks, we focused on their right hemispherical counterparts as well. The sample for the present study consisted of 55 pre-readers (mean age 6 years, 2 months) of which 31 children had a familial risk (FRD+) for developing dyslexia, defined by having a first-degree relative with dyslexia, and 24 children had no familial risk (FRD−). All children underwent an anatomical scan (T1) in a 3T-scanner at the end of kindergarten. The participants were retrospectively classified as typical readers (TR, n=41) and dyslexic readers (DR, n=14) based on reading and spelling tests at grade 2 and grade 3. Children scoring below the 10th percentile on a reading test at two time points, or children scoring below the 16th percentile on a reading test at two time points and below the 10th percentile on a spelling task at two time points, were considered dyslectic. In a first step, we compared dyslectic readers (n=14) with FRD− typical readers (n=24). Consecutively, we investigated whether differences in surface area and thickness sizes were either driven by dyslexia per se or by a familial risk for dyslexia. For this purpose, we compared all children developing dyslexia with all children developing typical reading skills, regardless of their familial risk (DR vs. TR), and we compared all children with and without a familial risk (FRD+ vs. FRD−). All structural T1 analyses were run using FreeSurfer software (www.freesurfer.net), implementing the Desikan-Killiany atlas. The results

revealed that surface area of the group of children who develop dyslexia later on differed from FRD− typical readers in the left fusiform, right pars opercularis and bilateral inferior temporal surface area. The DR children had a smaller surface area in these regions, which seemed to be driven by dyslexia per se in the left fusiform region and both by dyslexia and familial risk in the right inferior temporal region. Differences in cortical thickness were absent. To conclude, already at pre-reading age surface area anomalies in left and right hemispherical reading-related regions are present in children that develop dyslexia later on.

5:50 pm

A3 Age-Related Increase in Neural Noise Influences Predictive Processing during Reading

Shruti Dave[1,2], Trevor Brothers[1,2], Tamara Y Swaab[1,2]; [1]Center for Mind and Brain, Davis, CA, [2]University of California, Davis

The neural noise hypothesis (Crossman & Szafran, 1956; Cremer & Zeef, 1987) posits that age-related reductions in effective signal-to-noise in the brain can provide an explanation for cognitive slowing in normal aging. Recent studies (Voytek & Knight, 2015; Voytek et al., 2015) have attributed age-related increases in neural noise to desynchronized neuronal population spiking, such that age differences have been found in the shape of EEG power spectra as measured from the scalp. The goal of the present study was to determine if EEG spectra differences provide a reliable individual difference measure across tasks, and if age-related increases in neural noise also play a functional role in predictive language processing. In two experiments, EEG/ERP was recorded from two groups of younger adults (Experiment 1; n=24, mean=19.5, range=18-28; Experiment 2: n=24, mean=20.5, range=18-33) and one group of elderly participants (n=23, mean=72.0; range=64-79). In the first experiment, participants read single high cloze and low cloze sentences for comprehension. In the second experiment, participants read moderately constraining two-sentence passages, and were asked to actively predict the final word of each. Measures of neural noise were assessed in both experiments by calculating EEG spectra for each reader using a fast Fourier transform. The slope of the logged power spectral density (1/f neural noise) was calculated across a logged frequency range of 2-40Hz, excluding visual cortical alpha power (7.5-12.5Hz) (similar to procedures established in Voytek et al., 2015). Compared to younger adults, elderly readers showed reductions in low-frequency power and increases in the high-frequency range. 1/f slopes differed across groups for each task (t=4.77, p<.001 for comprehension task; t=3.53, p<.001 for prediction task), and neural noise showed a strong correlation with age (R=.60, p<.001). These findings replicate the results of Voytek et al., 2015 in showing increased neural noise for older in comparison to younger adults. In ERP analysis of the prediction task, significantly reduced N400 amplitudes were observed for correctly predicted passage-final words (Brothers et al., 2015, Dave et al., 2015), but these N400 effects were typically delayed and reduced in amplitude for elderly readers. Across young and older participants, neural noise was a significant predictor of the amplitude (R=.35,p=.02) and latency (R=.42,p=.004) of the N400 prediction effect, such that higher noise was associated with slower, smaller N400 benefits from prediction accuracy. Therefore, we found that age-related differences in neural noise impact predictive processing during language comprehension, contributing to reduced and delayed N400 prediction effects in older readers. When assessing how consistent neural noise is in adults, irrespective of task, we found that 1/f noise slope was highly reliable for elderly readers across both experiments (R=.82, p<.001), suggesting that neural noise is a consistent individual performance measure. 1/f neural noise may, as a result, provide a powerful tool to investigate cognitive declines among healthy aging adults.

6:10 pm

A4 Social categorisation affects sentence comprehension: the role of the angular gyrus as a multimodal hub for contextualised event interpretation

Ina Bornkessel-Schlesewsky[1], Sabine Frenzel[2], Arne Nagels[2], Alexander Droege[2], Jens Sommer[2], Richard Wiese[2], Tilo Kircher[2], Matthias Schlesewsky[1]; [1]University of South Australia, [2]University of Marburg

Social categorisation, in which fellow humans are classified into a socially relevant in-group (IG) or a socially disregarded out-group (OG), is an integral part of human social interaction (e.g. Tajfel, 1978). It not only structures our world in terms of social relations, but is also a driver for discriminatory behaviour (i.e. IG favouritism or OG discrimination). IG bias is thought to result from a strong association between the IG and the self (e.g. Tajfel & Turner, 1979). In many languages of the world, the IG bias is reflected in contrasts (e.g. in morphological marking) between 1st (self) and 3rd person referents. During language comprehension, the self appears to serve as a model for the actor of a sentence (i.e. the person or thing primarily responsible for the state of affairs described), possibly via embodied simulation (e.g. Bornkessel-Schlesewsky & Schlesewsky, 2013). Here, we tested the hypothesis that social categorisation modulates the neural correlates of language comprehension, and specifically of causal attributions during sentence comprehension. In an auditory fMRI study, we manipulated the IG or OG status of the speaker as well as competition for the actor role. Sentences were uttered from a 1st person perspective (i.e. the speaker was the actor) and the undergoer argument was either a second person pronoun (very high actor potential), a noun phrase (NP) referring to a human (high actor potential) or an NP referring to an inanimate NP (low actor potential). (Example, translated from German: I praise you/the scientist/the essay; high/medium/low actor competition) Thirty-two native speakers of German (15 female; mean age: 24.7) listened to sentences of this type. Prior to the fMRI scanning, participants filled in a fictitious personality questionnaire and received random feedback about their problem solving strategy (classifying them as either a sequential or a conclusive problem solver). Participants were told that the speakers uttering the sentences were either sequential or conclusive problem solvers, thus classifying them as either IG or OG members according to a minimal group paradigm (e.g. Tajfel et al., 1971). In a small proportion of trials, participants judged either the most likely cause of the state of affairs just described (the speaker or another person/situation) or the problem-solver strategy of

the speaker they had just heard. We observed an interaction between speaker group and actor competition in the right angular gyrus (AG), with increased competition leading to an activation increase for an OG speaker and to an activation decrease for an IG speaker. This result cannot be explained via length differences between the 2nd person pronoun and the two full NPs, as the activation pattern reversed according to the social status of the speaker. Our findings support the perspective that the AG serves as a "cross-modal integrative hub" for event interpretation within a broader context and in support of intended action (Seghier, 2013). The novel contribution of the present study lies in the demonstration that this contextualised, cross-modal interpretation appears to be influenced by the hearer's social categorisation of the speaker.

Slide Session B

Friday, August 19, 4:00 – 5:20 pm, Logan Hall

Speech Perception and Prediction

Chair: Ina Bornkessel-Schlesewsky

Speakers: Jona Sassenhagen, Dave F. Kleinschmidt, Helen Blank, Matthias J. Sjerps

4:00 pm

B1 Multilevel modeling of naturalistic language processing: An application to cross-level predictive processes

Jona Sassenhagen[1], Christian J. Fiebach[1]; [1]University of Frankfurt

For speech, a multilevel message has to be encoded into a one-dimensional, interference-prone, narrow-band channel. As a consequence, listeners have to instantaneously reconstruct multilevel structures from impoverished input. Predictive Coding frameworks suggest this process is made possible by relying on contextual predictability, highlighting the importance of investigating prediction error signals. Prediction error responses have been observed in multiple experiments, but we develop a framework for studying the interaction of surprisal and contextual support (1) in coherent natural (as opposed to artificially constructed) language, and (2) simultaneously across multiple linguistic levels (rather than by experimental isolation of specific levels of linguistic representation). Massive, time-resolved regression analysis of neural time series (Smith & Kutas, 2015) was combined with state-of-the-art tools from computational linguistics that quantitatively describe the speech signal at multiple levels, allowing for model-based, multilevel analysis of naturalistic language processing. For multiple experiments (EEG and MEG; $n > 75$), we algorithmically generated multi-level (i.e., combined phonetic, semantic, syntactic ...) descriptions of natural linguistic stimuli (homogenous sentences, popular audio books). For example, semantic-level predictors included word frequency, vector estimations of word meanings, and information-theoretic measures (such as entropy); syntactic predictors included, e.g., distance to the syntactic head. To compute neural responses to each of these representational levels, we jointly analyzed full data sets (in contrast to an analysis of specific epochs). The time-resolved, multilevel predictor matrices and the full neural time series are treated as linear systems and solved for the least-squares coefficients, corresponding to the independent change of the neural responses per unit of each predictor over time. These coefficient vectors also constitute encoder models that predict neural responses, allowing a statistical test if a feature significantly contributes to the prediction of the whole brain signal. Using this approach, we observe statistically significant signatures of predictive coding across levels of linguistic representation. More specifically, on each representational level, primary primary effects are increasingly attenuated by increasing amounts of (top-down, predictive) constraint from the sentence context. For example, we observe that early word onset-locked temporal cortex activity (equivalent to the N100) is more attenuated later compared to earlier in a text, when listeners become attuned to the rhythm of speech. Also, higher-level surprisal effects, e.g., an N400-like response to unconditional word probability in coherent sentences, are attenuated for contextually predictable words. We also observed cross-level interactions, e.g., between semantic predictability effects and low-level acoustic effects, corresponding to an attenuation of low-level surprise if individual words are better predictable. Using cross-validated prediction of the EEG signal, we observe that a multilevel model predicts neural activity significantly ($r > .11$, $p < 0.01$), and better than simpler single-level models. In conclusion, our data demonstrate the feasibility of accounting for the richness of naturalistic language in electrophysiological investigations. Our method can be employed as a plug-and-play test for a wide range of linguistic theories, to the degree to which they are well specified. It highlights the interaction of simultaneous predictive processes across multiple levels of naturalistic language.

4:20 pm

B2 Neural mechanisms for coping with talker variability by rapid distributional learning

Dave F. Kleinschmidt[1], T. Florian Jaeger[1], Rajeev Raizada[1]; [1]University of Rochester

Talker variability presents a substantial problem for speech perception: successful and efficient comprehension of each individual talker's speech requires a different mapping between acoustic cues and phonetic categories. Listeners rapidly recalibrate to an unfamiliar talker's accent, adjusting their category boundaries based on talker-specific distributions of acoustic cues (e.g., Norris, McQueen, and Cutler 2003; Kleinschmidt and Jaeger 2015). The neural mechanisms of this rapid learning, however, are not clearly understood. Previous work has focused on the mechanisms on how audiovisual or lexical labels are integrated with ambiguous cues to drive learning, but these labels are not in general available to listeners. We take a different approach, probing the mechanisms by which purely distributional information changes phonetic classification of a /b/-/p/ continuum (cued by voice-onset time, VOT). In our experiment, 20 listeners (plus 2 excluded for not categorizing reliably) performed a distributional learning task while being scanned with fMRI. On each of 222 trials, listeners classified b/p minimal pair words, indicating by button press whether they heard, e.g., "beach" or "peach". Each word's VOT was randomly drawn from a bimodal distribution, which implied a particular category boundary. Listeners heard either a low- or high-VOT

"accent", which differed only in terms of the distribution of VOTs. Critically, for both accents, 0ms VOT is a /b/, and 40ms is a /p/. But for the low-VOT accent, 20ms clusters with the higher-VOT /p/ distribution, and for high-VOT accent, 20ms clusters with the /b/s. All three of these stimuli occur equally frequently within and across accents. Behaviorally, listeners did learn the different accents, classifying the 20ms VOT stimulus more often as /b/ in the high VOT accent condition than the low. Brain images were collected with fMRI using clustered volume acquisition (2s TA, 3s TR) with a 3, 6, and 9s jittered TOA. We performed a searchlight similarity analysis of these images to determine where talker-specific VOT-category mappings could be decoded. We extracted activity patterns for each unique VOT via GLM. Within 3-voxel (6mm) radius searchlights, we calculated the similarity of the 20ms VOT stimuli to 0ms and 40ms based on the correlation of the searchlight pattern pairs (across runs to mitigate collinearity). We tested whether the (listener-specific) within-category pair was more similar than the between category pair for each searchlight, and randomly permuted accent condition labels to get the null distribution of largest cluster extent ($t>4$) and maximum t value. The largest cluster was in the left inferior parietal lobule (IPL; peak: -40, -52, 20), with 53 voxels ($p < 0.05$), and contained the largest $t = 8.7$ ($p < 0.001$). Previous work has shown the IPL plays a role in adjusting phonetic categories based on audiovisual (Kilian-Hütten, Vroomen, and Formisano 2011) and lexical labels (Myers and Mesite 2014). We find that the IPL represents rapidly learned talker-specific phonetic category structure, even when that information must be extracted from the distribution of acoustic cues alone, suggesting a more general role in flexibly recognizing speech in the face of talker variability via distributional learning.

4:40 pm

B3 Predictive coding but not neural sharpening simulates multivoxel fMRI response patterns during speech perception

Helen Blank[1], Matthew H Davis[1]; [1]MRC Cognition and Brain Sciences Unit, Cambridge, UK

Successful speech perception depends on combining sensory input with prior knowledge. However, the underlying mechanism by which these two sources of information are combined is unknown. Two different functional mechanisms have been proposed for how expectations influence processing of speech signals. Traditional models, such as TRACE, suggest that expected features of the speech input are sharpened via interactive activation. Conversely, Predictive Coding suggests that expected features are suppressed such that unexpected features of the speech input are processed further. The present work aimed at distinguishing between these two accounts of how prior knowledge influences speech perception. We analysed sparse imaging fMRI data from 21 healthy participants. To investigate the effect of prior knowledge on speech perception, participants read neutral ("XXX") or matching written words before hearing degraded spoken words (noise-vocoded at 4- and 12-channels). In catch trials, participants said aloud the previous written or spoken word. By combining behavioural, univariate and multivariate fMRI measures of how sensory detail and prior expectations influence speech perception, we tested computational models that implemented Predictive Coding and Sharpening mechanisms. To do this, we focused on the representation of speech in the left posterior superior temporal sulcus (pSTS) since previous studies showed that prior knowledge influences the magnitude of activity in this brain region during speech perception. Behavioural results showed that both increased sensory detail and informative expectations improve the accuracy of word report for degraded speech. Univariate fMRI analysis revealed a main effect of matching vs. neutral prior knowledge on BOLD response magnitude in the left pSTS ($p<0.05$ FWE voxel correction). Mean beta values extracted from this region showed a reduction during match in contrast to neutral conditions. Our computational simulations of Sharpening and Predictive Coding during speech perception could both explain these behavioural and univariate fMRI observations. However, multivariate fMRI analyses revealed that sensory detail and prior expectations have interacting effects on speech representations: Increased sensory detail enhanced the amount of speech information measured in superior temporal multivoxel patterns only when prior knowledge was absent, but with informative expectations the amount of measured information during presentation of clearer speech was reduced. This interaction revealed by multivariate fMRI observations was uniquely modelled by Predictive Coding and not by Sharpening simulations. In summary, the present results show that both increased sensory detail and matching prior expectations improved accuracy of word report for degraded speech but crucially had interacting effects on speech representations in the pSTS. The combination of multivariate fMRI analysis with computational modelling was methodologically critical to discriminate Predictive Coding from Sharpening mechanisms and provides a unique contribution to understand the observed interaction of sensory detail and matching prior expectations. Our findings support the view that the pSTS does not represent the expected, and therefore redundant, part of the sensory input during speech perception, in line with Predictive Coding theories.

5:00 pm

B4 Hierarchical, acoustically-grounded, distinctive features are the dominant representations of perceived speech

Matthias J. Sjerps[1,2], Matthew K. Leonard[3], Liberty S. Hamilton[3], Keith Johnson[2], Edward F. Chang[3]; [1]Radboud University, Nijmegen, the Netherlands, [2]University of California, Berkeley, United States, [3]University of California, San Francisco, United States

INTRODUCTION: Previous large-scale behavioral studies of speech sounds presented in noise have shown that some speech sounds are more likely to be confused than others, and these confusions are related to distinctive features in those speech sounds: Consonant-Vowel syllables (CVs) that differ only in place of articulation (e.g., /pa/ vs. /ka/) are more likely to be confused with each other compared to sounds that differ only in frication (e.g., /ta/ vs. /za/), which are in turn more likely to be confused than those that differ only in voicing (e.g. /sa/ vs. /za/). This result suggests that these features are, perceptually, represented in a hierarchical relation (where Voicing is more robust to distortion than Frication, which is in turn more robust than Place). In addition, recent work from our lab has indicated that acoustically-grounded distinctive features are the dominant form of representation in secondary

auditory cortex during (passive) listening under clear conditions. Others, however, have suggested that gesturally-grounded distinctive features encoded in production-related cortical regions are involved in speech perception as well, especially under challenging listening conditions. Here we addressed two questions: (1) Is the feature-hierarchy that has previously been reported in perception reflected in neural encoding of speech? And, (2) Does activity observed in motor regions, especially when speech is presented in noise, provide additional discriminative information? METHODS: Three epilepsy patients, implanted with subdural high-density electrocorticography (ECoG) grids over the left hemisphere for clinical purposes, participated in the study. Coverage included the superior temporal gyrus (STG), middle temporal gyrus (MTG), inferior frontal gyrus (IFG), and sensorimotor cortex (SMC). While neural activity was recorded from these areas, participants listened to 12 CV sounds (e.g., /pa/, /ta/, /sa/ etc.) and indicated what sound they perceived. Stimuli were presented in clear conditions (without noise), or embedded in white noise with a signal-to-noise ratio of +6dB or 0dB. RESULTS & DISCUSSION: We examined distances between in neural encoding of these CVs with Multi-Dimensional Scaling to investigate whether the perceptual hierarchy mentioned above was also reflected in auditory responsive cortical regions. We found that CVs with the same distinctive features show similar spatiotemporal patterns of activity across speech responsive regions in peri-Sylvian cortex, and that these representations indeed adhere to the same hierarchy (Voicing>Frication>Place). We also compared the discriminability of different CVs in cortical regions typically associated with speech perception (STG & MTG) with regions typically associated with speech production (IFG & SMC). We observed that whereas perception regions discriminated between CVs, production regions did not allow for meaningful discrimination, regardless of the SNR level. This observation argues against a direct role for motor-regions in discriminating between speech sounds, whether in clear or more challenging listening conditions. Together, the results show that hierarchically organized distinctive features, grounded in acoustic similarities, are the dominant representation of speech sounds.

Slide Session C

Saturday, August 20, 12:10 – 1:30 pm, Logan Hall

Language Disorders and Therapy

Chair: David Corina

Speakers: Idan Blank, Diego L. Lorca-Puls, Magdalena Sliwinska, Kyrana Tsapkini

12:10 pm

C1 Functional reorganization of the brain networks that support language processing following brain damage in aphasia

Idan Blank[1], Sofia Vallila-Rohter[2], Swathi Kiran[2], Evelina Fedorenko[3]; [1]MIT, [2]Boston University, [3]Massachusetts General Hospital

Studies of functional brain reorganization in people with aphasia (PWAs) focus on fronto-temporal language regions (Binder et-al., 1997) because they respond selectively to language in healthy adults (Fedorenko et-al, 2011), and damage to them compromises linguistic processing (Geschwind, 1970; Bates et-al, 2003). The prevailing hypothesis is that language processing in PWAs relies on spared, ipsi-lesional left-hemispheric language regions (Cao et-al., 1999; Fridriksson, 2010) or contra-lesional, right-hemispheric homologues (Dressel et al., 2010; Vitali et al., 2007). However, in healthy adults, language processing additionally recruits fronto-parietal multiple-demand (MD) regions (Duncan, 2010). MD regions constitute a distinct functional network: they are domain-general, responding across diverse demanding tasks (Fedorenko et-al., 2013), and their activity is not synchronized with activity in language regions during naturalistic cognition (Blank et-al., 2014). Importantly, however, language processing, especially when effortful, does engage the MD network (e.g., reading nonwords, ambiguous or syntactically complex constructions) (Fedorenko, 2014). We therefore hypothesize that MD regions increase their involvement in linguistic processing in PWAs, "coming to the language network's rescue". Indeed, some neuroimaging studies of PWAs report activations outside the language network during language processing (e.g., Brownsett et-al., 2014; Geranmayeh et-al., 2014; Meier et-al., 2016). However, interpreting these effects as MD activations is challenging because studies rely on group-based analyses that are not sensitive to inter-individual differences in the locations of MD and language regions, which lie side-by-side in the frontal cortex (Fedorenko et-al., 2012). Consequently, here we defined language and MD regions functionally, in each individual PWA, and characterized them. Eight PWAs (50-72yo; aphasia quotient: 34-97%) were scanned in fMRI at least 6 months following a left-hemispheric stroke. Sixty young participants (18-30yo) served as controls. Six bilateral language regions of interest (ROIs) were defined in each participant (Nieto-Castañón & Fedorenko, 2012) via reading of sentences vs. nonwords (speed-adjusted for PWAs) (this reliable localizer generalizes across tasks and input modalities; Fedorenko et-al., 2010). Nine bilateral MD ROIs were localized using a validated spatial working-memory task (more vs. fewer locations; difficulty-adjusted for PWAs) (Fedorenko et-al., 2013). All ROIs were tested for the Sentences>Nonwords effect-size (in independent data) and for inter-regional correlations of resting-state activity time-courses. Left language ROIs were similar across PWAs and controls in their Sentences>Nonwords effect-size, its spatial extent, and their synchronized resting-state activity. Right language ROIs trended towards a stronger Sentences>Nonwords effect in PWAs than in controls, suggesting increased recruitment during language processing. However, their resting-state synchronization patterns remained unaltered. Strikingly, in PWAs, several MD ROIs showed a "language-like" Sentences>Nonwords effect opposite to the expected Nonwords>Sentences effect. Moreover, in PWAs, left inferior frontal gyrus (opercular) and precentral gyrus MD regions showed greater resting-state synchronization with the language network than with the MD network, violating the language-MD dissociation. Controls did not show these effects even if we limited their ROIs to fall outside the lesion sites of PWAs. Aditionally, results did not generalize to non-MD frontal voxels surrounding language ROIs. Therefore, some

MD regions qualitatively alter their role within the networks engaged in language processing in PWAs, possibly supporting language recovery.

12:30 pm

C2 A new TMS-guided lesion-deficit mapping approach identifies brain areas where stroke damage impairs phonological processing

Diego L. Lorca-Puls[1], Andrea Gajardo-Vidal[1,2], Mohamed L. Seghier[1,3], Alexander P. Leff[1], Varun V. Sethi[1], Susan Prejawa[1,4], Thomas M. H. Hope[1], Joseph T. Devlin[1], Cathy J. Price[1]; [1]University College London, [2]Universidad del Desarrollo, [3]Emirates College for Advanced Education, [4]Max Planck Institute for Human Cognitive and Brain Sciences

INTRODUCTION: Transcranial magnetic stimulation (TMS) focused on either the left anterior supramarginal gyrus (SMG) or left pars opercularis (pOp) significantly increases response latencies during phonological relative to semantic tasks (Gough, Nobre, & Devlin, 2005; Sliwinska, James, & Devlin, 2015). Here we sought to establish whether the effects of these transient "virtual lesions" in healthy participants predict long term outcome of phonological abilities in patients with permanent damage to either SMG or pOp. METHODS: Our participants were 154 right-handed, English-speaking adults, 1-5 years after a left-hemisphere stroke selected from the PLORAS database, whose brain lesions were identified from high-resolution T1-weighted MRI scans using an automated procedure in SPM8. In order to establish how consistently our TMS-guided search for lesion sites identified patients with phonological difficulties, we, first, created two spherical regions of interest (ROIs) centred on the mean MNI coordinates reported in the TMS studies: xyz = [-52 -34 30] for SMG and [-52 16 8] for pOp, each with a radius of 5 mm (i.e. 0.5 cm3 in volume). Second, we grouped all the patients according to whether or not their lesions loaded heavily on either, both or neither (i.e. control group) of the TMS ROIs. And, finally, we compared the incidence and severity of difficulties on phonologically and semantically demanding tasks (from the Comprehensive Aphasia Test) across and within groups. RESULTS: The incidence and severity of phonological difficulties was significantly worse for patients in the SMG or pOp groups compared to the control group, but when lesion size was carefully matched across groups, only the difference between the SMG and control groups remained significant. Further investigation into the SMG and pOp lesions that were associated with phonological difficulties showed that these were far larger (>20 times) than the initial regions of interest from TMS. For 11/12 and 12/13 patients with phonological difficulties in the SMG and pOp groups, respectively, damage extended deep into the underlying white matter (WM). To quantify the importance of these extended regions (i.e. SMG+WM and pOp+WM), we reclassified all 154 patients according to whether or not their lesions loaded heavily on: SMG+WM, pOp+WM, both or neither. The incidence and severity of phonological difficulties in the SMG+WM or pOp+WM groups was significantly worse than that in the control group, even after accounting for the effect of lesion size. Moreover, the SMG+WM and pOp+WM lesions had a larger impact on phonologically than semantically demanding tasks; and the difference between phonological and semantic performance was significantly greater for both the SMG+WM and pOp+WM groups than the control group. CONCLUSIONS: We have shown how the effect of TMS-induced transient lesions in healthy participants guided the identification of lesion sites associated with persistent phonological difficulties 1-5 years post-stroke. Furthermore, the extent of the identified regions raises the possibility that the effect of TMS might be emerging from disruption to much larger areas than the recorded site of stimulation. Our novel TMS-guided analysis could be used to guide the search for lesion sites that predict language outcome after stroke.

12:50 pm

C3 Defining the importance of domain-general brain systems in language.

Magdalena Sliwinska[1], Ines Violante[1], Adam Hampshire[1], Robert Leech[1], Joseph Devlin[2], Richard Wise[1]; [1]Imperial College London, [2]University College London

There is now good evidence indicating that domain-general brain systems play a central role in various language processes, and potentially in the recovery from post-stroke aphasia. Part of the so-called salience network, consisting of adjacent areas in the midline superior frontal gyrus (SFG) and dorsal anterior cingulate cortex (dACC), forms a core component of these distributed systems. This study was designed to collect proof-of-principle data on healthy individuals, prior to a study on post-stroke aphasia, to assess whether our novel vocabulary learning task activates the salience network and whether cortical stimulation applied to this midline frontal brain region can influence vocabulary learning. In the first part of the study, twenty volunteers participated in a fMRI study where they were asked to learn associations between well-known objects and pseudowords. Without prior training, participants were asked to judge whether a novel heard pseudoword was the 'correct' name for an object they saw on a screen. After each trial, participants received feedback on their performance, which trained them in the arbitrary object-word associations over repeated trials. Each participant completed four blocks of this task and in each block they learnt five different associations. Each block was organized into four mini-blocks to track the learning process. Participants also performed an easy baseline task in which they were asked to determine whether a picture of a common object was correctly paired with a heard real word. The baseline task also involved a 'yes-no' decision on object-word associations but in the absence of new vocabulary learning. Successful learning was clearly reflected in the behaviour data. There was a significant linear improvement of accuracy and response times across each block of the learning task and performance in the final stage of this task did not differ from performance in the control task. At the same time, neuroimaging data demonstrated significantly increased activation in the midline SFG/dACC when the learning task was contrasted with the baseline task. In addition, activation in this region decreased across trials as learning progressed. In the second part of the study, fifteen volunteers participated in three separate TMS sessions. During each session they received off-line TMS for 10 mins at a frequency of 1Hz, with intensity set to 55% of the maximum stimulator output. In the first session, TMS was applied to the midline SFG and participants performed the novel vocabulary-

learning task. In the second session, participants received the same stimulation but they performed the baseline task. In the final session, participants performed the learning task, but after TMS had been applied to a more posterior midline control site. There was improved accuracy and faster responses in the first two mini-blocks of the learning task when stimulation was applied to the midline SFG. These results were specific to the learning task and stimulation to the midline SFG. This study clearly demonstrates the importance of the salience network during task-dependent language processes and it informs a future study in post-stroke aphasia, to determine whether stimulation of the SFG improves vocabulary relearning after aphasic stroke.

1:10 pm

C4 Imaging tDCS intervention effects in primary progressive aphasia

Kyrana Tsapkini[1], Andreia Faria[1], Ashley Harris[2], Yenny Webb-Vargas[3], Tushar Chakravarty[1], Bronte Ficek[1], Brenda Rapp[4], John Desmond[1], Richard Edden[1], Constantine Frangakis[3], Martin Lindquist[3], Argye Hillis[1]; [1]Johns Hopkins Medicine, [2]University of Calgary, [3]Johns Hopkins School of Public Health, [4]Johns Hopkins University

Primary progressive aphasia (PPA) is a clinical neurodegenerative syndrome that first and foremost affects language abilities. Recent evidence supports beneficial effects of tDCS after 10-15 sessions of intervention; however, the neural mechanism for these effects remains unclear. We used a multi-modality imaging approach (Faria et al. Neuroimage 2012; 61(3) 613-621) to identify changes in functional and structural connectivity (as measured by resting-state fMRI and diffusion tensor imaging, respectively) associated with tDCS in individuals with PPA. Additionally, we tested the hypothesis that one of the mechanisms through which tDCS works is by lowering GABA (an inhibitory neurotransmitter) in the stimulated area, as has previously been shown in healthy controls after a single application during motor learning (Stagg et al. Current Biology 2011; 21(6) 480-484). . We report on volumetric (MPRAGE), resting-state fMRI (rsfMRI) and diffusion tensor imaging (DTI) data from 13 participants before, immediately after, and two months after intervention. The intervention was anodal tDCS at the left inferior frontal gyrus (IFG) or sham stimulation for 15 daily sessions coupled with language therapy targeting written word production (spelling). We also report on GABA measurements in the left IFG (stimulated area) vs. right sensory-motor cortex (control area) in 19 participants before vs. after anodal tDCS vs. sham. The rsfMRI analysis revealed no differential change in connectivity from pre- to post-treatment for the tDCS condition compared to sham as measured by the correlation between the stimulated area and the rest of the spelling ROIs within the left hemisphere. However, functional connectivity between the left and right IFG increased significantly more in the tDCS condition relative to sham. This connectivity between the right and left IFG positively correlated with volume of right IFG and with improvement in behavioral scores even 2 months post-treatment. Functional anisotropy (FA) in white matter beneath both right and left IFG did not change due to either tDCS or sham. GABA significantly decreased in the left IFG but not in the right sensory-motor cortex, and only in the tDCS condition, whereas it remained the same in sham. In this study we identified two possible brain mechanisms for the effects of tDCS in PPA. First, we showed the contribution of GABA in long-term effects of tDCS: multiple consecutive applications of tDCS are correlated to reductions in GABA in the stimulated area in PPA. We also demonstrated that a possible brain mechanism for the advantage of tDCS over sham may be the strengthening of the functional connectivity between the stimulated area (left IFG) and homologous right IFG. The predictive value of the volume of right IFG for tDCS effectiveness has important implications for the prognosis and timing of intervention effects: intervention at earlier stages of the disease progression—when there is less atrophy in the right hemisphere—may be more beneficial than later intervention.

Poster Schedule

Poster sessions are scheduled on Thursday, August 18 through Saturday, August 20. Poster sessions are 2 hours, and presenting authors are expected to be present the entire time. Posters are located in Jeffery and Elvin Halls. You may post your materials on the board assigned to you starting at the scheduled "Set-up Begins" time shown below. Please note that any posters not removed by "Teardown Complete" time will be discarded. Do not leave personal items in the poster room.

IMPORTANT: Only the supplied velcro tabs are allowed to be used for securing your poster to your board.

Date & Time	Posters	Topics
Poster Session A	A1 - A4	Perception: Auditory
Thursday, August 18	A5 - A11	Perception: Speech Perception and Audiovisual Integration
10:00 am - 12:00 pm	A12 - A16	Multilingualism
Jeffery and Elvin Halls	A17 - A25	Meaning: Lexical Semantics
	A26 - A31	Language Development
	A32 - A37	Grammar: Morphology
	A38 - A47	Language Disorders
	A48	Perception: Orthographic and Other Visual Processes
	A49 - A52	Meaning: Combinatorial Semantics
	A53 - A55	Meaning: Discourse and Pragmatics
	A56 - A59	Perception: Orthographic and Other Visual Processes
	A60 - A61	Phonology and Phonological Working Memory
	A62 - A63	Signed Language and Gesture
	A64 - A66	Speech Motor Control and Sensorimotor Integration
	A67 - A69	Control, Selection, and Executive Processes
Setup Begins: 8:30 am	A70 - A71	Meaning: Prosody, Social and Emotional Processes
Teardown Complete: 1:00 pm	A72 - A74	Methods
	A75	Writing and Spelling
Poster Session B	B1 - B4	Perception: Auditory
Thursday, August 18	B5 - B11	Perception: Speech Perception and Audiovisual Integration
3:00 – 5:00 pm	B12 - B17	Multilingualism
Jeffery and Elvin Halls	B18 - B26	Meaning: Lexical Semantics
	B27 - B30	Language Development
	B31 - B32	Grammar: Morphology
	B33 - B36	Grammar: Syntax
	B37 - B46	Language Disorders
	B47 - B50	Meaning: Combinatorial Semantics
	B51 - B53	Meaning: Discourse and Pragmatics
	B54 - B57	Perception: Orthographic and Other Visual Processes
	B58	Language Disorders
	B59 - B60	Phonology and Phonological Working Memory
	B61 - B62	Signed Language and Gesture
	B63 - B66	Speech Motor Control and Sensorimotor Integration
	B67 - B69	Control, Selection, and Executive Processes
Setup Begins: 1:00 pm	B70 - B71	Meaning: Prosody, Social and Emotional Processes
Teardown Complete: 6:30 pm	B72 - B73	Methods
	B74	Writing and Spelling
Poster Session C	C1 - C4	Perception: Auditory
Friday, August 19	C5 - C11	Perception: Speech Perception and Audiovisual Integration
10:00 am - 12:00 pm	C12- C17	Multilingualism
Jeffery and Elvin Halls	C18 - C27	Meaning: Lexical Semantics
	C28 - C32	Language Development
	C33 - C38	Grammar: Syntax
	C39 - C48	Language Disorders
	C49 - C52	Meaning: Combinatorial Semantics
	C53 - C55	Meaning: Discourse and Pragmatics
	C56 - C58	Perception: Orthographic and Other Visual Processes
	C59 - C60	Phonology and Phonological Working Memory
	C61 - C62	Signed Language and Gesture
	C63 - C65	Speech Motor Control and Sensorimotor Integration
	C66 - C68	Control, Selection, and Executive Processes
Setup Begins: 8:30 am	C69	Meaning: Prosody, Social and Emotional Processes
Teardown Complete: 1:00 pm	C70	Methods
	C71	Writing and Spelling

Date & Time	Posters	Topics
Poster Session D	D1 - D4	Perception: Auditory
Friday, August 19	D5 - D11	Perception: Speech Perception and Audiovisual Integration
1:30 – 3:30 pm	D12 - D14	Multilingualism
Jeffery and Elvin Halls	D15 - D23	Meaning: Lexical Semantics
	D24 - D28	Language Development
	D29 - D35	Grammar: Syntax
	D36 - D45	Language Disorders
	D46 - D49	Meaning: Combinatorial Semantics
	D50 - D52	Meaning: Discourse and Pragmatics
	D53 - D56	Perception: Orthographic and Other Visual Processes
	D57 - D58	Phonology and Phonological Working Memory
	D59 - D60	Signed Language and Gesture
	D61 - D63	Speech Motor Control and Sensorimotor Integration
	D64 - D66	Control, Selection, and Executive Processes
Setup Begins: 1:00 pm	D67 - D68	Meaning: Prosody, Social and Emotional Processes
Teardown Complete: 4:00 pm	D69 - D70	Methods
	D71	Writing and Spelling
Poster Session E	E1 - E4	Perception: Auditory
Friday, August 19	E5 - E9	Perception: Speech Perception and Audiovisual Integration
5:30 – 7:30 pm	E10	Signed Language and Gesture
Jeffery and Elvin Halls	E11 - E12	Perception: Speech Perception and Audiovisual Integration
	E13 - E17	Multilingualism
	E18 - E26	Meaning: Lexical Semantics
	E27 - E31	Language Development
	E32 - E37	Grammar: Syntax
	E38 - E46	Language Disorders
	E48 - E50	Meaning: Combinatorial Semantics
	E51 - E53	Meaning: Discourse and Pragmatics
	E54 - E57	Perception: Orthographic and Other Visual Processes
	E58 - E59	Phonology and Phonological Working Memory
	E60	Signed Language and Gesture
	E61 - E63	Speech Motor Control and Sensorimotor Integration
	E64 - E66	Control, Selection, and Executive Processes
Setup Begins: 4:00 pm	E67 - E68	Meaning: Prosody, Social and Emotional Processes
Teardown Complete: 7:45 pm	E69 - E70	Methods
	E71	Writing and Spelling
Poster Session F	F1 - F2	Perception: Auditory
Saturday, August 20	F3 - F8	Perception: Speech Perception and Audiovisual Integration
10:00 am - 12:00 pm	F9 - F15	Multilingualism
Jeffery and Elvin Halls	F16 - F20	Meaning: Lexical Semantics
	F21 - F26	Language Development
	F27 - F31	Grammar: Syntax
	F32 - F36	Language Disorders
	F37	Language Genetics
	F38 - F44	Language Therapy
	F45 - F46	Meaning: Combinatorial Semantics
	F47 - F48	Meaning: Discourse and Pragmatics
	F49	Perception: Orthographic and Other Visual Processes
	F50 - F51	Phonology and Phonological Working Memory
	F52	Signed Language and Gesture
	F53 - F58	Speech Motor Control and Sensorimotor Integration
	F59 - F60	History of the Neurobiology of Language
Setup Begins: 8:30 am	F61	Animal Communication
Teardown Complete: 12:30 pm	F62 - F64	Meaning: Prosody, Social and Emotional Processes
	F65	Methods

Poster Session A

Perception: Auditory

A1 Different rule-based violations of stem vowels of German verbs evoke differential ERP effects

Natalia Bekemeier[1], Carsten Eulitz[1]; [1]University of Konstanz

Is morphosyntactic repair restricted to the violations of morphosyntax or can it also be triggered by rule-based phonological violations? To answer this question, we conducted an auditory ERP experiment that investigated the lexical retrieval of German verbs with morphological or rule-based phonological violations of the stem vowel. The non-violated and violated verbs were embedded in sentences that required a 3rd Pers. Sg. past indefinite form of the predicate. For the morphological violation, we chose the violation of ablaut patterns of German strong verbs. For the rule-based phonological violation, a specific feature of the Swiss German dialect was used. Swiss German preserved long high vowels ([iː], [uː], [yː]) that underwent diphthongization ([aɪ], [aʊ], [ɔɪ] respectively) in High German during the Early New High German period. Thus, the Swiss say "iistigä" instead of "einsteigen" (to get in). We mimicked this phenomenon with German weak verbs that carry a diphthong in their stem. The morphological violation produced a non-finite form of a strong verb (*gestern schreib er (yesterday write he) – gestern schrieb er (yesterday wrote he)). The phonological violation resulted in a non-existing stem that could be repaired by the application of the diphthongization rule (*er striikte [iː] – er streikte [aɪ] (he went on strike)). We hypothesized that the rule-based phonological violation should trigger morphosyntactic repair process, while the application of the non-finite form of strong verbs should trigger a semantic conflict. To test our hypothesis, we compared the processing of violated and non-violated strong and weak verbs in sentences. The strong verb conditions consisted of 42 past tense allomorphs (ControlS) and 42 bare stems/non-finite forms (BaS) of strong verbs. Forty weak verbs with a diphthong (aɪ, aʊ, ɔɪ) in the stem (ControlW) were used to create Swiss German variants (SGV). We expected the BaS items (i) to elicit an N400 effect if the non-finite form triggered a semantic conflict; (ii) a LAN effect should be observed if the non-finite form could be repaired. The predictions for the SGV items were as follows: (i) if the diphthongization rule could be applied online to repair the predicates, a LAN effect should be observed; (ii) an N400 should be triggered if the morphosyntactic repair was impossible. The results of the study revealed the following pattern: the BaS items elicited an N400 effect at 550-650 msec. The SGV items elicited a rather late anterior negativity (600-700 msec) reminiscent of LAN, followed by a P600 effect (800-900 msec) at centro-parietal electrode sites. Despite the non-existence of the Swiss German stems in High German, they could still be repaired via application of the diphthongization rule by German subjects who are familiar with that dialect, as indexed by the LAN and P600 effect. Although the BaS items represented the case of allomorph misapplication, they could not be interpreted within a finite context, hence the semantic conflict indexed by the N400 effect. The results of the present study delivered supporting evidence for our hypothesis, and showed that LAN effect can indeed be triggered by rule-based phonological violations.

A2 Vowel development in infancy: Multidimensional scaling of English vowels using cortical auditory evoked potentials

Kathleen McCarthy[1], Katrin Skoruppa[2], Paul Iverson[1]; [1]University College London, [2]University of Basel

Infants become specialized to perceive native-language speech sounds during the first year of life (e.g., Werker & Tees, 1984), but it isn't clear exactly how this specialization occurs. It is plausible that there is a level of general auditory processing that feeds into a developing language-specific phonology, or that there are lower-level changes to auditory/phonetic processing that precede lexical development (e.g., NLM-e, Kuhl et al., 2008; PRIMIR, Werker & Curtin, 2005). At least in adults, there is growing evidence that language experience affects early levels of auditory-perceptual processing (e.g., Krishnan et al., 2010; Iverson et al., 2003), even though most investigation has focused on phonological and phonetic categorization (e.g., Perceptual Assimilation Model, Best, 1995; Speech Learning Model, Flege, 1995). The present study investigated how vowel perception during the first year of life develops, as measured using early cortical auditory evoked potentials (CAEPs) within EEG. CAEPs are generated after a sound changes, (e.g., a spectral change in the middle of the sound), and do not require repeated presentation of a standard to build expectations (as in MMN); this measure can be considered to be earlier and more auditory than MMN. In the present study we examined how this measure changes during development, and whether those changes reflect broader auditory maturation or language-specific specialization. Eighty monolingual English infants (4-5, 8-9 and 10-11 months old) took part in the study. CAEPs were measured for spectral changes between concatenated vowels, which, for infants, typically evokes a positivity about 150-200 ms after each spectral change. One advantage of this measure is that the data can be collected quickly (e.g., 3 stimulus changes per second); this allowed us to measure 21 pairs of seven monophthongal vowels (/i/, /ɪ/, /ɛ/, /a/, /ɑ/, /ɔ/, /u/). ERPs were averaged across epochs following each spectral change, with the magnitude of the response for each vowel pair used as similarity measure for multidimensional scaling. The 4-5 month old infants had two-dimensional perceptual maps that closely matched the F1 and F2 acoustic differences between vowels. In contrast, the older infants response was less related to the vowel acoustics. They had selectively larger responses for spectrally similar vowel pairs (e.g., /i/-/ɪ/), suggesting a shift to a more phonologically driven processing. These results thus indicate that perceptual development for speech is occurring at a lower level than has been found before, and demonstrate how CAEPs can be used to produce detailed maps of infant speech processing.

A3 How does newborns' brain process speech temporal information?

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The present study seeks to explore what temporal acoustic information newborns rely on when perceiving speech. Psychoacoustics considers speech as a series of narrowband signals from high to low frequency composed of a relatively slow temporal envelope or amplitude modulation (AM) component and a faster temporal fine structure or frequency modulation (FM) component. Adults primarily rely on the

slowest AM cues, up to 16 Hz, that are related to the rhythm of speech, when perceiving phonetic contrasts, especially vowels. Consonant identification is more affected than vowel identification when fast temporal cues are reduced, i.e. AM cues over 16 Hz and FM cues, which are related to voice-pitch information and formant transition. Whether the two cues are weighed similarly at the beginning of language development is unknown. Therefore, the present study uses temporally-degraded speech sounds to investigate whether newborns rely more on fast or slow temporal cues when listening to vowels and consonants. Vocoders, which are speech analysis and synthesis systems, are used to manipulate the temporal modulations of speech in a specific number of frequency bands. Three vocoder conditions have been designed in order to preserve: (i) the original AM and FM cues (INTACT), (ii) the fast (< 256 Hz) AM cues only (FAST), and (iii) the slow (< 8 Hz) AM cues only (SLOW). French syllables varying in the place of articulation of either the consonant [pa]/[ta] or the vowel [pu]/[py] were recorded by a female native speaker and processed in these three conditions. We used Near-InfraRed Spectroscopy (NIRS) to record newborns' hemodynamic brain responses in the temporal, parietal and frontal regions to the syllables processed in the three conditions. One group of 20 infants were exposed to the consonant contrast and another group of 16 infants to the vowel contrast. Each infant heard 6 blocks of 25 syllables in each of the three conditions for a total of 18 blocks. Results show that the hemodynamic responses differ between vocoder conditions and hemispheres. Responses in the left hemisphere were similar between the INTACT and FAST conditions, but they both differed from the SLOW condition for the vowel as well as the consonant contrast. Moreover, the response was significantly higher in the left hemisphere to vowels than to consonants in the FAST condition, but not in the other two conditions. Thus, processing of fast and slow speech temporal cues may not involve the same neural mechanisms at birth and the fast temporal information may play a significant role in early speech perception. Moreover, newborns may rely more strongly on the fast temporal cues, related to voice-pitch information and formant transition, when perceiving vocalic contrasts than consonants. Overall, the present study suggests that newborns don't rely on the same temporal information as adults when perceiving speech sounds.

A4 Associations between language and cognitive skills and auditory discrimination in children. An ERP and behavioural study

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Introduction: In addition to correlations between neural and behavioral auditory discrimination, some studies have found an association between children's neurophysiological measures and their performance in speech-related tests (e.g. Lovio et al., 2012; Kujala et al. 2001). Indeed, in some cases, children's and infant's auditory event-related potentials (ERP) have even been found to predict their later speech abilities (e.g. Kuhl et al., 2008). Furthermore, some associations seem to exist between neurophysiological auditory discrimination and intelligence, both in adults (Light et al., 2007) and children (Mikkola et al. 2007; Partanen et al., 2013). However, these findings are scarce, and studies have mostly focused on clinical groups, e.g. schizophrenic (Light & Braff, 2005) or autistic (Weismüller et al., 2015) patients. We studied 5–6-year-old healthy children to find out whether their auditory ERPs were correlated with their linguistic and reasoning skills. Methods: We measured the children's ERPs in a phonemic multifeature paradigm, concentrating on two widely used measures of neurophysiological auditory discrimination, the mismatch negativity (MMN) and late discriminative negativity (LDN) responses. Auditory changes in the paradigm included deviations in vowels, consonants, frequency, duration and intensity. The ERPs of the children were categorized into two groups (higher vs. lower performers) in three different ways based on their behavioural scores in 1) Phoneme processing test (NEPSY – II, Korkman et al., 2008), 2) Word completion test (ITPA, Kirk, McCarthy & Kirk, 1974) and 3) Perceptual Reasoning Index, a combination of Block design and Matrix reasoning tests (WISC – IV, Wechsler, 2010). Results: We found that 1) higher group for Phoneme processing had larger MMN and LDN amplitudes than lower group. 2) Higher group for Word completion did not differ significantly from lower group in either response. 3) Higher group for Perceptual reasoning index differed from lower group in MMN but not in LDN responses. Conclusions: The results converge with previous studies showing that neural discrimination of phonemes is associated with linguistic skills, such as phoneme processing. In addition, the study suggests that children with better reasoning skills show enhanced neural discrimination of phonemes.

Perception: Speech Perception and Audiovisual Integration

A5 Characterization of phase entrainment to speech sounds in laminar recordings in monkey A1

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Neural oscillations adjust their phase to rhythmic stimulation, a phenomenon called phase entrainment. This mechanism seems to be of particular importance for the processing of speech: Correlated with speech comprehension, phase entrainment is omnipresent in current theories of speech processing. The auditory system is organized tonotopically and oscillatory processes seem to depend on the cortical layer they are operating in, and on the interplay between layers. Thus, the precise neural mechanisms underlying phase entrainment might differ between cortical sites or even cortical layers. However, the spatial resolution of most techniques used to measure phase entrainment, such as electroencephalography (EEG), is limited; this leads to the fact that the question for the

neural mechanisms of entrainment cannot be answered with common methods. A similar reasoning can be applied for the processing of everyday speech sounds, which is extensively studied using superficial recordings, but not intracranially. Nevertheless, rhythmic communication calls are not unique to humans, and phase entrainment has repeatedly been demonstrated in non-human primates. Thus, it is possible that laminar recordings in these species provide us with important insight into neural processes associated with phase entrainment to speech sounds. We presented one monkey with everyday speech and recently constructed speech/noise stimuli in which systematic fluctuations in sound amplitude and spectral content (here labeled "low-level features") have been removed (Zoefel and VanRullen, 2015a,b). The monkey listened passively to these stimuli while neural (as current-source density, CSD) oscillations were recorded in different parts of primary auditory cortex (A1). This setup made it possible to characterize neural mechanisms of phase entrainment with respect to the laminar profile in auditory cortex. As a result, we observed phase entrainment in all cortical layers and areas of A1; however, only those spectral components of speech corresponding to the "best frequency" (BF) of the recording site entrained neural oscillations to their high-excitability phase, whereas other components evoked an entrainment to the opposite, low-excitability phase. Together with the fact that low- and high-frequency components in speech alternate, our findings confirm previous speculation that phase entrainment reflects a particularly efficient way of stimulus processing that includes the preparation of the relevant neuronal populations to the upcoming input. Moreover, we were able to demonstrate that not only humans, but also monkeys can entrain to speech sounds in which systematic fluctuations in low-level features have been removed. This "high-level entrainment" was characterized by specific properties: By a change in the entrained phase (with respect to entrainment to everyday speech) and by a change in the frequency of the oscillatory amplitude the entrained phase is coupled to. These results indicate that phase entrainment in A1 includes a high-level mechanism with specific characteristics, and that this process might reflect a general mechanism of efficient stimulus processing that is conserved across species.

A6 Effects of phonetic category structure on brain activity during word recognition

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Existing neural models of spoken word recognition debate the role of the left inferior frontal gyrus (LIFG) in processing within-category phonetic variability. Notably, studies demonstrating LIFG sensitivity to phonetic competition (e.g., Myers, 2007; Minicucci, Guediche & Blumstein, 2013) have generally involved meta-linguistic tasks (e.g., phonetic categorization, lexical decision). Hickok and Poeppel (2004) suggest that under natural listening conditions, inferior frontal regions may not be recruited for processing phonetic variation, instead attributing this function to bilateral temporal areas. It is therefore unclear whether language-processing regions (particularly, LIFG and bilateral temporal areas) resolve phonetic competition under more naturalistic conditions. The present study employed a visual world paradigm with simultaneous fMRI to probe listeners' sensitivity to within-category phonetic manipulations, both behaviorally (as measured by latency of eye movements) and neurally (as measured by BOLD responses). Subjects were asked to look at whichever of two pictures was consistent with an auditory target. Critical trials began with voiceless stop consonants (e.g., "peacock") in which the voice-onset time (VOT) was an unaltered exemplar token (e.g., "peacock") or was digitally edited to be a competitor token (VOT shortened to render the initial consonant closer to the phonetic category boundary but still unambiguously voiceless, e.g. "p*eacock"), or an extreme token (VOT lengthened to make the initial sound a poor exemplar of the category but still unambiguously voiceless, e.g., "phheacock"). Lexical-level competition was manipulated by inclusion of a distractor picture of a voicing onset competitor (e.g., "beaker") or of an unrelated item (e.g., "sausage"). Results from an eyetracking behavioral pilot (n=15) demonstrated that participants were significantly slower to fixate on the target picture when a voicing onset competitor was present compared to an unrelated distractor. This effect interacted with target token type, such that the distractor effect was most pronounced for competitor tokens and smallest for extreme tokens, suggesting that phonetic competition and lexical competition combine to delay looks to the target. The combined eyetracking/fMRI experiment (n=18) revealed a similar behavioral pattern, although the interaction did not reach significance. Initial neuroimaging analyses reveal sensitivity to token type in bilateral primary auditory cortex, with greatest activation for extreme tokens and least for competitor tokens. Additionally, clusters in LIFG and bilateral posterior superior temporal gyrus demonstrate sensitivity to the type of visual distractor, with greater activation elicited for voicing onset competitors than unrelated distractors. Finally, a cluster in LIFG (pars triangularis) shows sensitivity to the interaction between distractor type and token type ($p<0.05$, uncorrected). Overall, results suggest that resolving competition along phonological and lexical dimensions recruits both frontal and temporal areas, even under more naturalistic eyetracking conditions. Consistent with previous studies using the visual world paradigm (e.g., Righi, Blumstein, Mertus & Worden, 2009), both inferior frontal and temporal areas show enhanced activation when an onset competitor is displayed. The present data add to the existing literature by demonstrating that within-category variability modulates how inferior frontal regions respond to onset competition during word recognition. Thus, results suggest a potential role for inferior frontal regions in integrating phonetic information with lexical properties.

A7 Tracking of Speech Rhythm by Cortical oscillations: an MEG study in typically developing children

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Recent findings highlight the close links between speech rhythm and cortical oscillations, allowing the brain to segment the continuous signal into meaningful linguistic units [1-2]. Studies in adults show that theta oscillations in brain auditory regions synchronize to the slow modulations (4-7 Hz) in the speech amplitude envelope, which characterize syllabic

information and speech rhythm and are crucial for intelligibility [3-5]. Similar alignment of neuronal oscillations to speech signals seems to be observed for the fundamental frequency (F0), which carries rhythm and stress information (i.e. prosody) [6-7]. Whether such phase-locking also occurs in typically developing children, especially for natural speech produced at a fast rate, has not been investigated so far. We here propose to tackle this issue in children using magnetoencephalograhpy (MEG). We recorded brain activity of 15 French-native right-handed, normal-hearing healthy children (8-13 years old) using a 275-channel whole-head MEG system (CTF-275). The protocol was approved by the French ethical committee. The stimuli were 300 sentences recorded first at a normal rate (6.76 syllables/s) and then at a faster rate (9.15 syllables/s). The mean F0 was 78.6 Hz for normal rate sentences and 88.1 Hz for fast rate sentences. The 600 stimuli (300 × 2 rate variants) were divided into two lists of 300 stimuli (150 from each rate condition). Forty filler trials (20 at a normal and 20 at a fast rate; not analysed), in which a sound was superimposed on the sentence second part, were further added to maintain children's attention throughout the experiment. Children had to listen to the stimuli and press a button whenever they heard a filler trial. Data segments contaminated by eye blinks, heart-beat or muscle artefacts were rejected (manually and with ICA). Analyses were performed with Fieldtrip toolbox. Coupling (coherence) between the MEG signals and the speech signal in each rate condition was further computed. Source-level analysis was performed with beamforming (DICS). Group statistical analysis was carried out using non-parametric randomization statistics (cluster-level permutation tests). The results provide evidence for an entrainment of neuronal oscillations to speech amplitude envelope in the frequency bands corresponding to the rates at which speech was uttered. Stronger coherence between auditory cortex activity and speech temporal envelope is indeed observed at 5.6-7.6 Hz for normal rate sentences and at 8-10 Hz for fast rate sentences. Moreover, our data suggest the involvement of a fronto-parieto-temporal network in fast speech rate perception. Interestingly, a shift in coupling frequency is also observed for the pitch, with cerebro-acoustic coherence in the (right) auditory cortex following the increase of F0 from normal rate to fast rate (from 78 to 88 Hz). Our findings reveal for the first time in typically developing children an involvement of oscillatory brain activity in the parsing of syllabic information during continuous speech perception. Synchronization between MEG and speech signals seems to follow syllabic speech rate and pitch, allowing to establish predictions on relevant acoustic events in speech and therefore to ensure efficient information processing [4, 8].

A8 Neural processing of congruent and incongruent audiovisual speech in school-aged children with and without specific language impairment (SLI)

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Introduction: Speaker´s articulatory gestures affect speech perception. Visual gestures that are incongruent with the sound can even change the perception of auditory speech signal, which is known as the McGurk effect. Children with specific language impairment (SLI) rely less on audiovisual and visual aspects of speech than typically developing (TD) children. Studies show that the McGurk effect is weaker in children with SLI than typically developing children, suggesting that children with SLI integrate audiovisual speech differently than their typically developing peers. In adults, an incongruent audiovisual syllable (McGurk stimulus) activates the auditory change-detection system even without changes in the auditory stimulus, and this can be seen in the mismatch negativity (MMN) brain response. No previous knowledge exists about the neural level correlates of the McGurk effect in typically developing children or children with SLI. Methods: Using event related potentials and eye-tracking method, we investigated brain responses for congruent and incongruent audiovisual syllables in 18 typically developing children (aged 6;11-11;1 years, mean 9;1 years) and 15 children with SLI (aged 7;10 -11;1 years mean 9;4 years). We used an oddball paradigm with congruent audiovisual /mi/ as the standard and congruent audiovisual /ni/ and incongruent A/mi/V/ni/ (McGurk stimulus) as the deviant stimuli. Eye fixations were recorded during the oddball paradigm in order to ensure that participants looked at the audiovisual stimuli. The strength of McGurk effect was also assessed with behavioral methods. Results: In the analysis time window of 150-350 ms after the auditory stimulus onset, the response to the congruent /ni/ deviant was significantly more positive at the frontal and central areas than response to the standard /mi/, and more negative at the occipital areas in TD children. In children with SLI, the response to the congruent /ni/ deviant was significantly more positive at the frontal and central areas than response to the standard /mi/, but no differences in the occipital areas were observed. The response to the McGurk deviant was significantly more negative at the occipital areas than response to the standard /mi/ in TD children. In children with SLI, response to the McGurk deviant was more positive at the frontal and central areas and more negative at the occipital areas. At the behavioral level, there were no differences in the McGurk effect between typically developing children and children with SLI. That is, they heard the A/mi/V/ni/ as /mi/ 61% of the time on average, showing relatively weak visual influence. Conclusions: The results indicate that children with SLI processed both congruent and incongruent audiovisual speech differently at the neural level than children with typical language development. Yet there were no differences in the McGurk effect at the behavioral level. The processing differences seen in neural level may reflect different visual influence on speech perception previously observed in children with SLI.

A9 Reorganization of the neurobiology of speech perception after sentence overlearning

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Existing models of the organization of language and the brain are fixed. They assume fixed linguistic units (like phonemes) that are combined into larger units (like words and sentences). Perceiving these units is said to be supported by a distributed but fixed set of brain regions. There is, however, little evidence for fixed linguistic units or stable language regions. Our NOLB Model is an alternative in which linguistic unit size and the corresponding neurobiology of speech perception

dynamically self-organizes as a function of prior listening experience and current context. Here we evaluate this model by testing the hypothesis that increasing experience producing specific sentences will increase their linguistic unit size, creating "prefabs". This will result in the reorganization of brain regions supporting the perception of those sentences. Based on studies of preserved formulaic speech in aphasia, we hypothesized that those would include right hemisphere regions and subcortical structures like the basal ganglia and cerebellum. In each of two functional magnetic resonance imaging (fMRI) sessions, 12 participants "passively" listened to two sentences repeated 60 times each and 60 other novel sentences. All sentences were 2.5 seconds long and randomly presented over the course of six runs in a slow event related design (TR=700ms). In a final run, participants heard and spoke the 60 novel (non repeating) sentences. The two fMRI sessions were separated by 15 days. During this period, participants trained at home by producing the two repeated sentences 30 times each, twice a day. Finally, they completed memory recall, sentence completion and lexical decision tasks in both sessions to assess learning. Behavioural results confirm that participants significantly overlearned the two sentences repeated at home and showed evidence that they were treated as "prefabs" during recall. For example, reaction times to complete the final word of repeated sentences decreased by over a second from session one to two. Correspondingly, we found a dramatic bilateral reduction in activity in posterior superior temporal, inferior parietal, insula, inferior frontal and ventral premotor cortices. There was an increase in cortical activity after training around the planum temporale bilaterally and a large increase in right motor and somatosensory cortices. There was also an increase in subcortical activity in the hippocampus, thalamus, caudate and cerebellum. These results suggest that the distribution of pattern of activity supporting speech perception is not fixed but, rather, dramatically shifts as of function of individual experience with speech production. Specifically, repeated experience speaking the same word sequence seems to change the memory representation of those words to be collectively more unit like or prefabricated. This trace is subsequently used by the brain in the process of speech perception, involving a different set of brain regions than is said to support language in most contemporary neurobiological models. Results are more consistent with the described NOLB model in which linguistic units and associated brain regions are dynamically organizing. Results also warrant a more serious consideration of how overlearning and formulaic speech might be harnessed to aid in recovery from aphasia.

A10 A Functional transcranial Doppler sonography (fTCD) study of hemispheric dominance during silent speechreading.

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Perceiving a speaker's articulatory movements plays an important role in spoken language comprehension (McGurk & MacDonald, 1976). fMRI studies have shown that left hemisphere activation for silent speechreading is modulated by speechreading skill and hearing status (deaf vs. hearing; Capek et al., 2008). fTCD is reliable in establishing hemispheric dominance during cognitive tasks (Deppe et al., 2004) and is sensitive to task difficulty (Payne et al., 2015). However, in fTCD studies, laterality indices (LIs) are often stronger for language generation than for receptive tasks (Buchinger et al., 2000). Here we aimed to determine whether a receptive silent speechreading task elicits measurable lateralization in the TCD signal, and whether the strength of such an effect relates to a word's intelligibility. Sixteen right-handed hearing English speakers performed a semantic judgment task using silent speechreading. We measured LIs for nonsense mouth movements (gurns) and English words. We also tested the effect of word intelligibility (easy vs. difficult). Results show stronger LIs for words than gurns, 67% of participants had negative LIs (right dominance) for gurns while 60% had positive LIs (left dominance) for words. No differences related to word intelligibility were observed. There was no correlation between LI and speechreading skill. The strength of lateralization found for speechreading of single words will also be compared to data from a second experiment, measuring strength of lateralization during speechreading of short stories. This will test the influence of increasing task difficulty and also, crucially, semantic content on strength of hemispheric lateralisation. Our findings contribute to our understanding of which task difficulty factors contribute to the fTCD signal. The results show that fTCD is sensitive to the distinction between linguistic and non-linguistic mouth movements and therefore may be useful to study hemispheric language dominance in special populations such as those born deaf.

A11 Do you listen to your brain? Oscillatory activity and speech perception

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Speech perception occurs when the ongoing rhythms of the brain, the neural oscillations, get coupled or resonate with the rhythms of the speech signal (Giraud et al., 2007; Lakatos et al., 2005). Different theories suggest that intelligibility of speech is mediated by the cortical system of brain oscillators (Buzsáki & Draguhn, 2004), which should remain phase-locked to the rhythm of the auditory input to allow for effective comprehension of others' speech (Ghitza, 2011; Ghitza & Greenberg, 2009; Giraud & Poeppel, 2012; Luo & Poeppel, 2007). In the current study we investigated whether a similar coupling process would take place between brain oscillations and self-speech while one person is speaking to another. We based our initial hypothesis on the evidence demonstrating that 1) speakers continuously monitor speech production in order to adjust the vocal output if necessary (Hason et al., 2012), 2) that an internal copy of the efferent signal (articulation) is generated to achieve perceptual stability and that this signal may also permeate the neural system (Jeannerod, M., 2003), and 3) that production and comprehension are tightly interwoven (Pickering & Garrod, 2013). We investigated the brain oscillatory patterns related to speech perception and to speech production in a real-life conversational scenario in which pairs of participants got engaged in a guided conversation. Signal of the neural activity of speakers and listeners was obtained through EEG recordings. Results demonstrated that both talking and listening elicited similar power spectra synchronization in delta, theta and beta-low as compares to a silence control condition. Interestingly, the oscillatory

patterns while talking or listening to another persons' speech were highly similar, with minimal differences being found in upper alpha band frequencies, which have been suggested to be specifically related to retrieval of semantic information (Rohm, Klimesch, Haider,& Doppelmayr, 2001). These results suggest that speech production and speech perception are highly interrelated processes at the brain oscillatory level, with coupling occurring both with the message being uttered as well as with the message being perceived.

Multilingualism

A12 Behavioral and neural correlates of bilingual language switching in virtual reality

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In everyday life bilinguals often switch between their languages as a function of the language background of their interlocutor. A conversation with a colleague in one's second language (L2) may, for instance, be followed by a phone call with a friend in one's native language (L1). The neurocognitive mechanisms supporting such bilingual language switching capacities have traditionally often been studied using cued-picture naming paradigms: participants named pictures that appeared on a computer screen in either their first or their second language as a function of the background color of the screen. Recently this cued-picture naming paradigm has been criticized for being unnatural, not reflecting everyday out-of-the-lab language switching. We made use of recent advances in virtual reality technology to overcome this limitation by investigating bilingual language switching in a contextually rich, ecologically valid setting while maintaining experimental control. Three separate picture naming experiments were carried out with TrialType (switch, non-switch) and Language (Dutch, English) as independent variables in a 2x2 design. In each experiment, 24 different Dutch-English late bilingual participants from the same student population named pictures in their L1 Dutch or their L2 English. Experiment 1 was a baseline experiment using the traditional cued-picture naming paradigm. In Experiments 2 and 3, participants named pictures for two virtual agents in a virtual environment that was rendered via a head-mounted display, creating a fully immersive virtual experience. Before the start of these two experiments, one virtual agent indicated in Dutch that she only understood Dutch, and the other indicated in English that she only understood English. The virtual agents sat behind a virtual monitor on which pictures appeared that participants named in Dutch or English as a function of the virtual agent that looked at them at picture onset. The physical appearance of the virtual agents in relation to their language identity (Dutch or English), and their position behind the virtual monitor (left vs. right) were fully counterbalanced across participants. In Experiment 3 participants' electrocencephalogram (EEG) was recorded. Linear mixed effects regression models of the picture naming latencies revealed similar symmetrical switch costs in all three Experiments. Switching languages led to significantly slower reaction times than not switching languages, but adding the interaction term (TrialType x Language) to the model did not improve the model fit. Data-driven cluster-based permutation tests on the EEG data collected in Experiment 3, time-locked to picture onset, revealed a more negative ERP wave for switch compared to non-switch trials, which was most pronounced between 540 ms and 700 ms after picture onset, reflecting a language-independent neural marker of language switching preceding speech onset. Similar to the behavioral data, no interaction with Language was found. These results confirm the ecological validity of the cued-picture naming paradigm to study bilingual language switching and open up a wide range of possibilities to use virtual reality technology in the study of language production and comprehension in bilingual and other communicative settings.

A13 Beyond bilingualism - Multilingual language experience correlates with bilateral caudate volume in polyglots

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Multilingual individuals face an ongoing challenge in managing their language system. In order to efficiently communicate, a polyglot brain must have mechanisms that permit the selection of the relevant lexical, syntactic and even pragmatic set for the communicative environment. Behavioural evidence points to an impact of bilingualism on various domains of executive function such as conflict monitoring and task switching, suggesting that domain-general cognitive functions are affected by multilingualism. Consistent with this, functional imaging work on the neural basis of language control in multilinguals has implicated a number of regions associated with the executive control system, including the dorsal striatum, the supplementary motor area and the anterior cingulate cortex. There are also brain structural consequences of multilingualism, although the findings in the literature on structural differences between monolinguals and bilinguals are heterogeneous. In a previous study we observed functional recruitment of the bilateral caudate nucleus during a challenging language control task, namely simultaneous interpreting. Not only is this structure is also a key node in the executive control system, but it has also been shown to be enlarged in bilingual individuals compared to monolinguals. We elected to investigate the relationship between caudate nucleus volume and multilingualism in individuals who speak three or more languages, which we posit may have even greater language control requirements than bilingualism. For this, we acquired structural MRI data (T1-weighted MPRAGE, 1*1*1mm voxels) in 66 multilingual individuals (39 Female, mean age: 25.85 years). Participants reported speaking three or more languages (range: 3 to 9, mean 4.36), and were interviewed on their language acquisition and proficiency levels. In order to have a quantitative, continuous measure of language experience which takes into account more than just number of languages, we calculated weighted sums of age of acquisition (lower receiving higher weight) and proficiency (more proficient receiving a higher weight) ('LEXP'). Imaging data were processed using FIRST for segmentation of subcortical structures. Volumes of the caudate nuclei were extracted and tested for a relationship with LEXP using a partial correlation, controlling for participants' age, sex and total intracranial volume. In the light of previous reports we expected a positive correlation, and a one-tailed test was therefore performed. LEXP was found to correlate significantly with the volumes of both caudate nuclei (left: r=.260, p=.022;

right: r=.221, p=.043). Brainstem volume was tested using the same analysis as a null control, and showed no relationship with LEXP (r=.154, p=.117). These results indicate that the additional challenges posed by controlling, and possibly acquiring, additional languages beyond bi- or even trilingualism has an impact on the caudate nucleus. This is consistent with the increasing weight of evidence that points to the role of the dorsal striatum in multilingual language control.

A14 Language switching: beneficial or costly? Evidence from studies with second language learners and trilinguals

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When using multiple languages, how is interference from the irrelevant language prevented? Language switching paradigms have been used to study how different languages are controlled in the brain, particularly to probe language dominance differences between one's native tongue (L1) and less dominant second languages (L2) learned at a later age, or used less frequently. Previous research indicates that switches to the dominant language result in larger switching costs than switches to a second language (for a review, see Bobb & Wodniecka, 2013). This suggests that languages with high base activation levels need to be inhibited more strongly than a less dominant second language. Such research outcomes, however, depend also on language modality. When language switching takes place during language production, the switching costs in L1 and L2 are often asymmetric, whilst symmetric switching costs or no costs at all have been reported in behavioral measures during comprehension tasks (e.g., Gullifer, Kroll & Dussias, 2013; but see Pellikka et al., 2015, for an asymmetric cost in electrophysiological data). Here, we discuss switching costs in two studies on language switching during comprehension tasks. The first is an EEG study on language switches during written sentence comprehension in native speakers of English, and in L2 learners with a high or moderate proficiency in English. In monolingual English sentences, a classic semantic N400 effect was elicited after semantically incongruous target words in native speakers and high proficient L2 learners, but not in moderately proficient L2 learners. However, in this group of L2 learners, incongruous target words switched to L1 (Finnish) facilitated semantic integration processes, as evidenced by a restoration of the N400 effect. Although language switches elicited their own associated N400-like effect, switches back to L1 therefore are not necessarily costly on the semantic level. The second is an auditory MEG study on trilingual language switching. Early Finnish-Swedish bilinguals, with a high proficiency in the later acquired English, were presented with spoken words in mixed language word lists. The results suggest asymmetric switching costs (N400m brain responses) when language switching takes place from the non-dominant language to either of the two dominant native languages. This is in line with language control theories that assume the suppression of a dominant language during the use of a non-native language. However, when switching between the two native languages, switching costs were found to be diminished. This points towards a difference in the underlying control mechanisms, suggesting an effect of automaticity of language switching between two early acquired languages. Taken together, switching costs seem to depend on many factors involved in language processing. The interaction between language proficiency, age of acquisition and language automaticity may contribute to the way in which languages are controlled, but also language context seems to play a large role. The precise interplay of all involved factors has yet to be fully uncovered.

A15 Grey matter changes associated to bilingualism across lifespan: combining voxel-based morphometry (VBM) and cortical thickness (CT).

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The results of brain structural studies on bilingualism that have been performed mostly with young adults are not consistent. It has been argued that young adults are at the peak of their brain development (and cognitive performance), generating a ceiling effect that makes differences between bilinguals and monolinguals difficult to detect[1]. Potential brain structural differences will be easier to detect when the brain is still developing or in decline. Here we compare populations at either end of the lifespan: children and elderly. Specifically, 14 bilingual (Spanish-Basque) and 14 monolingual (Spanish) children with age range of 6-14 years and 17 bilingual and 17 monolingual elderlies with age range: 64-78 years. Monolingual and bilingual samples were matched on age, sex and did not differ in socioeconomic status. High-resolution T1-weighted MRI was acquired. Voxel-based comparison of the grey matter volume (using FSL-VBM protocol) and a vertex-based comparison of the CT (using FreeSurfer suite) were performed. A 2x2 between-subject factor ANCOVA analysis was run including two factors: Bilingualism (bilinguals/monolinguals) and Age-group (children/elderly) adjusted for covariates (TIV/IQ). A significant interaction between factors (Bilingualism X Age-groups) emerged in the grey matter volume of the right lingual/precuneus/posterior cingulate (PC) cortices and in the CT of the right precuneus. The planned comparisons showed that these interactions were driving by children: showing that the grey matter volume in these regions was significant greater and the CT significant thinner in bilingual than monolingual. Subsequently, for monolingual children we found that chronological age correlated positively with grey matter volume and negatively with the CT values extracted from these cluster-regions of difference. For bilingual children volume/CT values were not significantly associated with age. We obtained a significant interaction between the slopes of the correlation lines for both groups. The precuneus/PC are essential regions in the 'default mode network'[2,3] that typically undergoes a prolonged development during childhood[4], being the precuneus a region showing one of the highest index of maturation during childhood[5]. Additionally, some studies have showed lingual/precuneus/PC involvement after oral language training in children with

dyslexia[6]. In general, our results suggest that bilingualism might accelerate the maturation into these regions that are crucial for development and learning. References: 1. Bialystok, E., et al. Ageing Research Reviews, 27:56-60. (2016) 2. Leech, R., Sharp, D.J. Brain, 137:12-32. (2014). 3. Utevsky, A.V., et al. J Neurosci. 15,34(3):932-40. (2014). 4. Fair, D.A, et al. PNAS. 105(10):4028-4032. (2008). 5. Dosenbach, N.U.F, et al. Science, 329(5997):1358-1361. (2010). 6. Temple, E., et al. PNAS. 100(5), 2860-2865. (2003).

A16 Regulation and resolution: How bilingualism and cognitive aging affect the use of executive function in comprehension

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The relationship between bilingual language use and cognitive performance is necessarily complex. Some research suggests experience in switching languages or resolving conflict between two or more languages may have consequences for the neural networks that support this behavior (i.e., the Adaptive Control Hypothesis; Green & Abutalebi, 2013; Bak, Vega-Mendoza, 2014; Gold et al., 2013). It is unclear at what point across the lifespan these changes might occur, and what threshold or type of bilingual language experience may be sufficient for changes to occur. In addition, very little is known about how those executive function skills that support bilingual language regulation, may also provide support for every day language tasks, such as reading comprehension. To this end, we recruited monolingual and bilingual young adults (N = 52) and older adults (N = 28) for a series of studies. Participants were immersed in an English-dominant environment. For young adult bilinguals, this supported the less proficient second language (L2), but made it more difficult to disinhibit the more dominant first language (L1). For older adult bilinguals, whose language dominance was more likely to have shifted over time, this English immersion context supported either the less dominant language, one of two balanced languages, or the dominant language. All participants completed a reading comprehension task, during which they were presented with English sentences via RSVP while their EEG was recorded. In some cases, these sentences included a conflict (between an expected and unexpected word) that required resolution for successful comprehension to occur. Participants were also administered a battery of language proficiency and cognitive performance tasks, including semantic category verbal fluency and picture naming (in both the L1 and L2; e.g., Linck et al., 2009), an operation span task, as well as a cognitive control task (i.e., the distractor version of the AX Continuous Performance Task; Braver et al., 2001). Across age and language groups, a specific pattern emerged: when participants were likely to have been generating expectations for what word was likely to come next in the sentence, they experienced subsequent costs when that expectation was not met. This was reflected in a frontally distributed, positive ERP response that was larger for unexpected words. This type of effect is often found for words that are unexpected (Coulson, King, & Kutas, 1998), require reanalysis (Friederici, 1995; Kolk & Chwilla, 2007), or are more difficult to integrate (Kaan et al., 2000). Across all young adult readers, this ERP response was reduced if an individual had better inhibitory control (see Zirnstein et al., under review). This inhibitory effect was only found for young adult bilinguals who were better regulators of the non-target language. For older adults, this conflict-related ERP response was greatest for bilinguals, who performed better in working memory and were more successful at negotiating between goal maintenance and inhibition on the control task than monolinguals. These findings highlight an aspect of language use that dynamically interacts with executive function as we age, a relationship that is strengthened for bilinguals in older adulthood.

Meaning: Lexical Semantics

A17 Influence of the degree of object typicality in the course of word production : an ERP study

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In healthy speakers, successful naming can be modulated by intrinsic properties of objects/words or by the presence of distractors belonging to the same category of the object to be named. However, the greater case of impaired access to conceptual information is observed in patients suffering from semantic dementia (SD). Importantly, several studies showed that SD patients have difficulties in naming and categorizing when they have to deal with object typicality. Patients tend to fail in considering atypical representations of objects as correct members of one category (relatively to prototypes), therefore revealing their difficulty in the retrieval of relevant object features. Yet, little is known as to whether such difficulties would be restricted to conceptual processing or distributed across other encoding stages during naming. In the present study we address this issue by exploring the influence of the degree of typicality of objects on picture naming in healthy subjects. To do this, we constructed a database of 5 colored pictures of the same objects that were evaluated for several psycholinguistic variables such as image agreement (IA). IA was obtained by asking participants to mentally represent the object corresponding to a word written on the screen. Then, a picture corresponding to that word was presented and participants had to indicate (on a 5-points scale) the degree of accordance between their mental picture and the projected picture. This allowed us to compute two sets of typical (high image agreement) and atypical (low image agreement) representations of the same objects (basic categories). We then recorded Event-Related Potentials (ERPs) while participants named typical/atypical pictures of objects that were matched for pertinent psycholinguistic variables (e.g. name agreement, visual complexity). Results indicate that healthy participants were more accurate to name pictures of typical representations of objects (MeanTyp=82%; MeanAtyp=76%; $p<0.01$) and production latencies were significantly longer for atypical (Mean= 914ms) compared to typical representations (Mean= 841ms ; $p<0.001$). ERPs indicated significant modulations of waveform amplitudes between 380 and 500 ms post picture onset. These modulations corresponded to differences in the time-distribution of common topographic patterns as indicated by increased duration of the microstate starting around 300 ms for atypical representations of objects. No effects were observed on response-aligned ERPs. The reported effects seem relatively late according to the time-line of conceptual

processes suggested in a meta-analysis (i.e. prior to 200 ms after picture onset)[1]. However, these results are compatible with recent work suggesting that lexical-semantic processes can be observed around 300 ms post picture onset[2] and provide additional evidence that semantic retrieval, such as retrieval of features, continues in parallel to word encoding. References : [1] Indefrey P (2011). The spatial and temporal signatures of word production components: a critical update. Frontiers in Psychology, 2, 255. doi:10.3389/fpsyg.2011.00255 [2] Fargier R, Laganaro M (2015) Neural dynamics of object noun, action verb and action noun production in picture naming. Brain Lang 150:129–142. doi: 10.1016/j.bandl.2015.09.004

A18 The older the better: how language shapes brain connectivity through lifetime

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Considering the increasing age in the provisional demographic curve, a better understanding of the mechanisms required to maintain cognitive performance during aging is essential. For example, clinical manifestations of Alzheimer's disease are known to appear later for individuals who uphold continuous cognitive training, allowing an efficient use of brain plasticity. This therefore suggests the existence of adaptive mechanisms. These recent data offer an encouraging lead for neuroscientists as they relate to modifiable factors that could initiate a potential preventive action to deter cognitive decline. As a result of the rise of neuroimaging methods, it is presently acknowledged that language requires the simultaneous participation of both cerebral hemispheres and various interconnected areas. Interestingly, and despite neurostructural decline, language functions generally appear to be preserved in aging when compared to other cognitive domains, such as memory. The description of neurofunctional mechanisms underlying language functions through lifetime therefore represents a major area of interest to help determine the constituents of optimal cognitive aging. From a sample of 300 individuals, ranging from 20 to 80 years old, language and general cognitive performance has been explored in correlation with age, education and other socio-demographic characteristics. A sub-sample of 258 individuals has been tested systematically for multiple brain connections to find consistent differences between age group, performance groups and education groups when performing two semantic tasks (antonyms, synonyms). Significant correlations are found between age and performance. While exhibiting a general cognitive decline, older individuals perform significantly better at all language tasks. This results can not be fully explained by education level or other sociodemographic factors. Connectivity analysis show few or no differences between age groups in connectivity frontal and temporal regions in charge of semantic processing, but lower connectivity with posterior temporal and parietal regions. Individual variables such as education, life experience, gender in conjunction have an significant weight in the relationship with performance and age. Semantics in language therefore appears as a function-specific domain in aging, which is behaviourally improved through lifetime. The underlying processes seem mostly automatized but differences in connectivity profile are observed in the antero-posterior network. This work is in line with current models of cognitive reorganization in aging. In the long term, this type of exploration might contribute to better prevention of cognitive decline.

A19 Prediction is production: ERP evidence in sentence comprehension

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Language comprehension is predictive. Readers actively predict upcoming words during sentence processing, when the sentence context is highly constrained. Recently, several frameworks proposed that prediction is production, meaning that the production system is implicitly used for prediction during language comprehension. We tested this argument by comparing two groups of native Spanish readers. The articulatory suppression (AS) group (AS+ group) had to read constrained sentences, presented word-by-word at the center of a computer screen, while pronouncing the syllable 'TA' on each word's display. By applying such AS, we attempted to tax the language production system. The control (AS-) group had to read the same sentences, while performing tongue-tapping on each word's display. This group was also performing double-tasking, but without taxing the production system. We recorded event-related potentials while AS+ and AS- participants read highly constrained sentences containing an expected or unexpected target noun (e.g., "En el mapa que tenían los piratas, la cruz indicaba donde estaba el tesoro secreto/la perla mágica"; "In the map that the pirates had, the cross indicated where the secret treasure/the magic pearl was"). Each sentence was followed by a "yes/no" comprehension question, to make sure that sentence comprehension was not compromised by double-tasking. Sentence comprehension was indexed by the percentage of correct responses to the "yes/no" question following each sentence. Word integration was indexed by the amplitude of the N400 effect elicited by the target noun, such that the more negative the N400, the harder word integration into sentence context. Lexical prediction was indexed by the amplitude of the N400 effect elicited by the article preceding the target noun, such that the more negative the N400, the less prediction as regards the target word. Both groups showed high comprehension scores (around 85%). Importantly, those scores did not significantly differ in AS+ and AS- groups, showing that articulatory suppression did not hinder sentence comprehension more than tongue-tapping. Regarding event-related potential results, the AS- group showed significant N400 effects both on the target noun and the preceding article, replicating the classical word prediction effect. The AS+ group showed significant N400 effect on the target noun, reflecting efficient word integration into sentence context. Interestingly, the AS+ group showed no significant N400 effect on the article preceding the target noun (no significant N400 amplitude increase for unexpected articles). Those results suggest that articulatory suppression – but not tongue-tapping – hinders prediction during sentence comprehension, without affecting word integration. Those major and novel results highly support the claim that prediction is production, meaning that the availability of the production system is mandatory for word prediction.

A20 Characteristics of abstract speech in bvFTD

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INTRODUCTION: Frontotemporal dementia (FTD) is a heterogeneous neurodegenerative disease, with atrophy predominantly affecting the frontal and/or temporal lobes. Fluency and semantic deficits have been extensively studied in FTD patients with Primary Progressive Aphasia, whose atrophy affects central language processing areas of the perisylvian regions and temporal lobes. By comparison, language function in the behavioral variant of FTD (bvFTD) is primarily localized to the frontal lobe, and language function in these patients is relatively spared. Yet, frontal regions have been shown to support key language functions, such as semantic selection and the processing of abstract words. It may be that traditional language measures, such as visual confrontation naming, are often not sensitive to the subtle deficits experienced by bvFTD patients. Here, we examine the production of abstract nouns in patients with bvFTD, and relate performance to regions of atrophy. METHODS: We collected speech samples during the Cookie Theft picture description task in 42 bvFTD patients and 32 age- and education-matched controls. The samples were transcribed, and the nouns produced were tallied and rated on concreteness, frequency, and semantic diversity based on published norms. A pairwise t-test comparing bvFTD grey matter probability to that of controls revealed regions of atrophy in bvFTD. Noun production in bvFTD was related to regions of atrophy. RESULTS: Control and bvFTD subjects produced equivalent numbers of nouns per 100 words. However, bvFTD patients produced significantly fewer abstract nouns. Nouns produced by bvFTD patients were also significantly less semantically diverse, though frequency of occurrence was no different than controls. Reduced abstract noun production related to atrophy of the left inferior frontal gyrus and to the left and right caudate. SUMMARY: Impaired abstract noun production is related to atrophy of the left inferior frontal gyrus and bilateral caudate in bvFTD.

A21 Changes in neural oscillations provide insight into the engagement of cognitive processes during word learning

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INTRODUCTION. Unlike most other linguistic domains, vocabulary acquisition continues throughout adulthood. Adults learn most of their new vocabulary by using the surrounding linguistic context to infer a new word's meaning. The relative contribution of different cognitive processes to word learning from linguistic context is not well understood, however. The current study addresses this question by examining changes in neural oscillations often associated with cognitive processes during a word learning from context task. METHODS. Twenty-one adult participants completed a word learning task in which they silently listened to naturally-paced sentence triplets that ended with a target novel word. In the Meaning condition, the three sentences in each triplet increasingly supported the novel word's meaning. The No Meaning condition provided a control to the Meaning condition in that each sentence provided little contextual support, making it difficult to derive meaning for the novel word. After each sentence triplet, participants were asked to identify the novel word's meaning, if possible. ANALYSIS. Time frequency analysis of the EEG data was used to quantify event-related spectral perturbations. EEG data were epoched in a -500-1500 msec range around the target word. Epoched data were Fourier-transformed, magnitude-squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects and computed using the log power values minus the baseline. Using EEGLAB, we performed random permutation statistical analysis of the EEG data, computing p-values for both the time and frequency points for each comparison of interest. A 2 Condition (Meaning, No Meaning) x 3 Presentation (1,2,3) ANOVA was conducted in the theta (4-8 Hz), alpha (8-12 Hz), and lower beta (12-20 Hz) frequencies between 350-550 msec post-target word onset. RESULTS. In the theta band the Meaning condition exhibited a significant power increase across presentations but the No Meaning condition exhibited a significant decrease across presentations. These findings indicate increased semantic integration when meaning was available for the novel word but a breakdown in semantic integration when no meaning was available. For alpha, we identified a significant main effect of presentation for the No Meaning condition only, interpreted as an increase in attentional demands when there was no meaning available for the novel word. For lower beta there was a significant condition x presentation interaction, driven by a greater power decrease across presentations for the Meaning condition versus the No Meaning condition. Among other processes, lower beta desynchrony has been associated with increased memory demands (Shahin et al., 2009); therefore, it seems that, while establishing meaning for the novel word, participants engage memory to check the meaning with prior sentences in the triplet. CONCLUSIONS. Findings indicate that semantic integration and memory are involved in word learning when meaning for the novel word is available. Conversely, attentional demands are engaged when there is no meaning available. This research establishes a basis for future studies to examine differences in the engagement of these processes by other populations (e.g., children) and across modalities (e.g., written word learning).

A22 Put it in context: Investigating the effects of task demand on word processing

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Introduction: Past research has shown that the process used to derive semantic information from a word may be a dynamic one, which changes depending on task demands. Tousignant and Pexman (2012) showed that altering the instructions given to participants appeared to change the semantic information used to categorize each word. In order to assess the semantic information used, the researchers manipulated words' rated body object interaction (BOI; how easily a human body can interact with the word's referent). They compared reaction times for words that were high in BOI to reaction times for words low in BOI. When the semantic decision was framed as "entity vs nonentity" reaction times were faster for high BOI words than for low BOI words (the BOI effect). In contrast, when the decision was "action vs nonaction", no BOI effect was observed. This behavioural finding suggested that body-based semantic information might only be accessed when relevant to task demands, but the behavioural findings did not provide resolution about the mechanisms involved; that

is, in the "action vs nonaction" condition BOI information might have been accessed and ignored, or not accessed at all. In the current study we investigated the neural mechanisms underlying this modulation of the BOI effect. In this experiment participants were assigned to one of two conditions. The conditions were identical except for the instructions given for the semantic decision task. Methods: Data were analyzed for 19 participants in the 'Entity' condition ("Is it an entity?") and 18 participants in the 'Action' condition ("Is it an action?"). All participants completed a semantic decision task during EEG recording, determining whether each word was an entity or nonentity (Entity condition), or an action or nonaction (Action condition). Response latencies for correct trials were analyzed with a 2 (Task condition) x 2 (BOI) repeated measures ANOVA. A multivariate analysis (Partial Least Squares, PLS) was conducted to examine the overall relationships among groups and word type. Results: Behaviourally, the BOI effect was observed only in the Entity condition, replicating the results of the Tousignant and Pexman (2012) study. Results from the PLS analysis failed to identify any significant differences within groups but did identify a significant difference in the relationship between word types between the groups. Discussion: The results indicate that participants recruited different information in each condition suggesting that the recruitment of semantic information is a dynamic process dependent on task demands. Results from the behavioural analyses indicate that the recruitment of semantic information is dependent on task demands with behavioural BOI effects being observed in the Entity condition only. Group differences in EEG analyses suggest task demands shape semantic processing. This suggests that embodied semantic information is not always processed for word stimuli but, rather, that this information is accessed as a function of task demands. Top-down modulation as a function of task context can shape semantic processing. These findings have implications for the current theory of how meaning is derived from words.

A23 Investigating the Effect of Experience on Concrete and Abstract Word Processing: A Study with Semantic Priming Task

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Introduction : Concreteness effect refers to the advantageous processing differences of concrete words over abstract ones. Studies showed better remembering, faster processing and faster recognizing performances for concrete words than abstract ones (Connell & Lynott, 2012). In our study we intended to show the effect of expertise in processing not only abstract and concrete words but also domain specific abstract law words. Lawyers were considered as an expert group with their intense deal with abstract concepts. We hypothesized that experience could cause a more concrete understanding of the abstract terms, which might result in processing differences between expert and control groups. Method: Repetition priming methodology was used in a semantic decision task. A lawyer group of 15 experts (age 42.53,±5.19,14F, 4M) who had worked for a minimum of 10 years and 15 novices (mean age 22.20,±1.37,7F, 8M) who had graduated within the last three years and two age-matched control groups participated. The experiment consisted of one study and one test phase with a 5 minute rest in between. In the study phase, the participants made semantic judgments (abstract/concrete) for 60 words (20 abstract, 20 concrete and 20 law) by pressing buttons. In the test phase, participants repeated the same judgment for 120 words (60 new, 60 old). Results: In the semantic priming task, primed words' RTs were faster than unprimed ones. Repetition priming and group interaction between expert and matched controls yielded significant difference $F(1.78, 49.94) = 3.44$ $p < .05$, $\eta\rho^2=.58$. Significance levels for each group were determined by using Holm's Sequential Bonferroni correction method. For the expert and matched control group, results yielded only marginally significant differences in abstract and law word processing, while concrete words' repetition priming showed no significant result: Experts' repetition priming scores for abstract words (M=64,45ms, SD=128,1) were marginally significantly $t(28) = -2.27$, $p=.078$ smaller than controls' (M=163,41ms, SD=90,10). Also law words' repetition priming scores were marginally significantly $t(28) = -2.63$, $p=.060$ smaller for experts (M=105,58ms, SD=125,05) than controls' (M=219,42ms, SD=141,01). On the other hand, between novice and younger controls there was no significant repetition priming group effect at all. Conclusion: The expert group has a clear stronger semantic association than age matched controls. The expert group demonstrated more expertise in word processing than the younger novice group. Especially in repetition priming, our expert group processed abstract words faster, just like concrete ones. This result can be taken as an indirect sign of stronger semantic associations for these two abstract word groups. Furthermore marginally significant abstract word processing between the experts and controls indicate that expert group seems to compensate the disadvantage of classical abstract word processing with their intense deal with words. References :Connell, L., & Lynott, D. (2012). Strength of perceptual experience predicts word processing performance better than concreteness or imageability. Cognition, 125(3), 452-465.

A24 Parietal circuit distinguishing between feminine and masculine entities: an fMRI study of gender agreement processing.

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The distinction between syntactic and semantic processes and its specific roles guiding language comprehension has been the focus of many investigations in the last decades (Binder et al., 2009; Kuperberg, 2007; Kuperberg et al., 2008; Zhang et al., 2013). However, despite the extensive amount of findings regarding how the brain deal with these kinds of information, an essential and still open question is whether the neural circuit(s) for coding syntactic and semantic information embedded in our linguistic code are the same or different, and whether the possible interaction(s) between these two different types of information leaves a trace in the brain response. To examine this, we took advantage of the Spanish gender agreement system, where it is possible to distinguish two different gender types depending on the animacy of the nouns – i.e., Conceptual (mostly living entities) and Formal (mostly non-living entities). Interestingly, the assignment of the

gender values in both gender types follows the same morpho-phonological rule. This property allowed us to determine how our brain processes agreement information distinguishing between merely syntactic dependencies and more complex agreement relations, where the interplay between form-based and conceptual signals could be an important constraint. Critically, it also enabled us to explore the possible interactions between these formal and conceptual factors, controlling the syntactic complexity of the grammatical units. Our results revealed that a specific brain circuit responds according to the gender agreement congruency between determiners and nouns. The pars opercularis and triangularis within the lIFG, the left middle frontal gyrus, as well as the left MTG/STG emerged as critical hubs for the computation of grammatical relations. In addition, we also demonstrated that others fronto-parietal areas in both hemispheres are actively engaged in contributing to this operation. The response patterns of these regions varied as a function of the congruency between the different elements involved in such grammatical relations. This empirical finding indicated that the neural circuit responsible for agreement operations is not circumscribed to the left prerisylvian regions that have traditionally been the key focus of the sentence processing literature (Friederici, 2011, 2012; Friederici & Gierhan, 2013; Hagoort, 2003a, 2005). However, even more important is the result concerning the interaction between conceptual and formal information during the establishment of local grammatical relations. We isolated a parietal cluster in the left hemisphere which included part of the angular gyrus and the inferior parietal cortex showing a significant interaction between Congruency Pattern and Type of Gender. These two parietal areas exhibited greater response for incongruent than for congruent items. However, crucially, this difference was only significant for Conceptual Gender. Taken together the current results provide crucial evidence concerning how our brain deals with agreement information. The interplay between one of the main hubs of the domain-general semantic network and the neural circuit involved in agreement computation suggests that for the processing of grammatical relations a complex circuit, which include language-specific and domain-general areas, is boosted. The fine-tuning of this system seems to be constrained by the available conceptual and/or formal information.

A25 Tracking the learning of new meanings for novel words and known words

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In addition to learning new words, people refine and add new meanings to words they already know. However, this second type of learning is less studied. The current study tracked the two types of learning by recording EEGs throughout the learning phase. Twenty-one native English speakers learned new meanings for known words (e.g., “plenty” with “causing fever”) and novel words (e.g., “tasdite” with “having a tight schedule”) in an associative learning paradigm in which words and meanings were presented consecutively. To account for the effect of mere exposure, another set of known words (e.g., “weapon”) and novel words (e.g., “attave”) without new meanings were presented and served as exposure controls. Each word was presented once in each of six learning blocks. Following the first block of study trials, blocks two through six were test-study trials, requiring participants to attempt to recall the new meanings before viewing them. For analysis purposes, the second and third learning blocks were defined as an early learning phase, and the last two blocks as a late learning phase. We compared ERPs of early and late learning phases for novel and known words under both meaning learning and exposure control conditions. Compared with the early learning phase, the later phase showed both a larger frontal negativity (200-800 ms) and a larger parietal positivity (especially within 400-600ms) for both known and novel words. This result occurred for exposure controls as well as words and novel words paired with new meanings, reflecting an increasingly successful episodic memory for all stimuli: even for exposure controls, the task appears to require a retrieval of the trial episode to determine whether the word was paired with a meaning. Novel words evoked a larger negativity relative to known words in central regions from 200 to 600 ms in both early and later learning phases, and this pattern held for words with new meanings as well as exposure controls. Additionally, in late learning but not in early learning there was a larger negativity within 600-800ms at Cz for known words with new meanings compared to their exposure controls. This effect was absent for novel words. This negativity for known words only in later learning reflects meaning competition between the new and original meanings that emerges with learning the new meanings. Coupled with other recent ERP experiments showing competition effects during learning of new meanings (Fang & Perfetti, under-review), we suggest that, prior to meaning consolidation, episodic memory for word learning events increases with learning and competes with previously established meanings.

Language Development

A26 Effects of familial dyslexia on neonatal speech sound processing as reflected by auditory ERPs

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Developmental dyslexia is a heritable learning disorder affecting reading and writing and predisposing to poor academic achievement. It is also associated with deficient language processing, e.g., difficulties in speech-sound processing. Although infants with a familial background of dyslexia are at an elevated risk to develop dyslexia compared to families without such background, it is not known which developmental factors predispose the at-risk infant to develop dyslexia. One major theory for the cause of dyslexia is the phonological deficit theory, which explains the reading difficulties by a deficient processing of language sounds in the brain. To target preventive interventions to infants at highest risk for dyslexia, it is paramount to identify these individuals as early as possible, preferably as soon after birth as possible. However, neurological markers of dyslexia at birth have been examined only scarcely. In this first part of a longitudinal study on dyslexia, event-related potentials (ERPs) to speech sound changes were recorded from healthy sleeping Finnish newborns. Specifically, our interest was to

evaluate mismatch negativity (MMN) responses, reflecting brains' automatic change detection, as a biomarker for speech sound discrimination accuracy. During the experiment, the Finnish pseudoword /tata/ and its variants (changes in vowel identity, pitch, and vowel duration; probability of each ca. 8.5%) were presented to the infants in an MMN paradigm. To assess the influence of familial dyslexia-risk on speech sound discrimination, ERPs were recorded from both infants with a familial background of dyslexia (at-risk group) and infants whose families reported no diagnosed language-related deficits among close relatives (control group). The groups were matched for age and gender. Our tentative results suggest compromised processing of speech sound changes in, e.g., frequency and duration, as reflected by MMN responses in infants at risk for dyslexia compared to the healthy control group. Differential processing of speech sound changes in at-risk infants might be indicative of possible deficient language processing later in development. Furthermore, the observed abnormalities in brain responses at birth may predict later language and neurocognitive outcomes which will be examined in the later stages of this longitudinal study. Taken together, our results on neonatal speech processing in infants at risk for dyslexia offer insights to the early identification of at-risk individuals and to the nature of language deficits associated with dyslexia. In the future, this knowledge can hopefully be applied to develop early intervention programs to prevent or ameliorate difficulties arising from dyslexia in at-risk individuals.

A27 Past tense production in children with and without specific language impairment: an fMRI study

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Studies of English past tense production have provided a powerful tool to test single and dual-mechanism theories of language morphology in adults. These theories have been used to generate hypotheses regarding the neural mechanisms at the root of language development and language impairments. However, such theories are based on the untested assumption that brain networks are comparable in adulthood and childhood, with no previous investigation of brain regions activated during past tense production in children. Specific language impairment (SLI) is a particularly interesting case, as one of the early hallmarks of this prevalent developmental disorder is an impaired ability to inflect verbs. To addresses this gap in knowledge we examined the fMRI correlates of past tense production in 44 school-age typically developing (TD) children and 27 age matched participants with specific language impairment (SLI; age range for both groups: 9 to 11 years) recruited from a longitudinal community cohort. During the task condition, participants had to complete sentences by overtly generating regular or irregular past tense forms. During the baseline condition, children simply listened to similar sentences, followed by noise. fMRI analyses were run within SPM8 using age, gender and PIQ as a covariates. We used both whole-brain correction for multiple comparisons (p=0.05) and small volume correction in three a-priori hypothesized bilateral regions of interest (inferior frontal gyrus, planum temporale, and striatum). Results were also examined at p=0.001 uncorrected for multiple comparisons (minimum 10 voxel cluster) for exploratory purposes. For the past tense task, the SLI group (median percentage correct 86.7, IQR=20) performed significantly lower than the TD group (median percentage correct 93.3, IQR=13.3; U=368, p=0.002). In the TD group, fMRI activation was observed in the left and right pre/postcentral gyri (peaks at x=-44, y=-12, z=32; T=6.01 and at x=46, y=-12, z=36; T=5.25), right superior temporal gyrus (peak at x=52, y=-20, z=-2; T=5.2), left insula extending into the basal ganglia (peak at x=-46, y=16, z=-8; T=6.29), right insula (peak at x=46, y=18, z=-2; T=5.31) and bilateral anterior cingulate (peak at x=0, y=18, z=20; T=5.71). For the regular versus irregular contrast, the TD group activated the left angular gyrus (x=-40, y=-56, z=18; T=5.3), while no significant difference was detected for the reverse contrast. No suprathreshold activation was detected in the SLI group for any of the contrasts, probably due to high within-group variability. Importantly, no statistically significant differences were detected between the TD and SLI groups. Two novel findings emerge from these results. First, the neural correlates of past tense production in school aged children differ from those published in the adult literature, suggesting protracted developmental changes of this language network. In particular, we found little evidence of inferior frontal gyrus involvement in children with and without SLI. Secondly, our inability to detect localized fMRI anomalies in children with SLI suggests a complex or heterogeneous neural basis for the condition. The findings are discussed within a connectionist framework, whereby past-tense deficits in children with SLI are thought to be rooted in distributed neural dysfunction or noise, rather than modular regional differences.

A28 White matter connectivity in children with speech and/or language impairment: a diffusion weighted imaging and tractography study

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Childhood speech and language disorders are common, affecting one in twenty preschoolers. Longitudinal studies have revealed the fluid nature of typical and disordered communication trajectories. Little is understood however, regarding the underlying neurobiology of these conditions, in particular white matter structural connectivity. Further, existing MRI studies are based on highly selected clinical samples with limited cross-sectional phenotyping, straddling broad age ranges. These restrictions limit our ability to interpret and generalize findings to the broader population with speech and/or language impairments. We hypothesized that developmental speech and language disorders would be associated with atypical development of tracts involved in speech motor control and in language functions, respectively. Here we captured T1 and diffusion weighted imaging (DWI) data on children

recruited from a longitudinal language study of almost 2000 children, where communication status was examined at 8 months of age and almost annually until time of scanning in the present study. Age of scanning (9 to 11 years) was carefully chosen to reflect a time when communication trajectories are relatively stable. Participants were recruited to 4 groups based on consistent longitudinal data: Typically developing controls (TD, n=44); Language disorder (LD, n=15); Speech disorder (SD, n=17); and co-occurring Speech and Language disorders (SLD, n=9). The three latter groups were combined into an "atypical" group for analyses. All participants had non-verbal IQ ≥ 80 as tested from 4 to 11 years and English as their only language. DWI data was collected on a 3T MRI scanner (64 directions, b=3000s/mm2). Probabilistic tractography of DWI images was performed in native space based on Constrained Spherical Deconvolution using MRtrix software (Version 0.2). Subsequent tracking was performed from conservatively drawn seed regions to generate the three segments of the arcuate fasciculus, the corticobulbar tract (CBT), and the extreme capsule system bilaterally. Mean fractional anisotropy (FA) values were extracted and compared between the TD and atypical group using a multivariate analysis of covariance (Track x Hemisphere x Group design), with nonverbal IQ as a covariate. Nonparametric tests were used for exploration of subgroup differences. There was a main effect of Hemisphere for the arcuate fasciculus direct (F= 4.91, p=0.030), and a Group by Hemisphere interaction (F=4.17, p=0.044) for the CBT. FA in the left CBT was lower in the atypical than TD group (t= 2.26, p=0.026). FA in the left CBT was significantly lower in the SD group relative to the TD group (U=213, p=0.007). Reduced FA of the left CBT has previously been associated with dysarthria in children with acquired brain injury. Here we report the first association between this tract and developmental SDs, suggesting atypical development of the left CBT may be a neural marker for SD. By contrast, despite our longitudinally-informed phenotyping and narrow age range, we found no significant association between classical language tracts and LD. Early white matter disruption in LD may not affect the classical language network, or may be heterogeneous between children.

A29 Where is the red ball (moving)?: Differences in the use of locative and directional prepositions in high-functioning autism

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Autism Spectrum Disorder (ASD) is characterized by difficulties with social interaction and communication, as well as repetitive and stereotyped patterns of behaviour (APA 2000), and may be accompanied by language delay or impairment. Furthermore, the cognitive and language profiles of individuals with ASD display both deficient and enhanced abilities within particular areas (Tager-Flusberg, Joseph & Folstein, 2001; Vulchanova, Talcott, & Vulchanov, 2014). Peaks can be observed in the areas of e.g. visual discrimination, Block Design and vocabulary size, whereas troughs are found in communication, pragmatics or egocentric transformations. The main aim of the current study was to investigate the use of spatial language (i.e. descriptions of spatial relations between objects) in high-functioning autism and to what extent competencies in this domain can be linked to non-verbal abilities in the domain of spatial cognition of individuals with ASD. Since the use of spatial prepositions is based upon both linguistic and perceptual representations, it forms a natural bridge between language and cognition. In the current cross-sectional study we compare two groups of participants with high functioning autism: children (10-14 years old) and young adults (18-26 years old), and control participants matched on age and non-verbal IQ with the target groups. We have adapted a Spatial Naming Test, developed at the University of East Anglia (Markostamou, Coventry, Fox, & McInnes, 2015), to test the production of locative/relational (e.g. over, in, among) and directional prepositions (e.g. towards, downwards, onto) in individuals with high-functioning autism. The test, an analogue to the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 2001), consisted of 30 pictures with simple geometrical shapes: a red ball, a black cube and one or more black balls. Participants' task was to name as accurately as possible the red ball's position or its direction of movement in relation to the black cube abstracting away from distractor items in the scene (e.g. black ball(s)). Preliminary results showed deviant performance of the target group in the use of directional prepositions compared to locative/relational prepositions, revealing a particular difficulty with naming dynamic spatial relations in high functioning autism. However, the adults with ASD performed better than children with ASD pointing to a developmental trajectory of improvement in spatial language production. Observed difficulties with the use of directional prepositions might reflect abnormal motion processing in autism and can be explained in the framework of a dorsal stream deficiency hypothesis (Milne et al., 2006; Spencer et al., 2000).

A30 Impaired categorical perception of lexical tones in Chinese children with autism: An Event-Related Potential study

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Numerous studies have reported enhanced pitch perception in individuals with autism in comparison with age-matched normal controls. However, a recent study (Yu et al., 2015) reported domain specificity of this phenomenon in Chinese children with autism who showed enhanced neural sensitivity to pitch changes in simple and complex nonspeech stimuli but not to lexical tone contrasts in their native language. The present event-related potential (ERP) study was designed to investigate whether the distinct neural responses to speech and nonspeech conditions could be due to a potential deficit in categorical perception of lexical tones. A passive double oddball paradigm was adopted to examine Chinese participants' Mismatch Responses (MMR) to equivalent pitch deviations representing within-category and across-category differences in both speech and nonspeech contexts. Two groups of children participated in this study: 16 children with autism, and 15 typically developing

controls matched on age and IQ scores. Three stimuli were chosen from a 10-step lexical tone continuum used in previous CP studies (Xi et al., 2010; Zhang et al., 2012) in order to have both a between-category stimulus pair and a within-category stimulus pair equated for acoustic distance. We analyzed the ERP waveforms in each condition with a traditional approach, measuring the average MMR amplitude. The MMR results showed evidence for the lack of categorical perception in the lexical tone condition with an opposite trend in the harmonic tone condition for children with autism. Furthermore, using data obtained in the double oddball paradigm, we performed the time frequency analysis to explore the changes in EEG oscillatory neural activity in the beta band (13-30Hz) in categorical perception of lexical tones. Single-trial ERP data was decomposed into time-frequency representations with a fast Fourier transformation analysis for each channel centered around each time point. The EEG oscillation results showed that the increased beta was induced in the between-category offering a clear phonetic identify for typically developing children in speech condition while a similar phenomenon was not found for children with autism. All of the findings show that children with autism lack of categorical perception of lexical tone and the potential deficit may explain the distinct response to speech and nonspeech stimuli involved in previous studies. The results suggest a need for appropriate interventions that can overcome this categorical perception deficit in the processing of lexical tones, which may fundamentally affect the acquisition of lexical tones and language development in tonal-language speakers with autism.

A31 Early Parental Input affects Brain Activation during Auditory Sentence Comprehension in Preadolescent Children

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Early parental language input is an important environmental factor that contributes to individual variation in children's later language development. Parental use of decontextualized language (such as narrative, pretend, explanation) during preschool years uniquely predicts vocabulary development at school age. Despite the solid behavioral evidence for the importance of parental input, little is known about its relation to the neurobiology of language. In the current study, we assessed the quantifiable effects of early parental language on brain activation during auditory sentence comprehension in a group of preadolescent children. We hypothesized that children with greater exposure to decontextualized language, specifically narratives, in preschool years would exhibit higher activation in left perisylvian brain regions while listening to stories. Parental input quantity (total number of utterances) and quality (total number of narrative utterances) was assessed during longitudinal observations of spontaneous child-caregiver interactions at the age of 30 months in a cohort of children from the Chicago area. fMRI data were collected from 26 children (15 male, mean age = 13 yrs) on a Siemens 3T Prisma scanner (TR = 2000 ms, TE = 25 ms, flip angle = 80°, voxel size = 2 × 2 × 2 mm , FOV = 832 × 784). Children listened carefully to two-sentence "stories" presented in the scanner, each consisting of a context sentence followed by a target sentence. The context sentence would set up expectations that the target sentence either confirmed or disconfirmed making the story ending predictable or less predictable (e.g., Context: "Lindsey loved warm weather." Target: "Summer was her favorite season" vs. "Winter was her favorite season."). Early parental narrative input was entered as a covariate in the fMRI analysis for a subset of the children (n = 14) who had been studied longitudinally since the age of 14 months. Overall, the stories elicited activation in the bilateral superior temporal gyri and sulci and the left inferior frontal gyrus (pars opercularis, triangularis and orbitalis) (vertex-wise threshold p = 0.005; alpha = 0.05 after FWE correction). In our longitudinal sample, we found that activation in the left posterior superior temporal sulcus (pSTS) during the context sentence was modulated by the quality of early parental input, specifically the use of narrative. This effect remained significant even after controlling for parental SES. Our study demonstrates that children exposed to more narrative speech during early interactions with their parents show higher activation in the left pSTS while listening to short stories. Importantly, this correlation cannot be accounted for by the quantity of the parental input or SES. Activation in the left pSTS during narrative comprehension in young children has been shown to be related to their home reading environment, while the engagement of this area in narrative comprehension increases with age in longitudinal studies. To conclude, our results add to the existing literature on the role of the pSTS in narrative comprehension and highlight the importance of the quality vs. quantity of early parental input in later language processing.

Grammar: Morphology

A32 Neurocognitive Correlates of Verbs: Zero-Derivation versus Lexical-Selection costs

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Introduction: Many words in English are lexically ambiguous, having both verb and noun readings (e.g., bear, brush). Psycholinguistic studies have shown that ambiguous words take longer to process compared to unambiguous words. Processing such words also leads to increased activity in the left frontal cortex (for review, see Eddington and Tokowicz, 2015). In the domain of categorical ambiguity, two competing accounts have been proposed to explain this processing cost. One posits separate lexical entries (the brush and to brush), and argues that greater selection demands are required for lexical items with multiple entries (Grindrod et al., 2014; Jackendoff, 1976). The other assumes that only the noun (the brush) is stored, and the processing cost reflects online zero-derivation of the verb from the noun (Pliatsikas et al., 2014; Taft and Foster, 1975). To address this question, the current study used fMRI to examine the neural mechanisms associated with processing verbs with single and multiple unrelated lexical entries (e.g., bake, bear, respectively), and those derived from nouns (e.g., brush). We hypothesized that if derived verbs entail separate lexical entries, activation patterns similar to those seen for verbs with multiple unrelated representations would be forthcoming, reflecting lexical selection demands. In contrast, if derived verbs are formed from a single stored noun, then verbs with multiple unrelated representations would elicit greater activation than

derived verbs in regions involved in lexical selection. Method: Ten healthy, right-handed, young adults (6 females, mean age 24.07 years) performed an event-related fMRI grammaticality judgment task, in which they decided whether a two word sequence is grammatical ('to bake') or not ('the bake'). The study included three conditions: 1) v1: verbs with a single, verbal, lexical representation (to bake), 2) v2: forms associated with two lexical entries – a verb and a noun - where one is not derived from the other (to bear, the bear), and 3) v3: noun-derived verbs, which by hypothesis are derived on-line from a stored noun representation (to brush). There were 21 items per condition, repeated twice. Noun pairs served as baseline. Data were analyzed with SPM8, using a voxel-wise FDR-corrected threshold of $p<0.05$. The fMRI analysis focused on three primary contrasts: (1) verbs versus nouns, (2) effect of derivation (v3>v1; v3>v2), and (3) effect of lexical selection (v2>v1; v2>v3). Results: The noun vs. verb activation pattern revealed a left-lateralized frontal area associated with verb processing, and a bilateral temporo-parietal network elicited by noun processing. There were no effects of derivation. However, an effect of lexical selection (v2>v3) was found in the inferior and middle frontal gyri. Conclusion: The increased activity found within the left frontal cortex for verbs with multiple distinct meanings (bear) compared to noun-derived verbs (brush) suggest the existence of multiple entries for the former, but not for the latter, supporting the hypothesis that the latter are derived on-line rather than stored. Only for the former type of verb, additional resources are recruited in order to resolve the increased competition between two co-activated meanings (Grindrod et al., 2014, Thompson-Schill et al., 2005).

A33 Processing of nouns and verbs in different contexts: An fMRI study

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Neural representations for nouns and verbs in English and many other languages can be distinguished by lexical and semantics processes (e.g., Tyler et al. 2001; Palti et al. 2007). Further, neuroimaging studies have shown a morphosyntactic distinctions of nouns and verbs in English, Japanese, and other languages (e.g., Shapiro et al. 2005, 2006; Yokoyama et al. 2006; Berlingeri et al. 2008; Burton et al. 2008; Finocchiaro et al. 2010; Tsigka et al. 2014; Momenian et al. 2016). An increasing number of neuroimaging studies have indicated increased activation to verb processing as compared to noun processing in frontal and temporal regions as well as other brain areas using lexical or semantic judgment tasks (Bedny et al., 2008; Finocchiaro et al., 2010; Yu et al., 2013). Only a few studies have shown greater neural activation for the processing of nouns as compared to verbs (Sccuman et al., 2006; Pulvermuller et al., 2012). Previous fMRI studies comparing Chinese nouns and verbs using a lexical judgment task and three set of disyllabic nouns, verbs and class-ambiguous words showed non-differential activation across the brain (e. g., Li et al. 2004; Yang et al. 2011; Yu et al. 2013). The goal of the present fMRI study is to identify the neural correlates of Chinese noun and verb phrases in order to examine whether the processing of word categories in Chinese is specific or not, relative to other languages like English and Japanese. Seventeen native Chinese college students participated in the study. Our block-design study included two conditions (grammatical category vs. semantic category) presented in 2 contexts (syntactic context vs. semantic context), with the latter aimed at separating the contributions of syntactic and semantic processing of nouns and verbs. Our study showed a main effect for context: in the syntactic context, verbs over nouns resulted in activation of the LIFG, however, verbs over nouns resulted in activation of the LIFG, LMFG and LSTG in the semantic context. These findings indicate that verbs over nouns processing under a semantic context are more complex than in a syntactic context. Importantly, our results revealed greater activation in the LIFG for verb over noun processing under a syntactic context in Chinese-a language with minimal inflectional morphology. Moreover, the theory that the LIFG is only related to complex morphological inflectional language processing is not supported by the findings in the present study. Although the Chinese language lacks inflectional morphology, grammatical properties can be conveyed through the combination of words, which can be equal to the task of inflectional morphology processing in Indo-European languages. Furthermore, our results also indicate that under the syntactic context, the processing of verbs may be more efficient than that for nouns.

A34 Production of grammatical and lexical verbs in context: an ERP study.

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Grammatical and lexical words differ widely in content and function. Grammatical words are of particular interest as they represent the part of grammar that one can directly contrast with the lexicon. Data from brain-damaged patients (Gardner & Zurif, 1975; Biassou et al., 1997; Alario & Cohen, 2004), linguistic theories (Boye & Harder, 2012) and recent Event Related Potential studies (Bürki, Sadat, Dubarry, Alario 2015) suggest that their processing is operated at different stages in speech production. Speech models of sentence production propose that at the formulation stage, lexical words are processed at the so-called functional level while grammatical words are processed at the so-called positional level (Garrett, 1975; Bock & Levelt, 1994). Nevertheless, this proposal has been very difficult to investigate for several reasons. First, research in speech production has long been focused on the production of isolated words. Even though the past years have seen a significant increase in publications investigating multi-word messages, very little is known as to how speakers plan and process more than one word messages. Second, as the production of grammatical elements can only be done in context, much less is known about processing of grammatical words compared to processing of lexical words. Eventually, it is very difficult to compare elements (lexical and grammatical) which differ so much in function, frequency, age of acquisition and categorization. The current study attempts to fill this gap by comparing fully homonymous sentences with only a difference in verb status (grammatical vs. lexical) elicited by a specific context. In the lexical context, sentences contained

either a lexical verb such as “Lise has a missed call” and were followed by a question such as “What about Sophie?”. Participants were instructed to answer “So has she” as soon as they read the eliciting question. In the grammatical context however, sentences contained a grammatical verb such as “Lise has missed a call” and participants were also instructed to answer “So has she” after reading the eliciting question. This design allowed us to compare fully matched sentences (e.g. So has she) with only a difference in verb status (e.g. So has she (grammatical verb) VS. So has she (lexical verb)) as elicited by the context. Two different verbs were used. Reaction times (RTs) and Event Related Potentials (ERPs) were recorded. We predicted that if two sentences with equal phonological content differ in processing at the formulation stage, differences in RTs and ERPs should be observed for the words planned before articulation initiates. Stimulus-aligned and response-aligned ERPs based on each participant’s RTs were pre-processed using Independent Component Analysis and waveforms analyzed. Results are discussed in the light of psycho-linguistic and linguistic models.

A35 The role of memory consolidation in learning and generalising inflectional morphology: behavioural and fMRI findings

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Language learning and generalisation are tuned to input statistics. Inflectional morphology is a proving ground for investigating whether learners generalise based on how often individual words occur in the input (token frequency) or based on how many different words in the input follow a particular pattern (type frequency). In two experiments, we focused on the role of overnight memory consolidation in influencing the representation and generalisation of novel inflectional affixes trained with different type and token frequencies. Over the course of 9 days, we trained participants on an artificial plural system in which novel words referred to the occupation of male and female characters. On Day 1, participants learned the singulars (e.g. gleeti[fem,sing] = doctor [fem,sing], shilnu[masc,sing] = painter [masc,sing]). On Day 8, participants learned a first set of plural affixes for one gender (e.g. gleetaff[fem,plur] = doctors [fem,plur]). On Day 9, participants learned a new set of affixes for the other gender (e.g. shilnopp[masc,plur] = painters [masc,plur]). This design allowed us to make within-subject/between-affix comparisons in the generalisation and representation of affixes trained on consecutive days. The novel words were designed such that the majority were phonologically varied and took a high type frequency regular affix (e.g. gleetaff[fem,plur], shilnopp[masc,plur]), akin to phonologically varied regular English verbs (call-called, turn-turned). A subset of words contained an ambiguous phonological cue (e.g. arb) which was associated with both a high token frequency irregular affix (e.g. varbesh[fem,plur], yarbull[masc,plur]) and a high type frequency regular affix (e.g. farbaff[fem,plur], tarbopp[masc,plur] but also gleetaff[fem,plur], shilnopp[masc,plur], etc.). This mimicked phonological similarities between regular and irregular English verbs (e.g. fit-fitted, sit-sat). In Experiment 1, productive generalisations of the plural affixes to untrained phonologically ambiguous singulars (e.g. zarbi[fem,sing], zarbu[masc,sing]) showed greater influence of token frequency for affixes trained on Day 8 (consolidated) than for affixes trained on Day 9 (unconsolidated). In Experiment 2, we examined this consolidation effect further by using fMRI to compare neural responses to affixes trained on Day 8 (consolidated) and Day 9 (unconsolidated). This revealed a neural effect of consolidation restricted to affixes trained in the context of an ambiguous phonological cue. For high token frequency irregular affixes, we observed an elevated response for Day 9 (unconsolidated) compared to Day 8 (consolidated) affixes in the left inferior frontal gyrus and the left superior temporal gyrus. By contrast, for high type frequency regular affixes, we observed an elevated response for Day 8 (consolidated) compared to Day 9 (unconsolidated) affixes in the left posterior hippocampus. Overnight changes in generalisation performance (Experiment 1) and in the involvement of different memory systems (Experiment 2) according to the type and token frequency of irregular affixes trained in the context of an ambiguous phonological cue suggest a role for overnight memory consolidation in the extraction of statistical patterns underlying inflectional morphology. This is consistent with a complementary learning systems account which proposes a division of labour between a fast learning hippocampal system which encodes the specifics of individual episodes and a slow learning neocortical system that extract generalities across multiple episodes.

A36 Precision grip and whole hand grasp nominal classifiers in Japanese: An fMRI study

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Nominal classifiers in Japanese classify noun classes that reflect pinch grip (PG) (□, e.g. hito-tsubu no sakurambo ‘a cherry’) and whole hand grasp (WHG) (□, e.g. ikko no gurasu ‘a glass’) sizes of the noun referent. We wanted to investigate if such specific semantics had consequences for the neural activation in modal areas corresponding to the meaning of these grammatical markers, as predicted in embodied cognition. Since these classifiers are grammatical categories generalising over a closed set of size-related nouns, the affordances of the noun referents make out the sole semantic content of the -tsubu and -ko classifiers. Through language acquisition and use, these classifiers generalise over multiple grasp experiences with everyday, familiar objects. Entrainment plays a role in PG grasping. A PG impaired patient showed exaggerated anticipatory aperture with unfamiliar wooden blocks for laboratory use, but his deficit was much less marked with familiar objects, e.g. a lipstick (Jeannerod et al., 1994). Castiello (2005) argues that for commonly used objects, cognitive cues and previous knowledge can be used to determine the size of the object, indicating that ‘the meaning attached to an object might modulate classic grasping circuits’. Multiple studies demonstrate that the neural circuits for the two grasp types differ (Ehrson et al., 2000; Begliomini et al., 2007; Kuhtz-Buschbeck et al., 2008). For example, in an in fMRI study by Begliomini et al. (2007), the left anterior intraparietal sulcus (aIPS) was reported to be involved in PG but not in WHG, when these grasp types are compared to reaching, and similar differences were also found in the

pre- and postcentral gyri. The importance of aIPS in PG but not in WHG is corroborated by the fact that lesions at this locus impair the ability to perform PG whereas WHG remains unaltered (Jeannerod, 1986). TMS studies on aIPS show that inactivation of this area mainly affects PG and the visuomotor transformation of handgrip. Inferior premotor central sulcus and the cingulate sulcus have also been indicated as differentially significant for PG (Ehrsson et al., 2000). Research also shows that visual stimuli automatically activate motor information (Borghi et al., 2007) and action on PG and WHG (Grèzes et al., 2003). In order to investigate whether the known neural differences in grasp types are reflected in neural representation of linguistic categories, we carried out a passive reading, event-related design fMRI study with native speakers of Japanese (N= 23) using Japanese PG and WHG classifier phrases as stimuli. Each semantic condition was contrasted over a hash mark low-level baseline, and a number of a priori selected ROIs from the grasp type literature (e.g. aIPS, ventral SMA, pre- and postcentral areas, supramarginal area, the right cerebellum) were calculated. In addition, a data-driven analysis was carried out collapsing the PG and WHG classifier conditions, selecting the peak coordinates from the p-value table for cluster ROIs. From these results we discuss to what extent grammatical categories that depict real-world experiences are represented in modal areas of the brain and therefore grounded.

A37 White matter pathways associated with morphological processing

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Morphological processing is an essential component in visual word recognition. Behavioral and electrophysiological evidence suggests that derivational morphemes are extracted early in orthographic processing (Rastle & Davis, 2008). Functional MRI studies have identified several distant cortical regions involved in morphological processing, including the left inferior frontal, inferior parietal, and middle temporal cortices (e.g., Bozic et al., 2013, Bick et al., 2011). However, little is known about the white matter pathways that support this skill. Here, we used diffusion MRI (dMRI) to identify candidate white matter pathways hypothesized to be involved in morphological processing, and analyzed the relation between their microstructural properties and morphological processing skills in adult English readers. Morphological processing efficiency was quantified behaviorally using the morpheme interference paradigm (Crepaldi et al., 2010). To this end, written words and two types of pseudowords were presented in a lexical decision task. Real-morpheme pseudowords comprised two real morphemes (e.g., gasful), while invented-morpheme pseudowords incorporated one real and one invented morpheme (e.g., gasfil). Morphemic cost, defined as the difference in accuracy levels between real-morpheme and invented-morpheme pseudowords, served as an index of individual sensitivity to morphological information. We hypothesized that morphological processing relies primarily on ventral-stream reading pathways (Cohen et al., 2008; Cummine et al., 2015, Taylor et al., 2013), because morphemes provide prominent cues for mapping between orthography and meaning. Accordingly, we targeted the major ventral fiber tracts: inferior fronto-occipital fasciculus (IFOF), inferior longitudinal fasciculus (ILF) and uncinate fasciculus (UF). However, the main pathways connecting the cortical regions implicated in fMRI studies of morphological processing are dorsal-stream fibers. We therefore targeted the arcuate fasciculus (AF) and fronto-parietal superior longitudinal fasciculus (SLF) fibers, dorsal tracts known for their involvement in phonology and reading (Yeatman et al., 2011). 26 adult native English readers completed dMRI measurements and a behavioral battery that included the morpheme interference task and measures of phonological and orthographic processing. dMRI data were acquired in the same participants using a 3T Siemens scanner, b=1000 s/mm2, 64 diffusion directions, voxel size: 2x2x2mm3. The five tracts of interest were identified bilaterally in each participant's native space, using deterministic tractography with automatic tract segmentation (Yeatman et al., 2012). Fractional anisotropy (FA) and mean diffusivity (MD) profiles were calculated along each of the tracts-of-interest, and Spearman's correlations were calculated between morphemic cost and these diffusivity profiles. Significant negative correlations were found between morphemic cost and FA in the left UF, right IFOF and left AF ($p<0.05$, family-wise error (FWE) corrected). In addition, significant positive correlations were found between morphemic cost and MD in the left UF and left ILF ($p<0.05$, FWE corrected). All correlations remained significant after partialling out nonword repetition accuracy scores, suggesting some level of specificity to morphological processing, beyond the contribution of phonological skills. Taken together, the results suggest that morphological processing relies on both ventral (UF, ILF, IFOF) and dorsal (AF) pathways, primarily in the left hemisphere. We interpret the results as reflecting the contribution of morphological processing to lexical access as well as to phonological segmentation of complex words.

Language Disorders

A38 Concentric Analysis of Category Naming Fluency in Frontotemporal Degeneration

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Recent work has demonstrated the importance of network-based approaches to understanding the neurobiologic basis of language disorders. This involves identification of multiple grey matter regions contributing to task performance, and the synthesis of these grey matter (GM) regions with white matter (WM) projections that integrate the identified grey matter regions. Both neuroimaging studies and clinical-pathological correlations have shown that large-scale neural networks play a role in single word processing and sentence processing. Recent advances in imaging analysis have adopted a game theory approach to evaluate the combined role of GM and WM regions in the identification of the anatomic associations of neurodegenerative syndromes such as Alzheimer's disease and frontotemporal degeneration (FTD). Previous work used a data-driven eigenanatomy approach to show that a combination of GM and WM was more robust statistically than either one of these modalities alone in defining the neuroanatomic basis for one of the most common language-mediated tasks - letter-guided category naming fluency (FAS) (Cook et al, 2015). In this study, we used game theory analyses to evaluate the large-scale network subserving FAS performance in behavioral

variant FTD (bvFTD). We examined 46 patients meeting research criteria for bvFTD (Rascovsky et al, 2011) and 46 healthy, demographically-matched controls. Here we studied bvFTD to minimize a variety of confounds that may be present in patients with speech disorders. Patients performed a letter-guided category naming fluency task (FAS). All participants also obtained T1-weighted MRI with 1mm isotropic voxels, and cortical GM was partitioned into 98 regions using the OASIS label set. Diffusion-weighted imaging used a 30-direction protocol. All WM voxels were seeded, and deterministic tractography was used to identify streamlines between 2 different GM regions (nodes). Fractional anisotropy (FA) was averaged across streamlines to weight projections (edges) between nodes. We obtained several measures of network integration and segregation. Our results showed widespread reduction in FA projections between nodes in frontal and left temporal regions. Regression analysis related FAS performance to these projections ($p<0.05$, Bonferroni-corrected). In addition, we found reduced degree centrality (number of projections between each node and other nodes in the network) and reduced closeness centrality (shortest projections between each node and all other network nodes) in frontal-temporal regions in bvFTD ($p<0.05$, FDR-corrected), and these measures of integration were related to FAS performance in frontal-temporal regions. While there were reduced frontal-temporal hubs (nodes through which shortest-path projections pass) in bvFTD, this was not related to FAS performance. We also found reduced cluster-coefficiency (a measure of segregation related to modularity) in frontal-temporal regions of bvFTD, but this was not associated with FAS performance. We conclude that large-scale neural networks are compromised in bvFTD, and that the deficit in these patients is most closely related to a specific disorder of network integration that reflects poorly integrated frontal-temporal nodes.

A39 Verbal Working Memory Capacities in Sentence Comprehension: Evidence from Aphasia

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Successful sentence comprehension often requires the ability to link non-adjacent constituents. Recent studies implicate that readers link non-adjacent constituents through an associative, direct-access mechanism, while working memory (WM) or short-term memory (STM) may not play an important role in this operation because only 1- 2 items could be maintained in the focus of attention (Van Dyke, 2007). However, prior studies with aphasic patients have supported a role for semantic STM and executive control in sentence processing (Martin et al., 2004; Vuong et al., 2011). Recently, a study with healthy subjects also demonstrated a role for semantic STM in resolving semantic interference, and a role for attentional control in resolving syntactic interference during sentence comprehension (Tan et al., 2011). These results suggested that semantic STM and attentional control are involved in semantic and syntactic aspects of sentence processing, respectively. This study further examined semantic and syntactic interference resolution in aphasic patients, who show dramatic variation in their WM/STM capacities. Semantic and syntactic interference were manipulated in a 2 x 2 design by varying the semantic plausibility of the intervening noun as the subject of the main verb and varying the syntactic role of the intervening noun (subj vs. obj). Both manipulations have been shown to increase difficulty in linking the head noun to the main verb. Example: Low-Syn: The student who was tired of the demanding assignment/coach yesterday was leaving. High-Syn: The student who said that the assignment/coach was demanding yesterday was leaving. Ten aphasic patients with good single word comprehension abilities but deficits on STM tasks were assessed on whole sentence RTs and on time and accuracy to answer comprehension questions (e.g. Was the student leaving?“). Interference effects were calculated by computing difference scores for RT and accuracy for low vs. high interference conditions. For RTs, the semantic and syntactic interference effects for most patients were within the range of controls. However, most of the patients showed exaggerated sensitivity to either semantic or syntactic interference for comprehension questions accuracy. Moreover, patients with relative better semantic STM made fewer errors in semantic interference resolution ($r = -.77$, $p = .04$), while patient with better attentional control made fewer errors in syntactic interference resolution ($r = -.93$, $p < .001$). However, neither phonological STM nor vocabulary was related to sentence processing. Our current results are consistent with the previous findings that WM and attentional control are critical for sentence processing. Poor maintenance of semantic information and deficits in attentional control lead to difficulties in semantic and syntactic processing. Reference Martin, R. C., & He, T. (2004). Semantic STM and its role in sentence processing: A replication. Brain & Lang, 89, 76-82. Tan, Y., Martin, R.C., & Van Dyke, J.A. (2011). Interference and WM in sentence comprehension. CUNY, Palo Alto, CA. Van Dyke, J.A. (2007). Interference effects from grammatically unavailable constituents during sentence processing. JEP:LMC, 33, 407-430. Vuong, L. C., & Martin, R. C. (2011). LIFG-based attentional control and the resolution of lexical ambiguities in sentence context. Brain & Lang, 116, 22-32.

A40 Artificial grammar learning tasks reveal global deficits in auditory sequence processing in vascular and progressive non-fluent aphasia

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Understanding the extent to which language specific or domain general processes are preserved or impaired in aphasia is of considerable importance. Patients with non-fluent aphasia caused by frontal pathologies can comprehend speech but exhibit grammatical impairments in perceiving and producing language. Recent studies have also identified auditory domain general processing deficits that are not specifically related to language. What remains unknown is whether non-fluent aphasia is associated with greater deficits in the ability to process auditory sequencing relationships that more closely resemble hierarchical relationships in natural language. Ten patients with

non-fluent/agrammatic variant primary progressive aphasia, 12 with non-fluent aphasia due to stroke and 11 matched controls were tested on their ability to implicitly learn an artificial grammar comprised of sequences of either auditory nonsense word or tone sweep stimuli. A novel, mixed-complexity grammar was developed to allow the generation of increasingly complex, more 'language-like' sequences that violated easy (linear), medium (configurational) and hard (hierarchical) sequence ordering relationships. A control task evaluated the ability to detect unexpected oddball nonsense words. No differences were observed between the groups in detecting the oddball stimuli. On the nonsense word and tone sequence processing tasks both patient groups were impaired relative to controls. However, this impairment did not interact with sequence complexity, demonstrating that the aphasic patients were not disproportionately impaired on the more language-like, hierarchical sequences, suggesting a global deficit in processing structured input. For the nonsense word task, while control participants outperformed the aphasic patients, all groups showed progressively poorer abilities to identify the sequences containing increasingly complex rule violations. Furthermore, the performance of all groups improved with repeated testing. The tone sweep task also showed that the control participants outperformed both the patient groups and that performance increased from the first to the last testing run. However, unlike the nonsense word task, performance did not systematically vary as a function of sequence complexity. Hierarchical cluster analyses supported these results, showing that learning profiles were similar across the patient and control groups, but did not generalise between tasks. Within each task, the pattern of responses was comparable across the aphasic and control groups, suggesting a global sequence processing impairment, which was not modulated by sequence complexity or stimulus type. Taken together, these results suggest: 1) vascular and neurodegenerative non-fluent aphasic patients show global impairments in processing structured auditory sequences, 2) they are comparably impaired at processing both easy (linear) sequences and more complex (hierarchical) grammatical structures, 3) implicit grammar learning does not readily transfer between different types of stimuli in either aphasic or control participants. The results raise the possibility that domain general sequence processing abilities are globally impaired in both vascular and neurodegenerative progressive non-fluent aphasia.

A41 From Oscillopathies to Neural Entrainment: Using Language Deficits in Autism and Schizophrenia to (Re)construct an Oscillomic Model of Linguistic Computation

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Introduction: Schizophrenia (SZ) and autism spectrum disorders (ASD) are characterised by marked language deficits, but it is not clear how these arise in the brain. Focusing on the distinctive neural oscillation profiles of the SZ and ASD brains, we use these 'oscillopathic' insights to refine our understanding of how the brain computes language. We believe that this goal can be more easily (and more reliably) achieved if both conditions are examined together, instead of focusing on one or the other separately. SZ and ASD have been hypothesised to be opposite poles of a continuum of modes of cognition also encompassing typically-developing (TD) cognition, and their opposed natures can be tracked from brain structure and function to neurodevelopmental paths, to cognitive abilities Methods: Because brain rhythms are heritable components of brain function and have been associated with some computational primitives of language, we believe that anomalous profiles of brain rhythmicity can help explain language deficits in SZ and ASD. We conducted an extensive literature review to construct the first 'oscillopathic' model of language deficits in SZ and ASD. We then contrasted this with existing models of the TD language-ready 'oscillome' to develop a theory of particular rhythm-based and region-based computational processes required for phrase structure building. Results: The SZ and ASD oscillomes are shown to exhibit reduced α, β and γ across regions implicated in language comprehension such as the left temporal lobe and left inferior frontal gyrus during a range of linguistic tasks. The strength of cross-frequency coupling (CFC) between language-relevant regions is also reduced, with CFC being increasingly seen as responsible for a number of higher cognitive capacities such as working memory and attention. A CFC-based model of linguistic feature-set composition is proposed under which the abnormally synchronised rhythms of the SZ and ASD brain may lead to a sub-optimal 'read off' of linguistic representations during phrase structure building, impairing comprehension. Conclusion: Our translational, oscillomic approach may improve existing understanding of the aetiology of SZ and ASD and their high prevalence among modern populations. We consequently conclude by outlining a 'joint intervention' strategy through which a therapeutic course targeting syntactic deficits in SZ and ASD will be delivered alongside a series of repetitive transcranial magnetic stimulation (rTMS) interventions used to modulate the oscillations responsible for the abnormal linguistic ASD profile. Similar approaches have already been taken to improve performance on visual tasks in SZ patients, and we hope that the evidence we present will convince researchers and therapists to consider the viability of a dual syntactic-oscillomic intervention in the SZ and ASD populations.

A42 Neural Specialization for the Combination of Parsing and Task Performance

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Thirty one people with aphasia (PWA) were tested for the ability to parse and interpret four types of syntactic structures and elements -- passives, object extracted relative clauses, reflexives and pronouns – in three tasks – object manipulation, sentence picture matching with full sentence presentation and sentence picture matching with self-paced listening presentation. Accuracy, end-of-sentence RT and self-paced listening times for each word were measured. Performance on experimental sentences was compared to baseline sentences. MR scans were obtained and analyzed for total lesion volume and for lesion size in 48 regions of interest. To identify lesion effects on specific syntactic structures, forward regression analysis was performed in which accuracy, RT to respond in sentence picture matching, or corrected self-paced listening times for critical words for experimental sentences in a sentence type was the dependent variable, and independent

variables were measures of working memory, performance on the corresponding measure in the baseline sentences, percent lesion in left hemisphere cortex, and lesion volume in each ROI in which 8 or more PWA had a lesion (21 ROIs). To determine if lesions affected syntactic comprehension differently in different tasks, the difference in unique variance (squared semi-partial ("part") correlations) on the measures was compared. In no case was the effect of lesion size in an ROI on performance on a sentence type found in all tasks. In three ROIs – T1p, AG, SMGp -- the difference between the part correlations associated with the lesion in the task in which the lesion effect on the sentence type was significant and at least one task in which the lesion effect on the sentence type was not significant was moderate or strong using Cohen's criteria. The results indicate that the effects of lesions in some ROIs on the ability of a PWA to assign and interpret particular syntactic structures differ in different tasks. The effect of a lesion in those areas is therefore not to affect parsing and/or interpretive operations themselves, which would lead to effects on the structure in all tasks.
The effect of lesion is also not on the ability to evaluate the congruence between the thematic roles depicted in pictures and those in a spoken sentence, or to enact thematic roles, because those abilities are required in all the sentences presented in the SPM and OM tasks. Rather, the effect of a lesion in these areas is on the combination of the parsing and interpretive operations in that sentence type and the use of the information derived from those operations to perform a task. The view that brain areas support the combination of comprehension and task-related operations is consistent with a "situated" model of cognitive and language, that maintains that knowledge is attained through activity associated with social, cultural and physical contexts and is represented in relation to such activity.

A43 Neural mechanisms of auditory sentence comprehension, canonicity, and syntactic movement in people with aphasia

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Comprehension of noncanonically ordered sentences, where the theme is encountered before the agent (in English), is often impaired in people with aphasia and particularly in those with agrammatism. Government and Binding Theory (Chomsky, 1981, 1986, 1995) suggests that noncanonical sentences results from syntactic movement, the displacement of sentence constituents to argument (NP-movement) or non-argument positions (Wh-movement). Previous neuroimaging studies on aphasia have focused on regions recruited for auditory sentence comprehension, but few have examined noncanonical sentence processing and none have investigated syntactic movement. The present study investigated canonicity and syntactic movement during auditory sentence comprehension in six individuals with aphasia (2 females, 29-64 years of age, 16-38 months post-stroke) secondary to a left hemisphere stroke and a group of twenty right-handed cognitively healthy controls (9 females, 24-61 years of age). Participants performed an auditory sentence-picture verification task in a MRI scanner. They indicated with a button press whether a spoken noncanonical, e.g., passive and object-cleft (OC), or canonical sentence, e.g., active and subject-cleft (SC), matched or mismatched a concurrently presented scene depicting semantically reversible actions. In a baseline condition, participants pushed a button after hearing time-reversed speech and seeing scrambled versions of the scenes. Behavioral analyses revealed that all aphasic individuals were more accurate for canonical compared to noncanonical sentences, three of whom were significant. Four of six aphasic individuals exhibited faster reaction times for canonical compared to noncanonical sentences, one of whom was significant. Controls were significantly more accurate and quicker to respond to both canonical versus both noncanonical sentence types. Neuroimaging analyses showed that, for general sentence processing (sentences>baseline), at least five of six aphasic individuals significantly activated bilateral language regions similar to controls and additional right hemisphere regions including the inferior and middle frontal gyri, precentral gyrus, superior parietal lobe, cuneus, and cerebellum. Noncanonical sentences elicited no activity in aphasic individuals, but engaged a left hemisphere network including left inferior and middle frontal gyri and temporoparietal junction in controls. Two aphasic individuals had some significant differential activity for Wh-movement or NP-movement, and one aphasic participant demonstrated significant activity for both. For controls, Wh-movement elicited significant activity in left inferior and middle frontal gyri, supplementary motor area, inferior parietal lobule, and posterior middle temporal gyrus, but no activity for NP-movement. The inferior frontal gyrus activation for Wh-movement in adults provides evidence for its role in integrating information across clausal boundaries and handling syntactic working memory demands. The left temporoparietal activation observed for noncanonical sentences in controls is consistent with accounts for its involvement in thematic role assignment. These syntactic processes are likely impaired in people with aphasia, as suggested by our behavioral results, though canonicity and movement elicited no consistent activation patterns across the aphasic participants. However, our neuroimaging results are consistent with previous studies showing people with aphasia recruiting intact left hemisphere language regions and right hemisphere non-language regions for auditory sentence processing. Further research is required to better understand how the canonicity effect in people with stroke aphasia, seen behaviorally, is neurally represented.

A44 On the association between memory capacity and sentence comprehension: Insights from a systematic review and meta-analysis of the aphasia literature

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Introduction: Language comprehension is a complex task and several aspects of it utilize memory. One such aspect is syntactically based comprehension. Because the time frame over which it takes place is short, several models postulate that sentence comprehension is supported by Short-Term Memory (STM) and Working Memory (WM). However, the data from both neurologically intact individuals and neuropsychological cases are contradictory. The aim of this meta-analysis is to re-assess the association between memory capacity and sentence comprehension by systematically reviewing all relevant studies in the aphasia literature. Methods: We searched Web of Science, PubMed, Medline, PsychINFO and Scopus for relevant studies between 1980 and 2016, using a combination

of the keywords aphasia, sentence comprehension and memory. The inclusion criteria for the final selection were: 1) the study reported original data from patients with aphasia (PWA) due to stroke; 2) the study reported data from at least one sentence comprehension task and one memory task. Studies were coded for language of testing, type of study (research, treatment, and imaging), sample size, aphasia profile, lesion information and type(s) of sentence comprehension and memory tasks used. The studies reporting data from correlation analyses were pooled in the meta-analysis. We combined pooled estimates for the relationship between sentence comprehension performance and performance on memory tasks using a fixed-effects model based on the correlation coefficients extracted from included studies. We calculated confidence intervals for Pearson correlations using Fisher's z transform given a sample size of #n and a sample correlation of #r. Results: 75 potential articles were identified. After reading the abstracts, this number was narrowed down to 35. Reading the full text of the remaining articles resulted in a final set of 27 articles that met the predetermined inclusionary criteria. The association between memory capacity and sentence comprehension has been explored in a total of 562 PWA of different types cross-linguistically. Comprehension of different types of sentences (including both semantically reversible and irreversible ones) has been explored using various tasks and associated with memory measures of various types. The 52% of the studies identified were smaller-scale studies (22% case-reports, 30% studies with less than 10 PWA). From larger-scale studies, six provided data from correlation analyses and were pooled in a meta-analysis. The meta-analysis demonstrated a positive and significant association between memory capacity and sentence comprehension (pooled estimate: 0.41, 95% CI: 0.30-0.52, $p < 0.0001$). Conclusion: To our knowledge, this is the first systematic review and meta-analysis that pools together data from different studies exploring the overall association between memory capacity and sentence comprehension, an important topic in psycholinguistics, neurolinguistics and cognitive psychology. The meta-analysis demonstrated a positive correlation between the two functions. This finding, however, should be interpreted (and will be discussed) in the context of the heterogeneity between the relevant studies, as revealed in the systematic review of the literature. Potential sources of heterogeneity and bias include among others: number and type of tasks used to assess memory capacity and sentence comprehension, type of aphasia, type of statistical approach, availability of lesion information.

A45 The role of the Uncinate Fasciculus in learning to read

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Introduction The uncinate fasciculus (UF) is a white matter pathway that connects the anterior temporal and the orbitofrontal lobes. The UF has been implicated in semantic processing (Catani et al., 2013) and more recently also in reading (Cummine et al., 2015). However, the role of the UF in children with dyslexia remains unexplored. In a combined longitudinal – cross-sectional design, we used diffusion tensor imaging (DTI) tractography to study the UF in individuals developing typical reading skills (TR) and individuals developing dyslexia (DR). Method A first cohort of 61 children (39 males) was tested twice: prior to reading onset (i.e. pre-readers, mean age 6.1 years) and after two years of reading instruction (i.e. early readers, mean age 7.9 years). Thirty-four of these children had a familial risk for dyslexia, which elevates the chance of developing dyslexia from 5-10% in the general population to 30-50% (Gilger et al., 1991). Participants were (retrospectively) classified as TR or DR based on longitudinal reading and spelling skills. Fifteen children developed dyslexia. A second cohort of 57 adults (i.e. advanced readers, mean age 21.5 years, 29 DR, 17 males) was also analysed. DTI was acquired on a 3.0T MRI scanner (Philips, Best) using a single shot EPI with SENSE acquisition. In the longitudinal sample acquisitions were identical. Sagittal slices were obtained using the following parameters: repetition time 7600 ms, echo time 65 ms, voxel size 2.5 x 2.5 x 2.5 mm, b-value 1300 s/mm², 6 non-diffusion-weighted images, 60 non-collinear directions. In the adults the following parameters were used: repetition time 11043 ms, echo time 55 ms, voxel size 1.96 x 1.96 x 2.2 mm, b-value 800 s/mm², 6 non-diffusion-weighted images, 45 non-collinear directions. Two identical scans were averaged. The UF was dissected (Catani & Thiebaut de Schotten, 2008) using TrackVis and the FA index was extracted. At every reading stage, age-appropriate phonological awareness and orthographic knowledge measures were conducted. At the early and advanced reading stages, standardized reading tests were administered (Brus & Voeten, 1973). Results No group differences were observed in FA of bilateral UF between TR and DR groups (ps > .50). Prior to reading onset, FA in bilateral UF correlated with phonological awareness (left: rs = .280, p = .032, right: rs = .319, p = .012). No correlation was found in early readers and adults (ps > .07). After two years of reading acquisition, FA of the right UF correlated with orthographic knowledge (r = .333, p = .009) and word reading (rs = .309, p = .015), while no association was observed for the left UF (p = .086). In advanced readers no significant correlations were observed (ps > .16). Conclusion Our results indicate that, in children, maturational changes of the UF, especially in the right hemisphere, parallel reading acquisition . The lack of correlations in adults, when reading is automatized, suggests that advanced reading is sustained by other routes, as previously reported (e.g. Vandermosten et al., 2012).

A46 Subcortical Correlates of Receptive Language Impairment in Children Aged 8-10 with Developmental Coordination Disorder

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Developmental Coordination Disorder (DCD) is a developmental disorder that affects 2-5% of school-aged children. It is characterised by an inability to learn age appropriate motor skills in the absence of a known genetic, neurological or severe psychosocial disorder. DCD frequently co-occurs with language impairments. Similarly, one review has suggested that between 40-90% of children with speech and/or language impairments also have coordination problems (Hill 2001). Yet to date there are no studies investigating the neuroimaging correlates of language impairments in DCD. The basal ganglia have a role in both motor learning and language functions. The two major input structures of the basal ganglia, the caudate nucleus and the putamen, were therefore considered good candidate markers of language impairments in DCD. The present study investigated language abilities and subcortical correlates in 15 children aged 8-10 years (Median= 9y9m, IQR= 1y3m) with a diagnosis of DCD. Receptive and expressive language abilities were assessed using the CELF-4 (UK). All children underwent a T1-weighted structural MRI scan (1mm voxels isotropic). Volumes of the caudate and putamen were extracted in both hemispheres using FSL FIRST and corrected for total grey matter volume. Language abilities and subcortical volumes were compared and correlated using non-parametric statistics. Of the 15 children, ten had both receptive and expressive language indices above 80 and were classed as language unimpaired. Two children had expressive language indices (ELI) in the normal range, but receptive language indices (RLI) below 80 and were classed as receptive language impaired. One child had an ELI below 80 and RLI within normal limits so was classed as expressive language impaired. Finally, two children had both ELI and RLI in the impaired range. Left putamen volumes were significantly correlated with RLI (rho= 0.530, p=0.042). This correlation was significant for both subtests of the RLI (Concepts and following directions: rho=0.541, p=0.037; Receptive word classes: rho= 0.531, p=0.042). Caudate volumes and right putamen volumes did not correlate with either language index. This preliminary work provides the first evidence of a neural correlate of language deficits in children with DCD. The putamen receives input from sensorimotor and posterior prefrontal regions, which are implicated in procedural learning of motor skills and motor control. The neuroimaging literature shows more consistent anomalies in the caudate than the putamen (Liegeois et al 2014) in children with specific language impairment, but evidence is limited. Our findings suggest that there may be a subtype of children with DCD for whom the aetiology of language impairments is a domain general deficit linked to procedural learning systems, also thought to be impaired in some children with DCD. This hypothesis would be consistent with evidence that non-verbal procedural learning predicts receptive grammar abilities in typically developing children (Conti-Ramsden et al 2015). The putamen may act as a marker for receptive language ability in future studies in children with Developmental Coordination Disorder.

A47 Language Comprehension and Functional Connectivity in Individuals with Optimal Outcome from Autism Spectrum Disorder

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Introduction: Autism spectrum disorder (ASD) is usually a lifelong condition; yet, some individuals with ASD overcome their symptoms such that they no longer show social and language impairments. Few studies have investigated the underlying neural mechanisms that may support the change in behavior in optimal outcome (OO). One of our previous functional magnetic resonance imaging (fMRI) studies demonstrated that, in response to a language comprehension task, OO individuals showed compensatory and ASD-like residual activation patterns, rather than normalized activation patterns (Eigsti et al., 2016). It is unclear, however, how the connections between brain regions may be reorganized in order for the OO individuals to approximate typical behavioral outcomes. The current study examined the connectivity between certain language-related regions of interest and the whole brain based on the data described in Eigsti et al. (2016). Methods: Groups of individuals with OO (n=15), ASD (n=21) and typical development (TD; n=16) completed an fMRI scan while performing a language comprehension task, where the participants made true or false judgment of sentences with high and low imageable content. A selection of regions of interest in the Eigsti et al. (2016) study included nine language- and compensatory- (non-linguistic) areas: left inferior gyrus, left and right middle frontal gyri, left and right superior temporal gyri, left and right supramarginal gyri, left precuneus, and right posterior cingulate gyrus. For each group, a psychophysiological interaction (PPI) approach was employed to pinpoint functional connectivity between each seed region and the whole brain, as a function of behavioral events. Results: Preliminary results suggested that the three groups had distinct functional connectivity networks when comprehending sentences. For example, the left and right middle frontal gyri showed modest connectivity with the canonical fronto-temporo-parietal language network in the TD controls; on the other hand, these two seed regions had a much more extended and intensive connectivity across the whole brain in the ASD individuals but had a wide range of anti-correlation in the OO group. Conclusion: Our preliminary results were consistent with previous findings indicating compensatory brain activation in OO individuals, not only within individual regions, but also for communication across regions. These results suggest significant reorganization of brain networks must underlie the behaviorally typical performance in OO individuals, and in particular, the recruitment of canonical cognitive control and default mode networks. While further analyses are needed, the current study provides a comparison of group differences that illuminate the compensatory neural mechanism underlying language reorganization.

Perception: Orthographic and Other Visual Processes

A48 The English can't stand the bottle like the Dutch: ERPs show an effect of language on object perception

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Previous research shows that linguistic labels affect perception, reflected in modulations of ERP components (P1/N1/P300; Thierry et al. 2009; Boutonnet et al. 2013). Here, we go beyond terminology to examine how perception is influenced by argument features of verbs: Dutch uses posture verbs (staan/liggen 'stand/lie') to describe locations of objects, encoding object position (Lemmens 2002). In contrast, position is not obligatorily encoded in English ('there is a cup on the table'). We ask, whether this difference is reflected in object perception, by recording ERPs in English and Dutch participants during a picture-matching task. Dutch (N=28) and English (N=26) participants saw sequentially presented pairs of pictures (N=400), each showing an object on a surface (e.g., a suitcase on a table). Each object (N=10) was manipulated across two spatial dimensions, i.e., rotated 90 degrees along the horizontal or the vertical axis. The former manipulation reflects the obligatorily encoded position distinction in Dutch verbs. Participants pressed a button only when they saw a different object in the second picture. We used an oddball design with four conditions: (a) Object Match (frequent condition, 70% of trials), (b) Object Mismatch (response oddball, 10%), (c) Orientation Mismatch (control distracter oddball, 10%), and (d) Position Mismatch (critical distracter oddball, 10%). ERPs were time-locked to the onset of the second picture. Analyses revealed a significant Language by Condition interaction on amplitudes of an early component associated with automatic and prelexical perceptual discrimination processes (the N100, the earliest negative going peak; cf. Boutonnet et al. 2013): Whereas an enhanced N100 was obtained for the response condition in both groups, Position Mismatch oddballs elicited an N100 modulation only in Dutch participants. In sum, Dutch participants displayed increased selective attention to verbally encoded object features, before this information can be accessed lexically, adding to the evidence that language affects our perception of the world. References: Boutonnet, B., Dering, B., Vinas-Guasch, N., & Thierry. G. (2013). Seeing objects through the language glass. Journal of Cognitive Neuroscience, 25 (10), 1702-1710. Lemmens, M. (2002). The semantic network of Dutch posture verbs. In J. Newman (Ed.), The linguistics of sitting,standing and lying (pp 103–139). Amsterdam: John Benjamins. Thierry, G., Athanasopoulos, P., Wiggett, A., Dering, B., & Kuipers, JR. (2009). Unconscious effects of language-specific terminology on pre-attentive color perception. PNAS, 106 (11), 4567–4570.

Meaning: Combinatorial Semantics

A49 Effects of language modality on the neural correlates of semantic ambiguity processing

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The ability to resolve lexical semantic ambiguity is critical to successful language comprehension. For example, to understand the sentence "Pat picked up the cricket", it is necessary to recognise that in this context the word "cricket" refers to a type of insect rather than a sporting game. The need for semantic ambiguity resolution is encountered frequently during everyday language comprehension; it has been estimated that more than 80% of commonly used English words have more than one meaning. Previous behavioural, electrophysiological and functional neuroimaging studies have typically investigated semantic ambiguity processing within a single language modality, either spoken or written, and it has generally been assumed that resolution of lexical-semantic ambiguity in sentence context is supported by shared, modality-independent neural resources, so that findings in one language modality can be extrapolated to another. However, demands on cognitive processes such as working memory during resolution of semantic ambiguity may differ for spoken and written sentences, particularly when ambiguous word meaning must be verified against contextual information within a sentence. For example, disambiguation of written sentences could potentially entail a lesser working memory load, as sentence content remains directly accessible during disambiguation. However a number of previous studies of semantic ambiguity have employed serial presentation of written sentences (word-by-word or phrase-by-phrase), rather than simultaneous presentation of whole sentences. Although it may replicate the dynamic nature of speech, this non-naturalistic mode of written language presentation may impose a disproportionately increased working memory load. The contribution of modality-specific effects and variations in working memory demands on neural activation associated with semantic ambiguity resolution remains uncertain. In this functional MRI study of 15 neurotypical subjects, we investigated the effects of language modality and working memory demands on the neural correlates of lexical-semantic ambiguity resolution in sentence context. The experimental paradigm utilised so-called "late-disambiguation" sentences, in which disambiguating context is presented after the occurrence of an ambiguous keyword. For example, in the sentence "Sally worried that the ball was going to be too crowded", the more common "spherical object" meaning of the word "ball" may be retrieved initially, but this meaning is incompatible with the disambiguating word "crowded", so that semantic reanalysis of sentence content is required in order to achieve comprehension. Late-disambiguation sentences were presented in three formats: spoken sentences, whole written sentences, and written sentences in which sentence content was presented word by word (rapid serial visual presentation: RSVP). Within each of these presentation modes, neural activation during comprehension of late-disambiguation sentences was compared to that of control sentences containing low-ambiguity keywords. The results of this study indicate that although semantic processing evokes responses in a shared, amodal frontotemporal network, different presentation modalities are associated with specific neural signatures. When making claims about similarities and differences between disambiguation processes for spoken and written language, researchers should consider the processing demands associated with different language modalities and presentation modes.

A50 Time course of contextual semantics in spoken language comprehension as revealed by MEG: From automatic lexico-semantic access at 50 ms to top-down control at 400 ms *Yury Shtyrov[1], Lucy J. MacGregor[2]; [1]Center of Functionally Integrative Neuroscience (CFIN), Aarhus University, Denmark, [2]MRC Cognition & Brain Sciences Unit, Cambridge, UK*

A body of recent results suggests that the earliest stages of lexico-semantic access to spoken single words commence at 30-60 ms; these early word memory-trace activations are automatic and independent of focussed attention on the speech input (e.g., MacGregor et al, Nature Communications, 2012; Shtyrov & Lenzen, Cognitive Neuroscience, 2016). How do these rapidly activated neurolinguistic representations interact in wider semantic contexts? Is context integration similarly automatic or does it depend on attentionally-driven top-down control mechanisms? To address these questions, we recorded neuromagnetic brain responses to prime-target pairs of spoken words, which were semantically related (e.g., quack-duck) or unrelated (dirt-grip), and had precisely defined recognition points (stimulus-final consonants). We manipulated the listeners' attentional focus on the stimuli using three tasks: (1) passive listening, where volunteers were engaged in a primary visual task distracting them from the spoken input, (2) explicit semantic task, where volunteers judged the semantic relatedness of the word pairs drawing their attention to speech meaning, and (3) phonological task, where volunteers detected an extended closure time in the words, which, although drawing their attention to speech, did not specifically encourage processing the meaning of words or their semantic congruence. MEG was recorded and event-related fields were calculated relative to the target word recognition points. The brain's neuromagnetic responses were first quantified in signal space, and then followed up by a more detailed investigation in source space using minimum-norm current estimates calculated on individual-subject MRI-based cortical models in order to localise the neuroanatomical substrate of surface MEG effects. Amplitude differences between brain responses to the target words (related>unrelated) were first observed in a transient peak at ~50-80 ms, which we suggest reflects lexico-semantic access enhanced through automatic priming by the preceding word. This ultra-rapid effect of semantic context, most prominent in left temporal lobes, was seen across all three conditions including passive listening, which indicates its resilience to attention withdrawal. The second response phase (115-135 ms) was modulated by the task demands: whereas the passive task continued to show an enhanced temporal response for related words (indicating continuing lexico-semantic access), the phonological task showed an increased response for unrelated relative to related words in temporal and inferior-frontal cortices, with this latter pattern (indicating enhanced lexico-semantic search for unprimed words in attention-demanding conditions) being also seen for the semantic task in temporal lobe only. A longer-lasting global effect (related>unrelated) emerged at 350-450 ms in all conditions, and was now most expressed in the middle frontal cortex for the phonological condition. This deflection also reflected task difficulty, with the strongest overall activation for the phonological task and the weakest activity for the passive one. The results support a cascade of neuro-cognitive processes underpinning the access and integration of semantic information. We suggest that context drives very rapid (<100 ms) automatic activation of related semantic information, which is followed by attention-modulated integration processes carried out by perisylvian language circuits and involving further frontal areas throughout the first 1/2 sec of word comprehension.

A52 Silent memory for language processing *Hartmut Fitz[1], Dick van den Broek[1], Marvin Uhlmann[1], Renato Duarte[2,3,4,5], Peter Hagoort[1,6], Karl Magnus Petersson[1,6]; [1]Neurobiology of Language Department, Max Planck Institute for Psycholinguistics Nijmegen, the Netherlands, [2]Institute of Neuroscience and Medicine (INM-6), Institute for Advanced Simulation (IAS-6) and JARA BRAIN Institute I, Jülich Research Centre, Germany, [3]Bernstein Center Freiburg, Albert-Ludwig University of Freiburg, Germany, [4]Faculty of Biology, Albert-Ludwig University of Freiburg, Germany, [5]Institute of Adaptive and Neural Computation, School of Informatics, University of Edinburgh, UK, [6]Donders Institute for Brain Cognition and Behaviour, Center for Cognitive Neuroimaging, Radboud University Nijmegen, the Netherlands*

Integrating sentence meaning over time requires memory ranging from milliseconds (words) to seconds (sentences) and minutes (discourse). How do transient events like action potentials in the human language system support memory at these different temporal scales? Here we investigate the nature of processing memory in a neurobiologically motivated model of sentence comprehension. The model was a recurrent, sparsely connected network of spiking neurons. Synaptic weights were created randomly and there was no adaptation or learning. As input the network received word sequences generated from construction grammar templates and their syntactic alternations (e.g., active/passive transitives, transfer datives, caused motion). The language environment had various features such as tense, aspect, noun/verb number agreement, and pronouns which created positional variation in the input. Similar to natural speech, word durations varied between 50ms and 0.5s of real, physical time depending on their length. The model's task was to incrementally interpret these word sequences in terms of semantic roles. There were 8 target roles (e.g., Agent, Patient, Recipient) and the language generated roughly 1,2m distinct utterances from which a sequence of 10,000 words was randomly selected and filtered through the network. A set of readout neurons was then calibrated by means of logistic regression to decode the internal network dynamics onto the target semantic roles. In order to accomplish the role assignment task, network states had to encode and maintain past information from multiple cues that could occur several words apart. To probe the circuit's memory capacity, we compared models where network connectivity, the shape of synaptic currents, and properties of neuronal adaptation were systematically manipulated. We found that task-relevant memory could be derived from a mechanism of neuronal spike-rate adaptation, modelled as a conductance that hyperpolarized the membrane following a spike and relaxed to baseline exponentially with a fixed time-constant. By acting directly on the membrane potential it provided processing memory that allowed the system to successfully interpret its sentence input. Near optimal performance was also observed when an exponential decay model of post-synaptic currents was added into the circuit, with time-constants approximating

excitatory NMDA and inhibitory GABA-B receptor dynamics. Thus, the information flow was extended over time, creating memory characteristics comparable to spike-rate adaptation. Recurrent connectivity, in contrast, only played a limited role in maintaining information; an acyclic version of the recurrent circuit achieved similar accuracy. This indicates that random recurrent connectivity at the modelled spatial scale did not contribute additional processing memory to the task. Taken together, these results suggest that memory for language might be provided by activity-silent dynamic processes rather than the active replay of past input as in storage-and-retrieval models of working memory. Furthermore, memory in biological networks can take multiple forms on a continuum of time-scales. Therefore, the development of neurobiologically realistic, causal models will be critical for our understanding of the role of memory in language processing.

Meaning: Discourse and Pragmatics

A53 The role of semantic control in production of coherent speech: Evidence from young and older adults

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Introduction: To communicate effectively, we must plan and monitor what we say so that ideas flow in a logical sequence and are relevant to the topic under discussion. These processes are known as maintaining the coherence of speech. As a group, healthy older adults produce less coherent speech than young adults, showing increased tendencies to deviate from topic and go off on tangents. However, the cognitive and neural bases of coherent speech production, and thus the cause of this age-related decline, is not understood. We investigated contributions to coherent speech production from two aspects of semantic processing: depth of semantic knowledge (i.e., how detailed is a person's semantic store) and semantic control (i.e., how well can they regulate their access to and use of semantic information in line with task demands). We hypothesised that the ability to regulate access to semantic knowledge would be critical in maintaining highly coherent speech. Method: We investigated the relationships between speech coherence and semantic abilities in 23 young (aged 18-30) and 24 older (aged 65-91) adults. Speech was elicited by asking participants to speak for 60 seconds at a time about specific topics that required access to semantic knowledge (e.g., How do you look after a dog?). Coherence was estimated using an automated process based on latent semantic analysis. A subset of the older group also produced speech during fMRI. Activation during 50 second blocks of speech on specific topics with contrasted with a low-level speech baseline (reciting nursery rhymes). Data were pre-processed using FIACH (Tierney et al., 2015), a toolbox developed to control for the additional head movement that occurs in speech production studies. Results: Depth of semantic knowledge was greater in the older adults but ability to exercise semantic control was poorer and, within the older group, declined with age. Speech coherence also declined with age and a regression analysis indicated that much of this decline was attributable to poorer semantic control. The fMRI study revealed activity in a broad network of semantic regions, including left inferior frontal gyrus (LIFG), bilateral ventral anterior temporal lobes and the angular gyrus. LIFG is strongly associated with semantic control processes. Activity in this region was significantly higher in the second half of each speech production block, at which point control demands are likely to be greater. Interestingly, this increase in activity was positively correlated with age. Conclusions: Semantic control processes, associated with the LIFG, play an important role in maintaining the coherence of speech. Poorer semantic control may lead to difficulty retrieving topic-relevant aspects of knowledge or failure to inhibit off-topic tangential information. These processes become increasingly important as a speech act progresses and the most readily accessible information is exhausted. Upregulation of LIFG activity in the oldest participants requires further study but may indicate compensatory processes involved in recovering coherence.

A54 Referential ERP Effects Swing with the Antecedents: A Compilation Study

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[Introduction] ERP studies of pronominal reference resolution have consistently found sustained anterior negativities (Nref effects) during processing of downstream pronouns in contexts with two acceptable antecedents (2REF: James1 told John2 that HE1/2/3…) or no acceptable antecedents (0REF: James1 told John2 that SHE3…) in comparison to contexts with only one available feature-matching antecedent (1REF: James1 told Allison2 that HE1/3…)(Nieuwland & Van Berkum 2006). Similar responses have also been shown when only one mismatching antecedent is present (1ANT_MISMATCH: Allison1 said that HE2…) compared to a single matching antecedent (1ANT_MATCH: Allison1 said that SHE1/2) (Nieuwland 2014). These results suggest that the observed negativities may correspond to inferential repair strategies utilized by the comprehender while resolving uncertain reference, but similar paradigms containing contexts with one matching antecedent (1ANT_MATCH: After a covert mission deployed Will1 for nine terrible months, HE1/2…) compared to those with no potential antecedent at all (0ANT: After a covert mission that required deployment for nine terrible months, HE2…) have shown like negativities for the 1ANT_MATCH condition where coreference is available (Barkley, Kleunder, Kutas 2015). The latter result is consistent with the back association hypothesis wherein the negativity could reflect retrieval processes necessary for establishing coreference with a previously mentioned antecedent. While the inferential repair and back association hypotheses are not necessarily incompatible, what portion of the observed effects correlate with either is currently unclear. [Study] The current effort addresses how the number and qualities of available antecedents may affect processing at downstream pronouns across two experiments, the first completed, the second currently ongoing. Experiment1 attempted to replicate findings for the aforementioned 2REF and 0REF conditions while adding separate conditions for subject (1REF_Subj: James1 told Allison2 that HE1/3…) and object (1REF_Obj: James1 told Allison2 that SHE2/3…) reference in order to gauge how the relative structural position of the matching and mismatching antecedents might affect reference resolution. Experiment2

includes a replication of experiment1 and additionally contained comparisons between the previously mentioned 1ANT_MATCH, 1ANT_MISMATCH, and 0ANT conditions. The goal of experiment2 was mapping how the number of antecedents and their relative feature-specification could affect responses at the pronoun. [Methods] Sentence presentation was standard RSVP across experiments. Experiment1 included a graded-scale grammaticality judgment task, while Experiment2 included a T/F comprehension task after 1/4th of trials. ERPs were time-locked to pronouns and were examined for 1200ms epochs (100ms baseline). Individual reading span scores were acquired for each participant prior to testing. [Results] Experiment1 showed anterior negativities for all cases relative to the 1REF_Subj condition, evidencing that the structural position of antecedent can affect responses at the pronoun and that Nref-like negativities may arise between conditions with a single acceptable antecedent. For experiment2 we predict a replication of past findings for the 1ANT_MISMATCH—1ANT_MATCH and 1ANT_MISMATCH—1ANT_MATCH comparisons. Furthermore we predict comparing difference waves between those pairs of conditions will yield a picture compatible with both the inferential repair and back association hypotheses with the 1ANT_MISMATCH—1ANT_MATCH difference wave reflecting additional anterior negative activity above and beyond what is seen for successful reference in the 1ANT_MATCH—0ANT comparison.

A55 The contribution of working memory during discourse comprehension: a fMRI study

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Introduction Discourse comprehension is a complex cognitive process that are influenced by multiple factors. Among the factors known to be relevant are discourse structure, coherence, and length(Ferstl & von Cramon, 2001; Klin, Guzmán, & Levine, 1999; Yang, Chen, Chen, Xu, & Yang, 2013). Previous studies have suggested that the processing of these factors places demands on working memory. However, it is still unclear whether and how these factors modulate the involvement of working memory during discourse comprehension. In this study, this issue was investigated using fMRI technique. Method A n-back localizer scan was first performed to localize the neural correlates of working memory. Five blocks of 2-back task were alternated with five blocks of 0-back task. After the n-back task, subjects were asked to performed a reading comprehension task, during which two-sentence discourses were presented sentence by sentence. The discourses were carefully manipulated such that the variables of discourse structure, coherence, and length were uncorrelated. Discourse structure was manipulated by varying the topic of the first sentence such that the second sentence either continues or shifts from the topic of the first sentence (topic-shift vs. topic continuation). Coherence between the first and the second sentence of each discourse was rated with a 5-point likert scale. Length was manipulated as the number of words in each sentence. Results Compared with 0-back task, 2-back task was associated with a frontal-parietal network of activations including superior, middle and inferior frontal gyri, inferior and superior parietal lobule, and precuneus. Using these areas as ROIs, we found significant effects of coherence in superior, middle and inferior frontal gyri, and inferior parietal lobule. Significant effects of length were also found in superior and inferior frontal gyrus. No significant effects of discourse structure in these ROIs were found. Conclusion These results provided evidence that discourse factors modulated the involvement of working memory during discourse comprehension. Also, they clarified the functional contributions of distinct working memory sub-regions to coherence and length processing during discourse comprehension. Key words: working memory, N-back, discourse structure, coherence, length References Ferstl, E. C., & von Cramon, D. Y. (2001). The role of coherence and cohesion in text comprehension: an event-related fMRI study. Cognitive Brain Research, 11(3), 325-340. Klin, C. M., Guzmán, A. E., & Levine, W. H. (1999). Prevalence and persistence of predictive inferences. Journal of Memory and Language, 40(4), 593-604. Yang, X., Chen, X., Chen, S., Xu, X., & Yang, Y. (2013). Topic Structure Affects Semantic Integration: Evidence from Event-Related Potentials. PloS one, 8(12), e79734.

Perception: Orthographic and Other Visual Processes

A56 What does it mean to regress? The neural basis of regressive eye movements during reading as revealed by concurrent fMRI/eye-tracking measures

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Comprehension difficulty in sentence reading has been linked to two behavioral parameters: increased fixation durations and a higher probability of regressive saccades. Although inter-word regressions occur frequently, their function has not been clearly determined. While some have argued for the combination of visuo-motor control and attentional re-orientation with linguistic processing, others have posited direct linguistic control over the execution of regressions (Mitchell et al. 2008; Frazier & Rayner 1982). Yet, behavioral measures cannot unequivocally distinguish between these competing explanations and with only one study reporting the modulation of neuronal correlates by fixation durations (Henderson et al. 2015), the functional significance and neural basis of regressive saccades in reading remains largely unknown. We conducted a combined eye-tracking/fMRI study that investigated the neural underpinnings of regressions, and the extent to which progressive and regressive saccades modulate brain activation in the reading network. We were particularly interested in brain regions associated with visuo-spatial attention (e.g temporo-parietal regions), visuo-motor control (e.g. cerebellum, frontal eye fields) and sentence processing (e.g. left superior and middle temporal regions, left IFG). Twenty-three monolingual native speakers of German read 216 sentences of varying structures, including semantically anomalous and non-anomalous material and sentences with target words that differed in lexical frequency and predictability. Based on the

eye-movement data, every progressive and regressive saccadic eye movement was identified and temporally correlated to the fMRI signal. On the subject level, every saccade onset was modeled as a critical event, either as a progressive or as a regressive saccade. On the group level, an event-related design was used to compare progressive versus regressive saccades against a resting baseline. First preliminary results show significant activation differences between the two types of saccadic eye movements. Progressive saccades reveal enhanced neural responses only in the left superior occipital lobe. In contrast, regressive eye movements show widely distributed activation patterns within a fronto-parieto-temporal network (e.g. left IFG, MTG, frontal eye fields). Importantly, this pattern seems not be driven by anomalous sentences alone. These findings suggest that inter-word regressions appear to be driven jointly by linguistic and oculomotor processes – as evidenced by the global activation pattern – whereas progressive saccades seem to mainly reflect automatic visuo-motor processing used to provide bottom-up information to proceed through the sentence. This supports previous findings that regressions follow attentional shifts in the perceptual span in reading (Apel et al. 2012) and the view that the eyes automatically scan the sentence with progressive saccades, while decisions regarding re-reading are guided by higher-order language comprehension and attentional re-orientation in oculomotor control.

A57 Where words and space collide: An fMRI investigation of the overlap between spatial attention and reading

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Spatial attention and reading processes have long been investigated in isolation, however there has recently been a shift to investigate their potential interactive effects. For example, Franceschini et al. (2013) found that dyslexic children showed reading improvements that rivaled one year of independent, spontaneous reading development from as little as 12 hours of attentional training. However, while the neuroanatomical correlates of reading and attentional processes have been investigated in isolation, their overlapping neural correlates have yet to be explored. In regards to reading, fMRI research by Oberhuber et al. (2013) has implicated the left putamen in reading processes. Similarly, attentional mechanisms have been shown to be reliant on basal ganglia structures, including the striatum, with some researchers suggesting that these networks are actually responsible for attention (Krauzlis et al., 2014). Based on these findings, we sought to investigate the overlapping neural mechanisms of spatial attention and lexical reading using fMRI, with a specific focus on the putamen. To test this, participants performed an attentional orienting task, as well as an overt word-reading task. In the word-reading task, all stimuli consisted of exception words, which are words that cannot be sounded out to be read correctly (e.g., yacht), in order to ensure reliance on lexical reading strategies. In the attention task, participants were required to identify whether an 'A' or 'H' was presented following either a valid or invalid spatial cue (50% cue validity). Results from the fMRI analysis showed overlapping activation in the left putamen for both word and spatial attentional processing. Additionally, we found overlapping activation in the right temporoparietal junction - an area strongly associated with attentional reorienting. These results elucidate several neuroanatomical regions of overlap between attentional and single-word reading processes that underlie their interactive effects.

A58 Graded Semantic Similarity Effects in Morphological Decomposition: Evidence from Event-Related Potentials

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Background: The decomposition theory of morphology holds that multimorphemic words are automatically decomposed into roots and affixes during reading. Data from morphological priming appear to support this view, given greater priming for related word pairs (FOOLISH-fool) and sometimes unrelated pseudo-affixed pairs (BURNISH-burn), compared to words overlapping in spelling only (HOSTEL-host). We explored the alternative perspective, that apparent decomposition effects are instead a result of the joint influence of orthographic and semantic similarity on word recognition. This theory predicts that graded effects of morphological relatedness will yield accordingly graded effects in facilitation to recognizing complex words. Methods: Neural responses to morphologically derived words were assessed with event-related potentials (ERPs) as participants performed lexical decision (Experiment 1) or semantic judgment (Experiment 2) of primed vs. unprimed targets. We also examined recognition of complex words in the absence of priming (Experiment 3), using a colour boundary manipulation; in this experiment a morpheme boundary was either congruent or incongruent with the colour groupings of letters (e.g., WRECK/AGE vs. WREC/KAGE). Across all three experiments, the critical stimuli manipulated semantic relatedness in a graded fashion while holding morphological similarity constant (Related: WRECKAGE-wreck; Quasi-related: BANDAGE-band; Opaque: DAMAGE-dam). Additional word stimuli included unrelated items which did not contain an apparent morpheme (CASHEW-cash), to assess the independent role of visual similarity. Conditions were closely matched on key psycholinguistic variables, and, critically, the distribution of English derivational affixes was also equated across lists. Degree of semantic relatedness of root and (pseudo-)affixed words was verified using latent semantic analysis (LSA). Results: All three experiments showed facilitation effects for words with transparent morphological endings. In Experiments 1-2, these consisted of significant attenuation of N280 and N400 components at frontocentral sites for transparent prime-target pairs. In Experiment 3, we observed enhanced negativity within these same time ranges for morpheme-incongruent vs. congruent colour boundaries; follow-up analyses suggested this was due to facilitation in accessing the stem meaning when the morphological boundary coincided with the colour boundary. Next, we also observed smaller but still significant effects for quasi-related forms across all three experiments. In contrast, opaque forms yielded only small facilitation effects that were not robust across all three paradigms, and which did not differ from non-morphemic control words. Discussion: The results support the view that semantic transparency can explain apparent morphological effects in reading. Indeed, the latency of these effects suggest semantic transparency influences visual word recognition at a relatively early stage in processing. Given that these effects

persisted across different task paradigms, we also conclude that this is a robust finding that is not due to idiosyncrasies of stimulus presentation or response types. These effects appear to be inconsistent with the theory that early morphological decomposition is performed irrespective of semantic analysis. Such a view instead predicts similar degrees of priming for stem-morpheme combinations irrespective of semantic transparency. Our failure to find strong neural priming in morphologically opaque forms may be due to how we closely matched the types of derivational suffixes in each condition.

A59 Top-down modulation of early word-like sensitivity in Chinese character recognition

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Neural sensitivity to word-likeness has been found within the first 250ms of stimulus processing across different writing systems, indicated by larger N1 negativity to words compared to control stimuli, such as symbols. While this sensitivity has been considered to reflect bottom-up tuning for print, other studies question such an interpretation by showing task effects within the first 250ms of stimulus processing. Using the event-related brain potentials (ERPs), the current study in Chinese thus explored whether word-like sensitivity effects can be modulated by task demands at early stages of visual word recognition. Familiar, high-frequency, left/right-structured Chinese characters and unfamiliar, stroke number-matched symbols (Korean characters) were used as stimulus conditions. While viewing the characters and symbols, 18 native Chinese speakers performed three tasks with responses to rare cues (10.4%): delayed naming task, repetition detection task, and blue color detection task. In the delayed naming task, participants were cued by question marks "?????" to name the previous character or say "symbol" for the previous Korean character; in the repetition detection task, subjects pronounced "repeat" when a stimulus occurred twice in a row; in the color detection task, subjects said "blue" whenever a stimulus was presented in blue font. In the ERP analysis we focused on the N1 component (based on GFP: 123-323ms) of the non-target stimuli and subdivided it into four 50ms segments to capture the dynamics of potential task-by-wordlike interactions. An overall ANOVA on amplitudes at occipito-temporal electrodes with the factors task, wordlike, segment, and hemisphere revealed a very significant task-by-wordlike-by-segment interaction, suggesting that the influence of task on word-likeness changed throughout the N1. Similar analyses were computed for each segment (Bonferroni-corrected). Accordingly in the first segment, a wordlike main effect reflected a stronger N1 to characters than symbols, irrespective of task. In the second segment a wordlike-by-task interaction reflected a more negative N1 to symbols than characters in both delayed naming and repetition detection, but not in the color detection. A significant wordlike-by-task interaction in the third segment similarly reflected different directions of the character-symbol differences between the tasks. Finally, in the fourth segment, a trend for a task main effect reflected that delayed naming and repetition detection tended to evoke larger negativities than color detection, irrespective of the wordlike conditions. Taken together, these findings indicate that neural sensitivity to word-likeness is modulated by task demands already within the first 250ms but is highly dynamic within the short duration of the N1 component. This may suggest that wordlike effects around 150ms are processed irrespective of task demands, possibly in a bottom-up driven or automatic interactive way. Different tasks, however, influence visual word processing already around 200/250ms, presumably by modulating how wordlike properties are further processed in accordance with type and difficulty of behavioral goals. Given that task demands can modulate reading-related processes at early stages of visual-orthographic processing, neural models of visual-orthographic processing should not only include bottom-up driven (or automatic interactive) processes, but also implement the influence of behavioral goals and how they affect processing over time.

Phonology and Phonological Working Memory

A60 Neural mechanisms for halting and monitoring in spoken word production: the role of phonology

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Speakers typically alter their word production adaptively when it becomes contextually inappropriate or halt it altogether. However, we know relatively little about the neural mechanisms responsible. According to the perceptual-loop theory (Levelt, 1989), the speech comprehension system monitors the output of phonological encoding during spoken word production via an internal loop, in addition to monitoring external speech (the outer loop). Indefrey's review (2011) proposed a role for the left superior temporal gyrus (STG) for both inner and outer loops. One study has suggested halting speech might rely on domain general inhibitory mechanisms in the right inferior frontal cortex (IFC) and pre-supplementary motor area (preSMA; Xue et al., 2008). We investigated the neural mechanisms of halting and monitoring in word production by employing a modified version of the stop signal task (SST) during functional magnetic resonance imaging (fMRI). Healthy participants (N=18) named target pictures (BUCKET or CAMEL) on go trials (75%) and withheld their naming response on stop trials (25%). Auditory stop signals comprised words that were phonologically related (initial phoneme) or unrelated to the target. The stop signal delay (SSD) was calculated using an adaptive online stepping algorithm to ensure 50% successful stops. If the speech comprehension system monitors both the output of word form encoding and external speech, then halting spoken word production should be affected by presenting phonologically related words as stop signals, as they engage the same central monitoring process. Stop signal reaction times (SSRTs) and accuracy did not differ between phonologically related and unrelated conditions. fMRI results for successful stop vs. go trials revealed extensive BOLD activity across regions typically associated with the SST, including bilateral IFC, preSMA and STG. No differential activity was observed for contrasts of phonologically related vs. unrelated stop signal types, for either successful or unsuccessful stops, mirroring the behavioural results. We therefore collapsed the conditions to identify mechanisms engaged in successful vs. unsuccessful halting of speech. Increased activity was observed bilaterally

in the posterior MTG, left IFC, left middle and superior frontal gyri and parietal lobe. The reverse contrast (unsuccessful > successful) revealed increased BOLD signal bilaterally in the posterior STG and in the left anterior STG along with right IFC. As unsuccessful stop trials included the same picture and stop signal as successful stops yet also entailed an erroneous speech output, these results likely reflect external self-monitoring of speech errors. The failure to observe an effect for phonologically related stop signals suggests internal speech monitoring might not rely on phonological codes.

A61 Cortical thickness of Planum Temporale in native language tone processing

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INTRODUCTION: Non-native linguistic tone learning ability has been found to be influenced by the anatomy of primary auditory regions in the left hemisphere (Wong et al., 2008). In native speakers, however, where phonemic categories are firmly established, variations in the macrostructure of more secondary auditory processing areas might be expected to affect performance. The present study investigated the relationship between cortical thickness of the Planum Temporale (PT) and the processing of tones in natural language stimuli by Swedish native speakers. PT has previously been found to be involved in processing Thai (Xu et al., 2006) and Swedish tones (Roll et al., 2015), and in phonological processing generally (Graves et al., 2008). In Swedish, tones on word stems function as predictive cues to upcoming morphosyntactic structure, due to associations between stem tone patterns and specific grammatical suffixes. The degree to which listeners evidence anticipatory behaviour in their responses to such cued suffixes thus can be assumed to be mediated by individual variation in processing preceding tonal cues. METHODS: Magnetic resonance imaging scans were collected from native speakers of Swedish. Participants listened to sentences in which the inflectional suffix on the target word was either validly or invalidly cued by the preceding tone. The time it took to decide on suffix meaning (singular/plural) after suffix onset was measured. Cortical reconstruction and volumetric segmentation was performed using the FreeSurfer image analysis suite (http://surfer.nmr.mgh.harvard.edu/). Each processed subject was transformed into common space (fsaverage) and the average cortical thickness of PT was extracted in FreeSurfer after transformation of estimation of PT as defined in the Harvard-Oxford cortical and subcortical structural atlases in FMRIB Software Library (FSL) into common space. RESULTS: Individual participants' response time advantage for valid over invalidly cued suffixes positively correlated with cortical thickness in the left PT, but not in the right PT. Thus, thicker left PT cortex was associated with relatively greater disruption in speech comprehension caused by an invalid tonal cue. Subgroup comparison also showed generally faster response times for participants with relatively thicker left PT cortex compared to individuals with thinner cortex in the same area. CONCLUSION: The results suggest that the cortical anatomy of the left PT affects native linguistic tone processing. The PT has been proposed to constitute a computational interface between incoming sound patterns, analysed into components, and stored auditory objects (Griffiths & Warren, 2002). From this perspective, the present results might indicate that the cortical thickness of the left PT plays a facilitating role in the extraction of linguistic tone patterns from stimuli and their matching with stored representations in memory.

Signed Language and Gesture

A62 Conduction Aphasia in American Sign Language: Implications for a Neural Model of Sign Language Processing

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Conduction aphasia has received renewed interest in the neurobiology of language as the proposed impairment highlights unique architectural properties of the language system. Patients with spoken language conduction aphasia have fluent speech production with good auditory comprehension, but show a disproportionate inability to repeat, with frequent phonemic errors in production. This pattern is typically explained as resulting from damage to the interface between separate auditory and motor systems (Anderson et al., 1999; Geschwind, 1965; Hickok, 2012; Hickok et al., 2000). We present a case study of a deaf user of American Sign Language who exhibits symptoms of conduction aphasia following bilateral strokes affecting the right temporal and left parietal lobes. The subject's sign language comprehension and spontaneous language abilities are near normal; however she shows a marked inability to repeat signed sentences, signed triplets and pseudo-sign sequences. She evidences limb apraxia and exhibits significant somatosensory loss of the arm, hand and fingers. To account for this unusual pattern of sparing and deficits we propose a model of sign language processing in which proprioceptive sensory signals define targets for sign actions. Here the disruption of internal proprioception limits the activation of lexical sign forms. This case study is important as it Illuminates components of lexical processing in a signed language and has implication for integrated state feedback control models of language (Hickok 2012) which argue for motor and sensory based phonological systems.

A63 Organization of symbols in the middle temporal gyrus

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Activity in the middle temporal gyrus (MTG) has been consistently associated with the processing of action-related words. This territory has also been demonstrated to be recruited during passive observation of gestures. However, the organization of action-related information along the MTG for words and observed actions remains unclear. In the current fMRI study we assessed whether there is an organizing principle for information in MTG which takes into account the input-modality and the (arbitrariness of) relationship between the sign and the meaning. We measured the blood-oxygen level dependent (BOLD) response in MTG to video clips of gestures and spoken words in N=17 participants. Gestures consisted of object-use pantomimes (iconic representations of object-directed actions; e.g. "playing guitar"), emblems (symbolic communicative gestures, e.g. "thumb up"), and meaningless gestures. Words, spoken by the same actress as in the gesture video-clips, were verbs and nouns. To examine which portions

of the MTG are sensitive to differences between the different conditions, we defined a region of interest (ROI) consisting of the entire MTG, separately for the left and right hemisphere, on the basis of anatomical criteria. Within that ROI, we compared the amplitude of the BOLD response, expressed as beta estimates resulting from a random-effects general linear model analysis, separately for each position along the y-coordinate, collapsing across the x- and z-coordinate. We performed a permutation analysis using Threshold-Free Cluster Enhancement (TFCE) to correct for multiple comparisons. We found bilateral activity in MTG for meaningful stimuli (gestures and words) as compared to meaningless stimuli, with an overall larger spatial extent in the left in comparison to the right hemisphere. Moreover, we found a posterior-to anterior-gradient both along the left and right MTG: posterior regions responded more strongly to gestures (pantomimes and emblems) than words; anterior regions showed stronger response to words than gestures. In an intermediate region along this gradient (around y-position -30) in the left hemisphere, we observed a significantly higher response to words and emblems (i.e., stimuli with an arbitrary sign-to-meaning mapping) in comparison to pantomimes. Our results show a gradient along the posterior-to-anterior MTG, which may reflect the input modality and/or the relationship between sign and meaning.

Speech Motor Control and Sensorimotor Integration

A64 Cortical representation of articulatory targets in speech movements

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Introduction Neural activity in sensorimotor cortex during speech production is correlated with linguistically-relevant phonetic features like place of articulation. However, little is known about how this activity relates to the specific kinematics of the articulators themselves during speech. To address this, we combined electrocorticographic (ECoG) recordings of ventral sensorimotor cortex (vSMC) with high-resolution monitoring of the major supralaryngeal articulators: the lips, jaw, and tongue. During speech the kinematics of some articulators are critical for producing a given phoneme, while others can vary significantly without task consequence. We hypothesized that instead of strictly representing all movement dynamics, vSMC primarily represents those articulatory kinematics that are relevant to the task. Methods We recorded ECoG signals from five participants with chronically implanted high-density subdural electrode arrays while they produced nine vowels (ɑ/æ/ʌ/ɛ/ɝ/ɪ/i/ʊ/u) in an hVd context (e.g. /hId/), and in isolation (e.g., /I/). Participants repeated these tokens as they were presented following a brief (1 s) delay (15-30 repetitions of each vowel). During the production of each sound, we simultaneously measured the produced acoustics, as well as the movements of the lips, jaw, and tongue using a minimally invasive vocal tract imaging system (Bouchard, Conant, et al., 2016). We investigated task-relevance representation in vSMC through analyzing the timing of High-gamma (HG) neural signals, and using multivariate regression to predict measured articulator kinematics from vSMC HG. Results We compared neural responses that were time-locked to three behavioral events: (1) Movement onset, (2) Acoustic onset, or (3) Target position onset. If vSMC primarily represents task relevant kinematics, then measured activity should be temporally anchored to the time of target acquisition rather than the behavioral events leading up to this time point. Indeed, neural activity averaged across trials has the lowest variance and largest magnitude when aligned to the time when the articulators reach their target position. Furthermore, classification of vowel identity from vSMC HG performed best when aligned to the time of articulator target acquisition. Together, these results indicate that vSMC activity is temporally organized by the achievement of the task goal. This is not to say that vSMC activity is primarily a feedback signal; most electrodes deviate from baseline activity well before acoustic or movement onset, suggesting that their activity is related to planning and executing the speech movement. Rather, it indicates that this activity is temporally anchored to the achievement of the task goal. Decoding of articulator movements from vSMC HG provides further evidence for preferential representation of task relevant articulator kinematics. Tongue movements, which are necessary for the production of vowels, are far better predicted than lip or jaw movements, which exhibit similar variance but are unnecessary for vowel production. Conclusions Both the timing and content of vSMC HG activity during vowel production suggest that vSMC primarily represents task relevant articulator kinematics. This relationship may reflect the precise nature of vowel production; the configuration of the vocal tract during voicing dictates the vowel identity, while the kinematics of the movements leading up to this point have no direct acoustic consequences.

A65 Speech Motor Adaptation in People Who Stutter

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Stuttering is a speech disorder affecting around 1% of adults that involves interruptions to speech flow by characteristic dysfluencies. It is hypothesised to involve aberrant processing of auditory feedback. We aimed to test this using a speech motor adaptation paradigm. Here, speakers hear their own speech fed back with a change in the frequency of the first formant (F1) that alters the percept of the vowel produced. Consequently, across trials, the speaker alters speech production to compensate for the perceived auditory error. We compared the speech motor adaptation performance of 15 people who stutter (PWS) and 23 age-matched control participants who were normally fluent; all participants were male, native English speakers and aged 18-50 years. During production of the word “head”, we shifted the frequency of the F1 upwards and fed this back to the speaker in real time. The shift resulted in an acoustic signal that was perceived as closer to an utterance like “had”. Speakers compensated for this shift by lowering their F1 to produce utterances closer to “hid”, which when fed back to them with the shift sounded closer to the target word “head”. We measured the frequencies of the first and second formants

(F2) for each of the vowel sounds in "head", "hid" and "had" at baseline to determine whether production variance or the contrast between vowels predicted subsequent adaptation. Results indicated that PWS significantly compensated for the formant perturbation, to the same extent and at the same rate as controls. There were no significant differences between groups in amount of compensation to the F1 shift or in recovery from adaptation once the perturbation was removed and normal feedback provided (wash-out phase). However, PWS recovered (or de-adapted) more quickly from the perturbation than did controls during wash out. At baseline, the two groups did not differ in the degree of variability of their production of different vowels in terms of F1 and F2 frequencies. The PWS group showed reduced contrast between the three vowel sounds, however. Specifically, the separation of the vowels in terms of F1 and F2 frequencies was significantly lower in the PWS group compared with controls. However, the baseline measures were not predictive of subsequent compensation on the speech motor adaptation task. Also, there was no relationship between stuttering severity and speech motor learning. To summarize, PWS show a similar ability as fluent speakers to compensate for altered auditory feedback but faster washout of this speech motor learning. These results imply a possible dissociation between spared use of auditory feedback for online adjustment of speech production and impaired use of feedback for updating of internal feed-forward speech models in stuttering.

A66 Neurophysiological correlates of action word and sound processing in healthy controls and in individuals with autism spectrum disorders: A mismatch negativity (MMN) study

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Recent approaches in the tradition of theories of semantic and conceptual "grounding" emphasize the role of perceptual and motor knowledge in language as well as in action understanding (Barsalou, 2008). Interestingly, individuals with autism spectrum disorders (ASD) show marked difficulties in sensory-motor processing as well as in language processing and social interaction. The recognition and understanding of observed actions and semantic action processing, in which motor systems are likely to play a key role, seem to be impaired in ASD, resulting in difficulties in communication and social interaction (Rizzolatti and Fabbri-Destro, 2010). Recent neuroimaging data show evidence for a category-specific semantic impairment and hypoactivity of the motor cortex in individuals with ASD when processing action-related words as opposed to non-action words (Moseley et al, 2013). However, to this end, the neurophysiological mechanisms underlying the observed semantic difficulties are not clear. In order to test whether any semantic processing problems in ASD are selectively related to deficits of the action (motor) system, we investigated neurophysiological manifestations of priming effects between action- and non-action-related words and sounds (see Grisoni et al., 2016). Using multi-channel event-related potentials (ERPs), we recorded the Mismatch Negativity (MMN) in a distraction-oddball design. Rare "deviant" mouth-related (reden, i.e. talk) and non-action (regen, i.e. rain) words were recorded in the context of frequent "standard" mouth- or hand related-action sounds (whistle, clapping) or non-action sounds (water drop, pure tone). 15 high-functioning individuals with ASD and 15 age- and IQ-matched controls participated in the study. As expected, results revealed a pronounced MMN to both deviant stimuli over fronto-central electrodes. Importantly, there was a significant word category x context interaction in the control group, showing a reduction of MMN amplitudes when the action word was presented in the body-part-congruent action sound context (i.e. whistle sound), as compared to the body-part-incongruent condition (i.e. hand clapping), a pattern of results consistent with semantic action priming. Preliminary analyses indicate that this modulation of the MMN by semantic action priming between words and sounds was not present in the ASD group. The results demonstrate neurophysiological MMN correlates of action-semantic word-sound facilitation effects in neurotypical controls, but not in individuals with high-functioning ASD. The data can be interpreted on the basis of grounded cognition evident across different stimulus types and categories and indicates a specific dysfunction of semantic processing in ASD when the action-motor system is involved. Barsalou, L. W. (2008). Grounded cognition. Annu Rev Psychol, 59, 617-645. Grisoni, L., Dreyer, F.R., Pulvermüller, F. (2016). Somatotopic semantic priming and prediction in the motor system. Cereb Cortex, in press. Moseley, R., Mohr, B., Lombardo, M. V., Baron-Cohen, S., Hauk, O., & Pulvermüller, F. (2013). Brain and behavioral correlates of action semantic deficits in autism. Front Hum Neurosci, 7 (725). Rizzolatti, G., & Fabbri-Destro, M. (2010). Mirror neurons: from discovery to autism. Exp Brain Res, 200 (3-4), 223-237.

Control, Selection, and Executive Processes

A67 Fronto-parietal connectivity in the extraction of language rules

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Much recent work has placed rule-learning in the centre-stage of research on language acquisition, yet views tend to remain encapsulated within-domain. An integrated account might nevertheless require considering the implication of other cognitive functions. In particular, and because of the temporal aspect in speech processing, the dynamic orienting of attention in time is likely to be crucial in the acquisition of morphosyntactic rules where sequential order is important. Specifically, attentional processes may aid in the selection of relevant information from the speech stream. Given the functional and anatomical overlap between left-lateralised language and attention-in-time fronto-parietal networks, it was hypothesized that the left arcuate fasciculus' (AF) anterior segment, connecting Broca's and Geschwind's territories, may be critical in facilitating implicit rule acquisition. 23

right-handed native Spanish speakers were MRI-scanned so as to delineate of the anterior fronto-parietal, posterior parieto-temporal and long fronto-temporal segments of the AF and extract surrogate measures of their axonal properties. Outside the scanner, participants were exposed to an artificial language with sentences containing AxC-type rules while performing a cover word-monitoring task. Rule acquisition was thus fostered at two distinct levels of attention (higher/lower) according to whether sentences contained the participant's target. After an initial learning phase, RTs to word monitoring provided an indirect measure of online incidental rule-learning performance. A subsequent recognition test was then used to gauge participants' recognition of the dependencies. Participants learned embedded rules ($F(1,20) = 4.796$, $p = 0.041$) regardless of the attentional level (no significant rule*attention interaction; $p > 0.1$) but were only able to discriminate in regards to the higher attention dependencies ($t(22) = 3.398$, $p = 0.003$ vs. lower attention dependencies: $t(22) = 0.016$, $p = 0.987$). A statistically significant positive correlation was found between implicit (lower attention) rule-learning performance and fractional anisotropy (FA) in the anterior segment of the left AF ($r = 0.61$, $p = 0.003$, corrected*) supported in terms of radial diffusivity (RD) ($r = -0.535$, $p = 0.013$, uncorrected). *Bonferroni correction 0.05/12, i.e. $p < 0.0042$. A statistically significant positive correlation was also found between d' dependency scores for the explicit (higher attention) rule and FA in the left posterior segment ($r = 0.588$, $p = 0.004$, corrected*), again supported by a correlation in terms of RD ($r = -0.502$, $p = 0.017$, uncorrected). For the first time, a white-matter correlate of implicit rule learning has been identified (LAS of the AF), complementing previous literature on the role of the AF in word learning. Its role may be linked to prediction and/or the automatic selection of relevant information. Null correlations between AF segments and more explicit rule learning suggest a different network might predominate, possibly related to the voluntary orienting of attention. The relationship between the LPS/LLS and explicit rule recognition may be linked to general retrieval and working memory processes, respectively, adding to the literature on the role of these AF segments in language.

A68 Syntactic processing and proactive interference effects on verbal working memory capacity: A comparison between non-fluent post-stroke aphasia and non-fluent variant PPA

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Introduction. There is extensive evidence showing dysfunction in executive abilities of individuals with traumatic brain injury or with lesions to the (pre)frontal areas using tasks based on response conflict and working memory (e.g. Christensen & Wright, 2010; Lê et al. 2012; Riès et al., 2013). A crucial aspect of these studies is that the tasks were non-verbal measures of attention and control and bore no obvious connection to language processing. The present study investigates the interaction between working memory and verbal processing in non-fluent variant Primary Progressive Aphasia (nfv-PPA) and non-fluent post-stroke aphasia. Method. Individuals with nfv-PPA, non-fluent post-stroke aphasia and their neurologically-intact matched peers were administered two tasks: (a) a dual-task paradigm where two tasks had to be performed in parallel: sentence comprehension through blocks of sentence-picture matching (SPM) task and a word-recall task (Ivanova et al., 2015) in which subjects had to recall a word at the end of a sentence of varied syntactic complexity (see example below). Syntactic complexity was manipulated by varying the structural complexity of the sentences (Sentences of low complexity: 4 transitives & 4 subject relatives; Sentences with high-complexity: 4 passives & 4 object relatives). Example 1st SPMT: The bike follows the bus (transitive) 1st word to be recalled: boot 2nd SPMT: The dog is bitten by the cat (passive) 2nd word to be recalled: clock 3rd SPMT: The lady that kisses the man pushes the girl (subject relative) 3rd word to be recalled: nose 4th SPMT: The girl that the young man kicks hugs the child (object relative) 4th word to be recalled: milk (b) a proactive interference (PI) task, where participants were asked to recall the words from consecutive lists sharing category membership (Bialystok & Feng, 2009). Results. In the working memory syntactic interference task, both SPM accuracy and word-recall scores were calculated. On the word-recall measure, both the post-stroke group and controls showed a significant Syntactic Complexity effect, with word-recall being more erroneous after processing passives and object relatives (versus transitives and subject relatives). Contrary, the nfv-PPA group did not show an effect of syntactic complexity on word-recall although they exhibited overall low syntactic comprehension accuracy, and in passives lower than the post-stroke group. In the PI task, the nfv-PPA group's retrieval of recent material did not appear to be impaired by prior exposure to similar items, in contrast to both the non-fluent post-stroke group with aphasia and controls who have experienced significant interference effects created by the PI paradigm. Conclusions. The results from the working memory syntactic interference task show that the nfv-PPA group was more impaired than the post-stroke group in syntactic comprehension, yet, such impairment did not seem to affect general working memory performance at the word level. In the PI task, the nfv-PPA group did not show a significant decline in recall across lists, indicating lack of normal interference from previously-presented material. Overall, the results provide preliminary evidence in favor of distinct performances of patients with PPA and non-fluent post-stroke aphasia on verbal working memory tasks.

A69 Oscillatory neural dynamics underlying the sentence superiority effect

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Sentences are recalled easier than random word sequences, a phenomenon called the sentence superiority effect. Previous research suggests that the sentence superiority effect reflects the use of sentence structure to efficiently chunk words into working memory during encoding, resulting in decreased retention demands for sentences compared to other verbal information. The current time-frequency EEG study independently manipulated task type (working memory vs. lexical decision task) and material type (sentences vs. word lists) to assess the neural oscillations underlying the sentence superiority effect. Our results show specific oscillatory

correlates of sentence encoding and retention: During encoding of sentences, delta power increased, while during retention of sentences, delta, theta, and gamma power decreased. Effects of task type, for both sentences and word lists, surfaced as a theta suppression for encoding and a sustained alpha increase during retention. The data suggest largely orthogonal oscillatory neural dynamics for linguistic and working memory processes, jointly leading to an overall behavioral benefit for retaining sentence structure in working memory. We argue that syntactic structure enables automatic chunking and storage, benefitting behavior without direct neural interaction with the working memory system.

Meaning: Prosody, Social and Emotional Processes

A70 Neural mechanisms for monitoring emotional valence during spoken word production

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How do speakers monitor emotional information during conversation? It is well known that the arousing nature of emotional words can capture attention at the expense of production processes (e.g., Slevc & Ferreira, 2006). This is also the case for prosodic cues (e.g., speaking with an 'angry' tone). Yet, little research has examined whether emotional valence can influence monitoring during speech production independently of these variables, or investigated the neural mechanisms that might be involved. Aside from regions involved in speech comprehension (e.g., superior temporal cortex [STC]; Indefrey & Levelt, 2004) and cognitive control (e.g., inferior frontal cortex [IFC] and pre-supplementary motor area [preSMA]; Xue et al., 2008), monitoring of emotional valence might engage regions such as the amygdala, medial frontal cortex (mFC) and temporoparietal junction (TPJ; e.g., Hervé et al., 2012). We investigated the neural mechanisms of emotional valence monitoring during spoken word production by employing a modified version of the stop signal task (SST) during functional magnetic resonance imaging (fMRI). Healthy participants (N=18) named target pictures (BUCKET or CACTUS) on frequent go trials and withheld their naming response on infrequent stop trials. Auditory stop signals, unrelated to the target, comprised words that were emotionally valent (positive or negative) or neutral. Valenced and neutral words were matched for a range of lexical variables including arousal and prosody. The stop signal delay (SSD) was calculated using an adaptive online stepping algorithm to ensure 50% successful stops. The ability to halt production was sensitive to emotionally valent compared to neutral content, reflected in significantly reduced accuracy and slower stop signal reaction times (SSRTs). However, accuracy and SSRTs for positively and negatively valenced words did not differ significantly. fMRI results ($p < .001$, whole brain cluster corrected $p < .05$) for successful stop vs. go trials revealed extensive BOLD activity across regions typically associated with the SST, including bilateral IFC, preSMA and STC. No significant differential activity was observed for contrasts of emotionally valent vs. neutral stop signal types, for either successful or unsuccessful stop trials. However, a direct contrast of successful stop trials to negatively vs. positively valenced words revealed significant activity in bilateral temporoparietal junction (TPJ). The behavioural findings show that emotional valence is monitored during speech production, and comes with a processing cost compared to neutral words that is independent of arousal or prosodic cues. The fMRI findings extend prior reports of emotive speech modulating TPJ activity by showing this can occur due to valence processing alone.

A71 Insult back or empathize with the insulter? Cognitive strategies for dealing with insults

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Being on the receiving end of an insult is not a pleasant experience. Indeed, people experiencing work or school bullying report high levels of negative affect (Dill et al. 2004). In the current study we explore how recipients can best regulate these negative feelings. One strategy that might help is to insult the insulter back. Another is to reappraise the situation by trying to understand the behavior of the insulter in an empathic way. The goal of the current study is to examine which of these strategies is more effective in attenuating the emotional impact of an insult. In order to do so we exposed our participants to a series of insults in a WhatsApp-like chat environment. One group was instructed to covertly insult the insulter back (e.g. "it takes one to know one!"), a second group to covertly empathize with the insulter (e.g. "you must be having a bad day"), and a third group to just passively read the insults. Emotional impact was measured with EEG and self-reported negative affect (towards themselves and towards the insulter, assessed repeatedly during the session). Unexpectedly, in the latency range of the Late Positive Potential (LPP), an EEG component sensitive to the emotional impact of stimuli, the empathy group displayed the largest positivity, whereas the insult-back group did not differ from the passive-reading group. Over the course of the experiment, participants felt increasingly negative about themselves, in all groups. However, while passive-reading and insult-back participants also felt increasingly negative towards the insulter, empathy participants did not develop such negative attitude. This suggests that while insults that are met with empathy still make people feel bad about themselves, and also induce additional 'late' processing, the empathy strategy does lead people to feel less negatively about the insulter. Compared to insulting back or doing nothing, reappraising the situation via empathy may thus lead to less total negative affect.

Methods

A72 Whole-brain fMRI activity at a high temporal resolution

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Introduction. Functional magnetic resonance imaging (fMRI) is frequently used to study the operation of the human brain. Current fMRI data analytic frameworks focus on revealing brain activity in the form of static, time-invariant maps. Here we introduce a new fMRI data analytic framework that yields dynamic, time-variant videos of whole-brain fMRI activity with improved temporal accuracy and temporal resolution. The new method is slice-based, meaning it extracts the fMRI

signal based on the veridical MRI slice acquisition times. In addition, the new method uses non-standard statistical modeling techniques, and a new way of data visualization. Here we illustrated and validated the new method in the context of a simple picture naming task (Glaser, 1989). Specifically, we compared the standard and new method in the context of four areas: 1. Basic signal extraction; 2. Temporal differentiation; 3. Functional connectivity; 4. Data visualization. Within these four areas we were particularly interested in the activity of the Anterior Cingulate Cortex (ACC). This region has been implicated in a variety of language production tasks (Christoffels et al., 2007), but its temporal dynamics remain poorly understood (Bonini et al., 2014). Methods. Thirty healthy participants performed the picture naming task while standard GRE-EPI fMRI data were acquired on a 3T GE Signa Excite scanner. Picture stimuli were line-drawings from a normed database (Szekely et al., 2004). On each trial, a picture or a fixation point appeared for 0.5 s followed by a 12 s ISI blank screen. A total of 108 stimulus presentations per participant were collected. fMRI data was pre-processed using standard FSL procedures. The data were 2D smoothed at 5 mm, and finally cleaned using ICA-Aroma (Pruim et al., 2015). For basic signal detection we compared vectorized versions of the t-value maps obtained with the standard and new method using Pearson correlation coefficients, and Dice indices. For temporal differentiation we compared time-to-peak values of the fMRI signal in four ROIs obtained using standard (FIR) methods and the new method at 2 second temporal resolution. For functional connectivity we compared each method's ability to identify task-based networks. For data visualization we explored the whole-brain fMRI signal during picture naming at 390 ms temporal resolution. Results. For signal detection, we found a high Pearson correlation coefficient between the two maps (r=0.92). We also found higher t-values in the new method, suggesting improved signal detection. For temporal differentiation we found later time-to-peak values in ACC compared to left motor cortex, but only using the high temporal resolution available in the new method. For functional connectivity, the new method yielded a biological network that was more biologically plausible. Finally, data visualization at 390 ms revealed a temporal gradient along a rostro-caudal axis in ACC. Conclusions. We found that the more accurate and higher temporal resolution modeling of the BOLD signal available in the new framework leads to improved signal detection, better temporal differentiation, functional connectivity and data visualization. This new framework is easily generalizable to other cognitive domains, and has applications in a broad range of neuroscience contexts.

A73 Functional segregation of linguistic functions within fronto-parietal networks

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Introduction: the superior longitudinal fasciculus (SLF) is a complex fronto-parietal system that activates for a number of cognitive tasks, including language. Advanced tractography methods have been recently employed to separate the three branches of the SLF in humans (Thiebaut de Schotten et al., 2011) but the specific functional correlates of each branch remain largely unknown. In this study we investigated the anatomical and functional segregation of linguistic functions supported by the three branches of the SLF using tractography and a novel meta-analytical approach. Methods: bilateral virtual dissections of the three branches of the SLF were performed in a dataset of 129 adult healthy participants, and their cortical projections were extracted (Thiebaut de Schotten et al., 2011). A comprehensive representation of the fronto-parietal networks was obtained by performing 14 meta-analyses of functions co-activating fronto-parietal regions, using the SDM software (www.sdmproject.com) (Radua & Mataix-Cols, 2012). Linguistic functions included semantic processing, phonological processing and verbal working memory, whereas non-linguistic functions included visuo-spatial and motor functions, emotion and number processing, decision making and mirror neuron related functions. We then quantified the overlap between the projections of the SLF and the meta-analytic maps, and assessed the involvement of each branch in each function by using one-sample t-tests in SPSS. Results: we found that linguistic functions were supported by all three branches of the SLF in the left hemisphere and were partially segregated. Indeed, semantic processing relied more on the left SLF 2 than phonological processing, and showed a greater contribution of the right hemisphere. Further, a significant ventro-dorsal segregation was observed between verbal and spatial working memory, with the former mainly relying on left ventral regions and the latter on more dorsal regions, fact that reflected on their different involvement of the SLF branches. This ventro-dorsal segregation was also observed between regions devoted to language and those supporting other motor-spatial functions. Conclusion: these results suggested the existence of both within-domain and between domains functional segregation. In fact, linguistic functions were partially segregated and differently supported by the three branches of the SLF, but also a ventro-dorsal segregation was observed more generally between areas (and related tracts) devoted to language and those supporting the processing of motor and spatial stimuli.

A74 Bad and good performers in a fMRI paradigm of three gendered language conditions – preliminary results

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In the frame of a multidimensional sex/gender analysis of functional language processing, a fMRI language paradigm consisting of a verbal fluency task (women favouring), verbal analogies (male favouring) and comprehension task (sex/gender indifferent) was implemented. The fluency condition is composed of covert, spontaneous language production, the analogy condition measures the capacity of processing logical relationships in quadruplets of words, and the comprehension condition comprises the auditory presentation of short stories of each ~1min blocks. Preliminary behavioural results on 17 participants reveal that individuals' outcomes throughout the three language tasks correlate with each other and that the individuals can be divided in two different types of performers: "good" (GP) and "bad" performers (BP). Altogether, functional activation is reproduced in the classical brain areas, for instance corresponding to the extended language network (Ferstl 2008) in the comprehension task. In the fluency task, activation is pronounced in left inferior frontal gyrus; in the

verbal analogy task, parietal regions show bilateral activation patterns. What concerns the two types of performers, BP show bilaterally more homogenous posterior temporal and less focused supplementary motor activation than GP performers. GP activate more predominantly left sided anterior parts of superior temporal regions than BP performers, and, finally, BP performers' functional inferior frontal activation is elicited in BA 44 and 45 whereas GP performers demonstrate activation in BA 44 only. These results are discussed in the framework of multidimensional analyses of sex/gender, i.e. we present how neuronal language processing as linked to different levels of performance has to be related with linguistic personal factors such as language-related socialization and non-linguistic personal factors (Canal et al. 2015) such as gendered socialization, traits, attitudes etc.

Writing and Spelling

A75 The impact of orthography on handwriting: A coupled fMRI and kinematics study of the interaction between spelling regularity and motor production.

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Writers adapt to the opacity of their written language, and apparently write regular and irregular words with the same flow. Recently however, behavioral studies have shown that motor processes in the course of handwriting are in fact modulated by word irregularity. Fine kinematic indexes display differences between regular and irregular words, and kinematic differences depend on the position of the irregularity. Based on this knowledge, we decided to investigate how the neuronal network controlling handwriting will be impacted by the presence of an irregularity and its position in the word. We hypothesized that the behavioral modulations related to the processing of the irregularity would be reflected by differential activations in the neuronal network involved both in central (spelling retrieval) and peripheral (motor production) processes. We coupled fMRI BOLD signal and kinematics recordings in 25 right-handed native French speakers during a task of single word writing under dictation, without visual feedback (in order to avoid reading). Participants were instructed to write, on an MRI compatible graphic tablet, as quickly and correctly as possible in a limited time. fMRI data were acquired on a 3-T MEDSPEC 30/80 AVANCE whole-body imager (Bruker, Ettlingen, Germany) scanner using an event-related design where the onset and duration of handwriting movements were specifically modeled. The set of 48 french words was separated into three groups: regular words, words with irregularity at beginning, and words with the irregularity at the end. The tablet recordings confirmed the presence of behavioral differences between irregular and regular words. Reaction times were increased for irregular words. Both length and duration of letter strokes also displayed an effect of irregularity, with increases located at the position of the irregularity. For words with the irregularity at the beginning, the duration increased specifically for the first letter. Conversely, for words with the irregularity at the end, differences in terms of length and duration were found for the last two letters. We found a set of 4 regions whose activation was reflecting the main effect of irregularity, in the course of handwriting execution. First, an extended cluster in the left inferior parietal region and superior parietal lobule, an area that is consistently reported as implicated in both central and peripheral processes during handwriting. Second, the supplementary motor area, a region crucial for controlling the planning and execution of complex movements. Finally, the left inferior frontal gyrus and right insula, which are typically activated in central spelling processes: respectively orthographic selection and retrieval and phonological processing. Interestingly, the activation of those regions was maximal when the irregularity was located at the end of the word. Those results indicate that writing an irregular word affects the activity of a specific brain network that is also sensitive to the position of the irregularity, in addition to modified kinematics parameters. This constitutes the first neuroimaging evidence of an interaction between word spelling and motor control in handwriting.

Poster Session B

Perception: Auditory

B1 Neural oscillations in the developing auditory brain: a longitudinal dyslexia study

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In the brain, the temporal analysis of many important auditory features relies on the synchronized firing of neurons to the auditory input rhythm. These so-called neural oscillations play a crucial role in sensory and cognitive processing and deviances in oscillatory activity have shown to be associated with neurodevelopmental disorders. In relation to this, it has been suggested that the literacy impairments observed in individuals with developmental dyslexia are a symptom of atypical synchronization of neural oscillations to temporal auditory information. A variety of auditory processing deviances have been proposed in poor readers, at the level of the brainstem, cortex or both. However, the precise nature of neural auditory impairments in individuals with dyslexia, as well as their occurrence before or during early reading development, remains debated. In the present study, cortical and brainstem auditory evoked potentials to 4, 20 and 80 Hz rate modulations were measured in 87 normal hearing children at high (n = 44) and low (n = 43) family risk for dyslexia during their development from prereader to beginning and more advanced reader. These children were investigated over a time span of six years at three different time points: at the age of 5 years (third kindergarten), at the age of 7 years (second grade) and at the age of 9 years (fourth grade). The results show maturational differences, indicating that the start of reading acquisition exerts a top-down influence on the emergence of mature neural oscillatory activity. Apart from developmental differences, an influence of dyslexia phenotype is shown at brainstem level, demonstrating that subcortical auditory processing mechanisms may play a role in the development of reading disorders before the start of reading instruction (at the age of 5 years). In contrast, cortical auditory processing deviances are absent before reading acquisition but seem to arise progressively as a consequence of reading failure in beginning (7 years) and more advanced (9 years) readers with dyslexia. In sum, this study indicates a possible role for neural auditory processing at cortical and brainstem level in the development of specific learning disorders such as dyslexia. Hereby, deviant subcortical auditory processing mechanisms seems to be a prereading marker for future reading problems, while cortical auditory processing deviances appear to arise after the start of reading instruction as a possible compensatory mechanism for reading failure.

B2 Neural auditory temporal processing at cortical and subcortical levels in children with and without (a family risk for) dyslexia

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Developmental dyslexia refers to a hereditary neurological disorder characterized by severe and persistent difficulties in reading and spelling despite normal intelligence, education and intense remedial effort. Although it is widely agreed that the majority of dyslexic individuals show difficulties in one or several aspects of phonological processing, the underlying cause of these phonological processing problems remains debated. A recent model suggests that a fundamental deficit in synchronization of cortical oscillations to temporal information in speech could underlie the phonological processing problems found in dyslexia. However, impaired auditory temporal processing could also arise from problems lower in the auditory pathway. In this study, EEGs were recorded in a group of nine-year-old children with and without (a family risk for) dyslexia during auditory stimulation with 2, 4, 10, 20, 30, 40 and 80 Hz amplitude modulations. Given that lower modulations (< 40 Hz) are predominantly processed in the auditory cortex, we assume that these conditions will allow to measure neural synchronization of oscillations in the auditory cortex (delta, theta, alpha, beta and low-gamma, respectively). In contrast, higher modulations (> 40 Hz) have shown to be mainly processed at subcortical levels, thus these conditions were included to determine whether the temporal processing impairment arises already at lower stages in the auditory pathway (thalamus or brainstem, respectively). Group analyses comparing children with (n = 32) and without (n = 34) a family risk for dyslexia showed reduced neural synchronization to 4 Hz modulations and enhanced neural synchronization to 80 Hz modulations in children with a family risk for dyslexia in comparison to children without a family risk for dyslexia. On the other hand, analyses comparing the same children now divided in a group with (n = 49) and a group without (n = 17) severe and persistent reading problems, i.e. dyslexia, showed enhanced neural synchronization to 20 Hz modulations in dyslexic readers in comparison to normal reading children. We found no group differences in neural synchronization strength to 2, 10, 30 or 40 Hz modulations. In sum, our results demonstrate reduced synchronization of cortical theta oscillations in nine-year-old children with a family risk of dyslexia regardless of their reading skills, but also enhanced synchronization of cortical beta oscillations in those children who developed dyslexia regardless of their family risk. Whereas theta rate undersampling could be related to syllabic level speech and phonological processing deficits, beta rate oversampling presumably reflects higher processing effort of phonemic level speech and phonological processing. In addition to these cortical processing differences, our results also reveal atypical subcortical processing at brainstem level, but only in children carrying a family risk for dyslexia.

B3 Not all who listen in babble use semantic context alike.

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An understudied question central to understanding individual differences in the ability to process speech in degraded listening environments is whether the relationship between neurophysiological and behavioral measures reflects individual differences in depth of facilitation for speech in semantic context presented in background babble. Our goal was to examine the relationship between reaction time (RT) responses and event-related potentials (ERPs – N400) as indicators of

an individual's increased reliance on semantic context when listening to speech in two-talker babble. The participants for this study were right handed monolingual English speaking young adults (20-35 years) with normal middle ear function and normal hearing thresholds bilaterally. The subjects listened in quiet and in two-talker babble to high predictability speech-in-noise (SPIN) sentences that either ended with a related final word, or an unrelated final word, spoken by a female speaker of standard American English. In a decision making task, subjects evaluated whether the final word was related or unrelated to the sentence stem. Stimuli were presented over headphones to either the left or right ear. During the babble condition, subjects were to ignore the two-talker babble that was presented simultaneously to the opposite ear at a +5 dB SNR. Intra-class correlation coefficients (ICCs) were calculated for the N400 (200-600 ms) of four conditions (left ear/related; right ear/related; left ear/unrelated; right ear/unrelated). An ICC value was calculated for each of the four ERP waveforms obtained in babble (ear of presentation left/right; relatedness related/unrelated), with the corresponding ERP waveform in quiet as the reference, reflecting the extent to which N400 activation was similar/dissimilar in two-talker babble vs. quiet. For each condition, a simple linear regression was calculated predicting ICCs based on reaction times for the same condition in two-talker babble. Significant regression equations were found for both related conditions (left/right). Individuals who showed ICC evidence of greater facilitation of the N400 in two-talker babble than in quiet (i.e., smaller ICC values), exhibited faster reaction times for the related conditions in babble. Reaction times in quiet and unrelated conditions were not found to predict ICC values, suggesting that our findings could not be explained simply by inter-subject variability in general speed of operation. Our findings suggest that not all young adult listeners increase their reliance on semantic context when processing speech in difficult listening conditions. Implications for semantic processing in difficult listening conditions will be discussed.

B4 Speaker identity in non-verbal signals – variability impairs generalization

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Introduction Voices are uniquely flexible signals that convey a wealth of information about a speaker's identity (Belin et al., 2004; Mathias & von Kriegstein, 2014). Most research looking at the extraction of identity-related information from voices has used speech signals, produced in a neutral voice. We thus know little about how natural flexibility in vocal signals affects identity perception. The extraction of speaker information is thought to rely on prototypical voice representations (Kreiman & Sidtis, 2011; Latinus et al., 2013). According to this model, unfamiliar voices are compared to prototypical representations based on population averages, while familiar voices are matched to representations of the specific speaker's vocal inventory. These proposed mechanisms predict differences in voice perception between unfamiliar and familiar listeners. In a behavioural study and an fMRI, we explored how identity-related information in voices is processed in familiar and unfamiliar listeners. Going beyond speech signals, explored how vocal flexibility and variability, introduced by different types of non-verbal vocalizations (laughter, vowels) and levels of volitional control during production (volitional laughter vs. spontaneous laughter) affects identity processing. Methods and Results Behavioural Study 23 familiar and 23 unfamiliar listeners performed a speaker discrimination task. Participants heard permutations of pairs of Volitional Laughter, Spontaneous Laughter and Vowels produced by 6 speakers. This yielded 6 conditions: 4 within-vocalization conditions (Vowels-Vowels, Volitional Laughter-Volitional Laughter, Spontaneous Laughter-Spontaneous Laughter, Volitional Laughter-Spontaneous Laughter), and 2 across-vocalization conditions (Volitional Laughter-Vowels, Spontaneous Laughter-Vowels). Participants were significantly better at matching the speakers in within-vocalisation pairings (e.g. Vowels–Vowels) than for across vocalizations pairings (e.g. Volitional Laughter–Vowels). Familiar listeners performed significantly better than unfamiliar listeners in each condition. Both groups were, however, equally affected by flexibility in vocal signals: there was an apparent failure to generalize identity information across different nonverbal vocalization types. fMRI study 19 familiar listeners and 20 unfamiliar listeners were presented with spontaneous laughter, volitional laughter, series of vowels and brief sentences produced by 6 speakers while performing a one-back speaker discrimination task. Univariate analyses showed a main effect of vocalization type in a widespread network including bilateral STG, IFG and superior medial gyri, mapping differences in acoustic properties and meaning. A main effect of speaker was found in bilateral STG, reflecting acoustic differences. A main effect of group was found in right superior medial gyrus, with activation being higher for unfamiliar listeners, indicating more demanding computations during voice perception (von Kriegstein & Giraud, 2004). Representational similarity analysis (RSA) was used to explore whether regions coding for vocalization type and speaker-identity could be identified. In line with univariate results, analyses reveal vocalization type-based coding in bilateral STG. Ongoing analyses are attempting to identify regions that code for speaker identity, and to explore potential group differences within those regions. Conclusion Our findings illustrate that our ability to generalize speaker identity across different kinds of vocal signals is limited, even when dealing with familiar voices. In line with behavioural evidence, identifying neural underpinnings 'categorical' speaker identity for familiar voices may be challenging in the context of highly variable vocal signals.

Perception: Speech Perception and Audiovisual Integration

B5 Language-specificity in early cortical responses to speech sounds

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The continuity of speech articulation ensures that in all languages, spoken sounds influence one another. Thus there are potentially cues to a sound's identity in the realisation of surrounding sounds. Listeners make use of such coarticulatory cues – but not always. It has long been known (Harris, Lang.

Sp., 1958) that English-speakers use this coarticulation to identify [f] but not [s]. The reason is that place of articulation cues can distinguish [f] from its very close perceptual competitor [θ] (deaf/death), while [s] has no such perceptual competitor and hence less need of such disambiguation. In languages with [f] but no [θ] (e.g., Dutch, Polish), listeners do not use coarticulation to identify [f], whereas listeners do use coarticulation to identify [s] where [s] has close competitors (Polish; Wagner et al., JASA, 2006). The patterning of coarticulation cue use is thus language-specific. In those studies, listeners' use of coarticulatory cues was revealed by comparing responses to the same sounds in matching versus mismatching phonetic context (e.g., in afa, asa either as originally recorded, or with the consonants cross-spliced); sensitivity to this difference signals attention to coarticulation. We used this same method to assess whether language-specificity could be observed in the early cortical responses to speech, by measuring auditory evoked potentials in response to change in an ongoing sound (Acoustic Change Complex [ACC]; Martin & Boothroyd, JASA, 2000). 18 undergraduate native speakers of Australian English (11 females) heard, while watching silent video, 900 bisyllables (150 repetitions each of afa and asa in original, identity-spliced and cross-spliced realisation, where identity-spliced afa has initial [a] from another utterance of afa, cross-spliced afa has [a] from asa). If the ACC exhibits the language-specific differential response to [f] versus [s], we predict a significant difference across stimulus types (cross-spliced versus the other two stimulus types) for afa but not for asa. Listeners' EEG was recorded (BioSemi, 64 channels), filtered between 0.1-30 Hz, divided into epochs from -100 to +1000 ms from token onset, and the epochs averaged separately for each bisyllable and stimulus type. The ACC amplitude was calculated from the grand averaged waveform across listeners as the difference in amplitude between the N1 and P2 peaks at the Fz electrode site; these differences were analysed in Bonferroni-corrected planned comparisons across the three stimulus types (unspliced, identity-spliced, cross-spliced) for each of afa and asa. For asa, the planned comparisons showed no differences at all between stimulus types. For afa, in contrast, the comparison between unspliced and cross-spliced stimulus types revealed that cross-spliced tokens generated a significantly smaller ACC: $F(1,17)=5.98$, $p<.05$. The amplitudes from the unspliced and identity-spliced afa stimuli however did not significantly differ. These findings indicate that English-speaking listeners' coarticulation usage patterns – sensitivity to cues in a preceding vowel in the case of [f], insensitivity in the case of [s] – can be detected in the ACC, suggesting that native language experience tailors even the initial cortical responses to speech sounds.

B6 Is cortical entrainment to speech a neural correlate of listening effort?

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In realistic listening environments, listeners often have to attend to speech that is masked by the speech from other talkers. Speech recognition in the presence of competing talkers places additional demands on attention and cognitive control, as there are competing information streams in addition to acoustic masking. Recent studies have shown that cortical oscillations become entrained to the amplitude envelope of speech in the delta/theta range (1-8Hz; e.g., Lakatos et al., 2005; Ahissar et al., 2001; Luo & Poeppel, 2007; Peelle et al., 2013). While listening to competing talkers, attention modulates auditory cortical activity, selectively enhancing the entrainment to the signal of the target talker (Ding & Simon, 2012; Kerlin et al., 2010; Zion et al., 2013). However, listening in a competing-talker background can be particularly demanding for non-native listeners. Previous research has shown that the detrimental effect of background noise is more pronounced for non-native listeners as they have less-developed linguistic representations of the target language (e.g., Mayo et al., 1997). The present study investigated how the higher cognitive load caused by competing speech affects speech recognition for native English speakers and Korean learners of English especially in tracking the amplitude envelope of speech, as measured using the phase coherence between EEG signals and amplitude envelopes of their corresponding speech signals. In addition, the N400 was measured to investigate word recognition processes. To this end, subjects listened to English sentences that differed in the predictability of the final word (i.e., anomalous sentences, low-cloze and high-cloze probability sentences). The sentences were recorded by two female talkers, which were presented to subjects simultaneously (one speaker in each ear). In each block, subjects were instructed to attend to one of the talkers and press a button whenever they hear a semantically anomalous sentence in the target ear. The results from the phase coherence analysis demonstrated that non-native listeners had stronger selectivity for the target talker than did native listeners. It seems that the L2 listeners' auditory-cortical entrainment to the target speech was particularly enhanced because they needed greater listening effort in the presence of competing speech. This suggests that entrainment to speech is modulated by listeners' use of cognitive resources in speech recognition. The results from the N400 analysis also indicated that non-native listeners were more strongly affected by the presence of competing speech at the level of lexical processes: their lexical search and use of context were reduced. More work is required in the future, but the findings of the current study provide a possible link between cortical entrainment to speech and listening effort.

B7 Audiovisual matching ability in 4.5-month old monolingual and bilingual infants

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Recent neuroimaging studies demonstrate that exposure to more than one language affects infants´ neural responses to the auditory linguistic signal alone (Ramírez et al., 2016; Petitto et al., 2012). In ecologically-valid situations, however, the auditory signal is often accompanied with other sorts of information, such as the speakers' articulation. This visual linguistic information is available to young infants (e.g., Kuhl & Meltzoff 1982; Patterson & Werker, 2003). Here, we tested whether exposure to one or two languages in early infancy has an impact not only on processing auditory information but processing auditory and visual linguistic information together. Spanish and Basque monolingual (n= 21) and Spanish-Basque bilingual (n= 17) 4.5-month old infants were assessed in an audiovisual matching task. Infants were presented with a female face mouthing either /i/ or /u/, while auditory /i/ or /u/

tokens were presented. Six matching (visual /i/ with auditory /i/, and visual /u/ with auditory /u/) and six mismatching (visual /i/ with /auditory /u/, and visual /u/ with auditory /i/) trials were presented while the infants' attention was measured using an eye-tracker. A repeated 2-way ANOVA on the average looking times (Condition: match or mismatch; auditory vowel: /u/ or /i/) revealed no evidence for audiovisual matching ability in the monolingual group. However, the bilingual infants exhibited an increased looking time during the mismatch condition. Interestingly, this effect was only observed when auditory /i/ was paired with visual /u/ to produce the mismatch. Additionally, we compared the proportion of time infants spent on looking to the eyes and the mouth. Both language groups spent more time on the speaker's eyes than on the mouth, and this pattern did not change as a function of the condition or vowel type (but see, Pons et al., 2015). Taken together, our results suggest that exposure to two languages in very early infancy affects not just auditory, but audiovisual processing as well. Bilingual 4-month-olds are more sensitive to incongruency between the auditory and visual information than their monolingual peers, suggesting that the development of audiovisual language processing is affected by environmental factors, such as exposure to one or more languages. Moreover, the type of linguistic information (/u/ vs. /i/) also interacts with infants' matching abilities. This might be due to development of speech sound productions during infancy (also see, Altvater-Mackensen et al., 2016) or to the salience of visual and auditory cues available across different types of speech segments.

B8 Theta oscillations determine auditory word segmentation

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Word segmentation is one of the initial processes that needs to be solved during first language acquisition. Acoustic cues like F0 rising are known to facilitate word onset detection. Evidence accumulates that slow neural oscillations track acoustic cues to arrive at speech comprehension (e.g., Peele et al., 2013, Cereb Cortex). Furthermore, slow neural oscillations can emerge in the absence of acoustic landmarks, e.g. in structure building (Ding et al., 2015, Nature Neurosci). Here, we would like to show that slow oscillations also play a role in speech stream segmentation, especially when segmentation is acoustically ambiguous. In French, liaisons, e.g. between determiner and noun, often pose problems of several segmentation possibilities (e.g., /lafiS/: "l'affiche" with liaison (VC-segmentation) means poster, whereas "la fiche" without liaison (CV-segmentation) means file.). An F0 increase on the first syllable (/la/) biases perception towards VC-, whereas an F0 increase on the second syllable biases perception towards CV-segmentation (Spinelli et al., 2010, Atten Percept Psychophys). The current experiment uses eight of such ambiguous 2-syllabic word-pairs for stimulation. Stimuli were controlled for being completely ambiguous in all aspects apart from F0 modulations. While recording the electroencephalogram (EEG; N=15), participants listened to streams of four, five, or six items either all with F0 rising on the first (VC) or all on the second syllable (CV), or all without F0 modulation (AM). The last word, however, on which participants had to perform a delayed segmentation decision, was always ambiguous and without F0 modulation. Behavioral results show a consistent bias across participants towards VC-segmentations probably due to the relatively short /la/-syllable. In VC-streams, however, more CV-segmentations were reported for the last ambiguous word, compared to CV- and AM-streams (46% vs. 40% and 43% resp.) speaking in favor of contrast perception. EEG data shows a general pattern of high phase locking of delta oscillations (~1.5 Hz) across the whole trial and of low alpha oscillations (~9 Hz) at the onset of each item, which is also visible in the ERPs. Interestingly and in line with the frequency of F0 modulations, the inter-trial coherence (ITC) of delta oscillations fluctuates anti-phase for VC- and CV-streams over fronto-central electrodes. This underlines the importance of F0 tracking for lexical access. In contrast, when analyzed by response ("VC" vs. "CV"), theta oscillations (~5 Hz) over fronto-central electrodes show first higher ITC when responses are going to be "VC" than "CV" (–1.7s - 0.85s) and second a phase shift between "CV" and "VC" responses of about 50° or 28ms (–0.37s - 0.05s). To conclude, with the current study we were able to dissociate stimulus-related entrainment of alpha and delta oscillations versus response-related theta oscillations in order to resolve ambiguous word segmentation. These results suggest that auditory word segmentation is not entirely based on perceptual evidence but also depends on internal brain states. Most importantly, the current data suggest that theta oscillations subserve not only low-level acoustic functions but also higher-level linguistic functions such as word segmentation.

B9 Tracking lexical garden-path resolution with MEG: Phonological commitment and sensitivity to subphonemic detail are independent

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Introduction: Behavioural studies posit that commitment to a phonological category can be delayed for over 1s after onset, using insensitivity to subphonemic variation (e.g. voicing) as a metric for commitment. Our results support a contrary claim: while sensitivity to phoneme ambiguity indeed extends over 1s, phoneme-category commitment is an independent computation that resolves earlier. Methods: Sixty-five word-pairs were selected that, apart from the initial consonant, have an identical speech stream until point-of-disambiguation (POD) (e.g. "parak-eet", "barric-ade"). Pre-POD onsets were morphed to create voicing {t-d, p-b, k-g} and place of articulation {t-k, p-t} continua, that spanned a target word and a cross-onset non-word (parakeet <-> barakeet). Before POD, no top-down information is available, as the speech stream is consistent with more than one lexical item. At POD, the word is uniquely identifiable and disambiguates word onset. POD-latency varied from 200-700 ms across word pairs to allow us to test a range of delay periods. In Experiment 1, participants (n=24) performed a 2AFC task on 11-step continua of just the first syllable of these word pairs (e.g., "ba", "pa"). In Experiment 2 (n=25), participants listened to full lexical items spanning 5-step continua. Magneto-encephalography was recorded concurrently during both experiments. Results: Phoneme-category ambiguity significantly modulated early responses in left Heschl's gyrus from 40-60 ms after syllable onset (Experiment 1), 40-60ms after word onset and 40-60 ms

time-locked to POD (Experiment 2). The same pattern was obtained for both voicing and place of articulation continua, illustrating that phoneme ambiguity arising from temporal and spectral cues elicits the same response. Crucially, sensitivity to onset ambiguity did not interact with POD-latency: words with greater ambiguity at onset elicited more activation time-locked to the POD phoneme at all delay periods. However, activation of competing lexical items (modelled by surprisal) did significantly interact: before ~500ms, expectations were weighted by subphonemic acoustic detail; after that, expectations were commitment-dependent. Conclusion: Our results implicate maintenance of subphonemic detail until at least 700 ms, reflected by reactivation of Heschl's gyrus. By contrast, phonological commitments are restricted to a short integration window. These findings suggest that modelling predictions of upcoming sounds is a reliable metric for phonological commitment, which is a separable neural computation - recruiting distinct neural populations - from retroactive sensitivity to subphonemic detail.

B10 Perceptual sensitivity to voicing onsets in continuous speech can be indexed by phase resetting of ongoing theta neural oscillations

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[Introduction]: Evidence suggests that phase characteristics of low-frequency (esp. theta, 4~8 Hz) brain oscillations recorded via EEG/MEG is important for speech perception. For instance, Luo & Poeppel (2007) found that phase-locking information of theta-band MEG can statistically classify different individual auditory sentences successfully; moreover, phase entrainment of theta oscillations to acoustic envelopes plays an important role for speech comprehension (Peelle et al., 2013; Doelling et al., 2014). Recent studies using combined EEG and intracranial recording methods have revealed that phase patterns of EEG theta oscillations can index stimulus-driven local neural excitability in the auditory cortex (Lakatos et al., 2005; Ng et al., 2013) and that this implicates the neural mechanism of theta phase encoding acoustic stimulus during speech perception (Ng et al., 2013). In the current study, we aim to investigate how theta phase encoding is involved in processing of phonetic/phonological features in speech, the topic of which is still largely unknown. Here, we analyzed phase resetting patterns of EEG oscillations in continuous speech time-locking to the onsets of two representative phonetic features, frication and voicedness. [Methods]: We analyzed EEG data obtained from the experiment of our recently published paper (Mai et al., 2016, NeuroImage, in press), in which 20 native Mandarin speakers listened to Mandarin spoken sentences (forward speech) and their time-reversed versions (backward speech). In each trial, a brief cue sound (< 300 ms, different across all trials) was presented prior to the target utterance and participants were asked to complete a forced-choice sound-matching task by judging whether the cue sound appeared in the target utterance or not, thereby forcing participants to pay active attention to the utterances. Ongoing EEG signals were bandpass filtered into narrow bands, and phase-locking value (PLV) based on Hilbert phase was calculated for each band relative (i.e., time-locking) to the fricative (both aspirated and unaspirated) and voicing (appearance of F0) onsets, respectively. PLVs were finally z-normalized according to the corresponding 100-ms pre-onset periods. [Results & Discussions]: First, significantly higher theta-band (4~8 Hz) PLV at 50~250 ms after voicing onsets was observed across central and frontal electrodes for forward speech than for backward speech. However, no significant effect was obtained with time-locking to fricative onsets comparing forward with backward speech. Second, within forward speech, we found significantly higher theta PLV with time-locking to voicing than to fricative onsets across central and frontal electrodes. Finally, we found that higher PLVs correspond well to larger magnitudes of ERP N1-P2 complex. The current results therefore showed that phase resetting of ongoing theta oscillations can index perceptual sensitivity to voicing onsets in continuous speech signals, underlining the role of theta phase encoding the phonetic feature of voicedness. Furthermore, the correspondence between theta phase resetting and N1-P2 complex indicates that the current finding may also be related to the cognitive processes of speech segmentation which was shown to be indexed by early ERP components (Sanders & Neville, 2003; Sanders et al., 2009).

B11 Representation of audiovisual speech features in superior temporal cortex investigated with intracranial surface electrodes.

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Recent studies have related speech acoustic parameters (e.g. speech modulation rate-scales, spectrogram frequencies, intensity envelopes) to neural responses (Pasley et al. 2012). However, it is unclear how vision alters acoustic representations in early and higher auditory areas and in particular which temporal brain regions respond to presence or absence of visual speech. To investigate this we devised an experimental task with bimodal (video+sound: audiovisual or AV) and unimodal (sound only: auditory or AVno) speech stimuli which are expected to optimally elicit spectro-temporal tuning in the brain. Altogether we presented 210 different audiovisual and auditory sentences to 7 patients implanted with subdural electrodes. Electrocorticography grids and strips were laid over the cerebral cortex with 492 electrodes in total, 222 temporal, 43 in STS-STG. Heschl's gyrus was used as anterior-posterior boundary to separate electrodes into anterior (auditory cortex) and posterior (multisensory/pSTS/STG) groupings. We hypothesised that upon delivery of bimodal stimuli two phenomena would be apparent in the brain: 1) The spectral components of brain oscillations would react differently to the presence of video speech specifically in temporal cortex auditory areas, 2) The acoustic 'intensity' of sentences (extracted by means of PRAAT software) would correlate optimally at different lags for the AV and the AVno conditions with brain activity. To answer the first question we performed time-frequency analysis of neural activity in the Fourier domain and applied t-statistics on magnitudes to answer the question if any electrode in any frequency band was presenting differences in AV vs AVno conditions (independent

Montecarlo t-test with 500 iterations, alpha=0.05 two-tailed, cluster analysis in time-frequency and space, cluster analysis with 'maxsum' method by means of FieldTrip software, epoch between 0 and 3 sec after speech onset analysed). To answer the second question we calculated the Pearson coefficient between multi-band brain rhythms magnitudes and speech intensity at different lags. We found: 1) strong high gamma increases with respect to baseline to both AV and AVno speech (130% to 230% magnitude increase in STG, 70-150 Hz), but no differences between conditions in early auditory areas. In contrast, posterior superior temporal gyrus (pSTG) showed stronger high gamma increases to AV compared to AVno speech (68% magnitude increase +/-5% SEM vs 52% +/-5% SEM, p=0.002, t=0.25-1 sec after speech onset, subject 4) and both alpha and beta rhythms magnitude decreases (36% +/- 4%SEM, 18% +/- 7% SEM, t=0-0.25 sec, p=0.002); 2) tracking of speech envelope in left anterior-to-posterior superior temporal lobe in high gamma power (mean rho=0.7, p=0.001, Kubanek et al, 2013) and alpha (8-13 Hz) /beta (15-30 Hz) frequencies (mean rho = -.4, p=0.0015). Our results suggest that auditory areas primarily process the auditory information in a bottom-up fashion, whereas more posterior high-order areas (pSTG) could be responsible for audiovisual integration, reflected both at high-gamma and alpha/beta frequencies. We are confident that further insight in the mechanisms of pSTG and adjacent areas will contribute to the understanding of the neural physiology of audio-visual speech. We thank SFB-TRR31 fund 'Das Aktive Gehör' for support in the research.

Multilingualism

B12 Unbalanced Math in Bilingual Minds

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Bilinguals show a preference for one of their languages in their arithmetic representations and learning; even when they are fully proficient balanced bilinguals (Spelke and Tsivkinm, 2001; Salillas and Wicha, 2012; Bernardo 2002; Salillas & Carreiras, 2014). We have suggested that this preferred language is the Language of Learning Math (LLmath), vs. the other language (OL), and that this preference is not just restricted to exact arithmetic. Here we further question whether the simple pattern of lexical dominance for number words is also dependent on early math learning. The present study tested a group of Spanish-Basque balanced bilinguals in two code-switching experiments. Based on previous studies (Alvarez et al. 2003; Meuter & Allport, 1999) balanced bilinguals do not show any switch asymmetries, however unbalanced bilinguals show an asymmetry when switching between languages (Costa & Santesteban, 2004). In the present study, ERPs were measured in two experiments involving two different numerical tasks presenting numbers in their written forms. Experiment 1 was a numerical comparison and Experiment 2 was a masked priming classification task. In both experiments, code-switch trials were compared to non-switch trials. Results from both experiments converged in a switch-cost asymmetry in the N400 component after the OL-to-LLmath switch. This asymmetric switch-cost could not be explained by analyses that considered the L1/L2 dichotomy. In conclusion, balanced bilinguals show unbalanced dominance for the linguistic codes for math.

B13 Why do bilingual speakers have bigger attentional blinks? Insights from ERPs

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Bilinguals have been proposed to have enhanced attentional control ability (Abutalebi & Green, 2007). However, this can manifest as a cost depending on task demands. For example bilingual speakers showed a bigger Attentional Blink (AB) effect compared to monolingual peers (Colzato et al., 2008). Attentional blink (AB) refers to the deficit to report the second (T2) of two targets when it appears 200-500 msec after the first target (T1), typically observed in a rapid serial visual presentation paradigm (RSVP) paradigm. One cause of AB is the online T1 depletion of attention, leaving inadequate cognitive resources for processing T2. This resource sharing/depletion view has been supported by electrophysiological measurements, namely by a positive correlation between P3 amplitude of T1 and the magnitude of AB (Shapiro et al., 2006) as well as increased T1 activity (P3) and reduction of T2 activity when T2 is missed (Pincham & Szucs, 2012). Bilingual speakers, who have been argued to have better attentional control ability, might be overly devoted to the processing of T1 and missing T2. The current study tested this hypothesis with electrophysiological evidences. 20 right-handed monolingual English speakers and 20 right-handed bilingual speakers of English and another language (matched for age, education, IQ and SES background) were tested in an RSVP task, while EEG was recorded. They saw 360 trials with each trial consisting of a continuous stimulus stream of 20 upper case letters, i.e. 2 white targets and 18 black distracters. Each letter was presented for 35.4 msec followed by a blank screen for 59 msec (monitor refresh rate was 85 Hz). The task was to identify and report the two white targets. At the end of each trial, participants were instructed to make three-alternative forced choices for both T1 (B, G or S) and T2 (K, X or Y). Three conditions were formed depending on the relative position of the two targets: T2 appeared at lag1, lag3 or lag7 after the presentation of T1. Behavioral results showed a typical AB effect for both groups: reduced T2 accuracy at lag3 compared with lag7. In addition, there was a marginal effect of group on the accuracy of T2 detection when T1 was successfully identified, with bilingual speakers having lower accuracy overall. Planned comparison showed that bilingual speakers were more likely to miss T2 when it appeared at lag 3 only, i.e. around 300 ms after T1, replicating Colzato et al. (2008)'s finding. Mean ERP amplitudes around the P2 and P3 peaks of T1 were compared between the two participant groups. Bilingual speakers tended to have a larger central-frontal P2 amplitude (measured at Cz) than monolinguals, while P3 amplitudes (measured at Pz) did not differ between the two groups. This result does not support the hypothesis that bilinguals devote more attentional resources to the processing of T1. The P2 effect suggests that the group difference is rather due to earlier perceptual processing differences. Implications for the bilingualism cognitive effect are discussed.

B14 Cortical Thickness Changes with Short-Term Second Language Vocabulary Training

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Learning a second language (L2) is associated with changes in both neural activity and gray matter structure (see Li, Legault, & Litcofsky, 2014 and Lövdén et al., 2013 for reviews). However, the majority of studies examining language training-dependent changes focus on long-term training, taking place over the course of months or years. The current study examines changes in cortical thickness (CT) in response to short-term (2.5 weeks) second language vocabulary training. Furthermore, we examine whether the context in which participants learn a second language leads to changes in CT in different regions. For our study, we compared traditional picture-word paired associative learning with learning in virtual environments constructed through Second Life (www.secondlife.com). Both groups learned the same 90 nouns in Mandarin Chinese during 7 training sessions over the course of 2-3 weeks. Finally, we also examined whether individual differences in cognitive performance correlated with CT. We used Freesurfer's longitudinal mixed effects (LME; Bernal-Rusiel, Greve, Reuter, Fischl, & Sabuncu, 2012) modeling to examine changes in cortical thickness in a priori designated regions of interest (ROIs). These ROIs were determined based on areas implicated in a language control network (Abutalebi & Green, 2007) as well as other regions previously indicated to be associated with second language training (Li et al., 2014). Results from our LME analyses indicate 1) an increase in CT in the right anterior cingulate cortex (ACC) after L2 training; 2) increases in CT in the left ACC and inferior frontal gyrus (IFG) as well as right inferior parietal lobe, which were positively correlated with performance during L2 training; and 3) CT increase in the left IFG was correlated with L2 retention scores 3 weeks after the last training session. Moreover, there were differences in CT across various regions between the L2 training groups. Finally, increases in CT were positively correlated with performance on working memory and executive function tasks. All together, these results show that short-term language training leads to changes in CT which are associated with performance during L2 training, and differ based on individuals' cognitive ability and training context.

B15 Bilingual Experience Influences Different Components of Cognitive Control: An fMRI Study

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Cognitive control involves various components including inhibitory control and response suppression. Inhibitory control is involved in inhibiting the irrelevant stimulus during information processing, while response suppression is considered to inhibit the irrelevant responses. Both of these components are important but they somewhat distinct role for cognitive control. It has been reported that bilingual experience can influence various components of cognitive control and the corresponding neural activities. In the level of behavior, bilingualism promoted the performance in the inhibitory control. However, it still remains unclear whether the influence by bilingualism could be presented in the neural network, and how bilingualism changes the neural basis of the cognitive control components specifically. To discuss the bilingual impacts on the neural basis of cognitive control, we conducted the present study, comparing the brain activation patterns between high vs. low proficiency Chinese-English bilinguals. The saccade paradigm was adopted in the study, which included the four experimental conditions, i.e. along-saccade, anti-saccade, eye-mixed task, and eye-moved conditions. Through the directions of eyes and asteroid, participants completed the four tasks by pressing the corresponding buttons the in scanner. Statistical analyses were performed by modeling different conditions as explanatory variables within the context of the general linear model. The analysis was performed individually for each participant. Applying group analysis based on a random effects model. To detect the neural substrate of components in cognitive control, a second-level analysis was conducted according to the above assessment between different conditions using the images that were computed by the task conditions minus the baseline conditions. The results showed that inhibitory control engaged the superior temporal gyrus (STG) and middle temporal gyrus (MTG) for low-proficiency Chinese-English bilinguals, but the right insular cortex for high-proficiency bilinguals. By contrast, response suppression recruited the middle frontal gyrus (MFG) for low-proficiency bilinguals, but the inferior patrietal lobe (IPL) for high-proficiency bilinguals. These findings suggest distinct neural correlates for different components of cognitive control in bilinguals, and how the components interact with the different levels of L2 proficiency in bilingual speakers. Our study provided new experimental evidence for the interplay between language experience and cognitive control, and our data offered further insights into the neuroplasticity of bilingual language experience in general.

B16 A tale of two enhancements: Monolinguals catch-up to bilinguals on executive control abilities during adolescence, auditory processing enhancements remain

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A bilingual advantage in executive control has been deemed by some as reliably present yet by others as decidedly absent. Often, this advantage is found for bilingual children relative to their monolingual peers, but not for young adults. When a bilingual advantage is seen, it is presumed to result from the co-activation of both languages during communication and the need to suppress the irrelevant one. However, this is not the only reason to engage executive control during communication. For example, both bilinguals and monolinguals call on executive control to facilitate listening in noise, a common occurrence of every-day listening environments. Given executive control's importance in daily communication, it is likely that monolinguals continue to hone this skill over time. The presumed disappearance of the bilingual advantage, together with the general importance of executive control for communication suggests that differences between bilinguals and monolinguals lie in the developmental trajectory of this skill, rather than overall attainment level. Because, bilinguals, in addition to relying on executive control for the same reasons as monolinguals, also utilize executive control to manage language co-activation, we hypothesize that development of this skill is accelerated in bilinguals relative to monolinguals but that both groups ultimately attain the same skill level. To test this hypothesis, Spanish-English bilingual and English monolingual adolescents' executive control abilities were

assessed at two time points: once at age 14, before executive functions mature, and again at age 18. Spanish-English bilinguals showed an executive control advantage at age 14, but monolinguals and bilinguals performed equivalently at age 18, with the monolinguals catching up to the bilinguals. Bilingual enhancements in executive control have previously been found at age 14 to track with neural processing of the fundamental frequency (F0) of speech sounds. Therefore, we also longitudinally examined F0 encoding differences between monolinguals and bilinguals. At both time points, bilinguals had enhanced processing of the fundamental frequency relative to monolinguals. Furthermore, the relationship between executive control and F0 encoding was maintained at age 18, consistent with previous findings in 14 year old bilinguals. This suggests that bilinguals continue to rely on a strengthened interaction between auditory and executive systems during communication, which may underlie the re-emergence of a bilingual executive control advantage in older adults.

B17 How Bilingual are Bilectal Speakers? An fMRI Study of Text Comprehension in Different Language Varieties.

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People speaking two languages since birth show different neuronal language processing than monolinguals (Abutalebi, 2008). It even appears that the processing of later learned languages is facilitated in these bilinguals. Moreover, other cognitive processes may also benefit from bilingual backgrounds (Bialystok, 2009). In contrast to the vast quantity of bilingualism studies, there is almost no neuro-cognitive research on bilectals, who speak a standard language and a regional dialect. Beyond that the few neurolinguistic dialect studies focused primarily on the perception of phonetic dialect features. In the present fMRI study, we therefore investigated the functional neuroanatomy of auditory comprehension of different language varieties on the text level. Forty participants were selected via a specifically developed dialect and language questionnaire. Half of them were native speakers of Standard German and South Alemannic, a dialect located in the southwest of Germany (bilectal). The other half spoke only the Standard (monolectal). Twenty-four fairy tales were translated and recorded in Alemannic. Recordings of Standard German and another variety, Central Bavarian, served as control conditions. For replication of bilingualism studies, a foreign language, English, and an unknown language, Vietnamese, were also included. Thirty of the fMRI participants took part in additional behavioral experiments (Stroop test, verbal fluency, and a picture verification task in Standard and Alemannic). Whole brain analyses revealed activations in the extended language network (ELN; Ferstl et al., 2008) for all participants. English or an unfamiliar dialect elicited more activation in bilateral STG, PFC, Cerebellum, SMA and ACC. Standard German elicited more activation in bilateral angular gyri and the aTLs. Only monolectals, but no bilectals, showed lower activation in left aTL for Alemannic compared to the Standard. The picture verification task revealed slower reaction times in Alemannic for monolectals but not for bilectals. Stroop performance and verbal fluency did not differ for the two groups. The results suggest that not only foreign languages but also unfamiliar dialects led to more activation in areas outside the ELN, reflecting comprehension difficulties and incertitude (Abutalebi, 2008). In contrast native varieties showed more activation in ELN areas involved in higher level text processing (Ferstl et al., 2008). For monolectals less activation in left aTL revealed comprehension difficulties in Alemannic, consistent with the results of the PVT. Against expectation bilectals did not show an advantage in cognitive flexibility as revealed by the Stroop and verbal fluency tasks. We therefore conclude that bilectal neuronal language processing resembles bilingual processing, with the left aTL playing an important role for mother tongue(s), but that other cognitive processes do not benefit from bilectalism.

Meaning: Lexical Semantics

B18 Selective Action Verb Processing Deficits: Voxel-Based Lesion-Symptom Mapping

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Activation of motor systems in the brain during action verb processing is often cited as evidence for “embodied” concept representation, but this evidence remains controversial, and the activation in question has also been interpreted as epiphenomenal. Selective action verb processing deficits in patients with motor neuron disease and Parkinson disease support claims of a causal link between motor system function and action verb comprehension, but the diffuse pathology associated with these degenerative conditions prohibits definite localization of the impaired networks. METHODS: We provide new evidence on these issues using voxel-based lesion-symptom mapping (VLSM) in 34 patients with chronic left hemisphere stroke. All patients were right-handed, native English speakers and at least 6 months from stroke onset. The patients performed semantic matching tasks (match a sample word to one of two choices based on similarity of meaning) with action verbs, abstract verbs, and concrete object nouns. The visual stimulus presentation and response procedure were identical across tasks. High-resolution T1-weighted MRI scans were obtained in all patients for lesion mapping. VLSM analyses used action verb accuracy as the dependent variable, with either object noun accuracy or abstract verb accuracy as covariates to suppress lesion-deficit correlations associated with non-specific deficits, such as attention, working memory, reading, or response selection impairments. Object noun accuracy provides controls for these non-specific deficits and for impairments related to retrieval of word meaning in general, allowing a specific focus on retrieval of verb concepts. Abstract verb accuracy provides controls for these non-specific deficits and for any impairment specific to the grammatical class of verbs, allowing a specific focus on retrieval of action verb concepts. RESULTS: Accuracy on the action verb (79%) and abstract verb (78%) tests did not differ ($p = .295$); both were worse ($p < .0001$) than accuracy on the object noun test (91%). Performances were moderately to highly correlated between tests (all $p < .0001$): action verb vs. abstract verb, $r = .83$; action verb vs. object noun, $r = .65$. With inclusion of object noun accuracy as a covariate of no interest, action verb deficits were associated with lesions in a large suprasylvian frontoparietal region including the pre- and postcentral gyri,

posterior inferior frontal gyrus (IFG), frontal operculum, insula, and anterior supramarginal gyrus. With inclusion of abstract verb accuracy as a covariate of no interest, action verb deficits were associated with a more restricted frontal suprasylvian region including the precentral gyrus, posterior IFG, frontal operculum, and adjacent mid-insula. CONCLUSION: Selective action verb processing deficits are associated with lesions of the precentral gyrus (premotor cortex), posterior IFG (pars opercularis and triangularis), and frontal operculum. These data provide compelling evidence of a necessary role for intact motor planning systems in action verb concept retrieval.

B19 Neuroplasticity of language in left-hemisphere stroke: evidence linking subsecond electrophysiology and structural connectivity

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Language function is often impaired following stroke to the left hemisphere, compromising quality of everyday life. Our current understanding of functional compensation is predominantly based on haemodynamic brain measures. With these measures, functional compensation by the unaffected right hemisphere has been observed in language recovery. Yet, language processing occurs in the subsecond time scale and language neuroplasticity must also be addressed by electrophysiological measures that track the time course of language function. We combined for the first time behavioral, electrophysiological, and structural-connectivity measures to characterize neuroplasticity underlying successful compensation of language abilities after left-hemispheric stroke. We recorded the electroencephalogram from six patients with stroke lesions to the left temporal lobe and matched controls during context-driven word retrieval, a key aspect of language production. Participants heard context sentences that either constrained the final word (e.g., "He locked the door with the [picture: key]") or not (e.g., "She walked in here with the [picture: key]"). The last word (e.g., key) was shown as a picture that participants had to name. We conducted individual-participant analyses. For the EEG, we focused on oscillatory power as a subsecond indicator of a brain region's functional neurophysiological computations. We also investigated the relationship between white-matter integrity and hemispheric lateralization using the patients' white-matter disconnection maps. Behaviorally, participants named pictures faster following constrained relative to unconstrained contexts. This effect was robust in all ($ps < .001$) but two patients ($ps > .086$), who had extensive damage to the left temporal and inferior parietal lobes. For the EEG, replicating prior findings, left-lateralized alpha-beta oscillatory power decreased in controls prior to picture presentation for constrained relative to unconstrained contexts ($p < .001$). In the patient group, the alpha-beta power decreases had the same time course and spectrum as in controls, but showed a striking lateralization to the intact right hemisphere ($p < .001$). Individual source localization analyses confirmed that the alpha-beta power decreases were predominantly right-lateralized in three patients. Given that posterior callosal fibers (i.e., splenium) directly connect left and right temporal lobes, we examined the relationship between hemispheric lateralization and splenium integrity. The patients' hemispheric lateralization depended on the integrity of the splenium (Spearman's rho = .942, $p = .017$). Finally, electrophysiological compensation enabled the behavioral compensation of language production, as only the patients without alpha-beta power decreases performed poorly behaviorally ($p = .033$). We provide novel evidence that intact interhemispheric white-matter connections enable the right hemisphere to compensate for impaired left-hemispheric language functions through similar neurophysiological computations. Our findings suggest that incorporating well-understood direct measures of neural activity into investigations of neuroplasticity can provide important neural markers to help predict language recovery, assess the progress of neurorehabilitation, and delineate targets for therapeutic neuromodulation.

B20 Cathodal tDCS of the bilateral anterior temporal lobe facilitates semantically-driven word retrieval

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Verbal fluency (VF) tasks involve generating words from a semantic category (e.g., animals) or words beginning with a given letter (e.g. the letter 'F') within a specified time. VF engages a number of cognitive processes, including "clustering" (i.e., successive production of related items from a particular semantic or phonological neighborhood) and "switching" (i.e., flexibly disengaging from an exhausted cluster to another). These cluster-switch functions appear to have dissociable neuroanatomical substrates. For example, a reduction in depth and breadth of category exemplars produced during semantic fluency in particular is an established neuropsychological marker of semantic impairments associated with temporal lobe pathologies. However, there is an ongoing debate regarding the role of anterior and posterior subregions of the temporal lobes in such tasks. Specifically, anterior regions are associated with semantic knowledge representation. A similar role has been suggested for posterior temporal and parietal regions, but an alternative hypothesis is that they subserve processes that act upon such content including controlled retrieval. Here we examined the effects of altering cortical excitability of the anterior temporal lobe (ATL) versus the temporoparietal junction (TPJ) on performance in verbal fluency tasks. We hypothesized that the modulation of semantic representational substrates would impact semantic fluency, specifically the number of words and the depth of clusters generated. In contrast, modulating regions supporting control would impact switching behavior in both fluency tasks. 12 neurotypical native English speakers took part in the study. Semantic and letter fluency was tested prior to and following 20 minutes of 2mA off-line bilateral cathodal tDCS. The study employed a fully counter-balanced repeated measures design including three sessions held on separate days, each with a different stimulation montage that targeted either the ATL, the TPJ or a dorsal frontal control region (via 10/20 probabilistic electrode placement). Effects of tDCS were evaluated using four performance measures; the total number of words

generated, the number of clusters generated, the number of words within clusters and the number of switches. In three measures (all but 'number of switches'), we observed enhanced performance in the semantic fluency task following anterior temporal stimulation. There was no effect of temporo-parietal or control site stimulation. This site-specific effect was also limited to the semantic fluency tasks, as no observable effects occurred in letter fluency performance. Modulation of cortical excitability of the bilateral anterior temporal cortex impacts semantic VF. This is consistent with a role of this region in the representation of semantic category structure. Enhanced performance following tDCS could plausibly reflect induced facilitation of associative semantic processing. We observed no indication that neuromodulation of the temporo-parietal cortex can influence VF in line with prior data that suggests these tasks primarily engage an anterior fronto-temporal network. Further, these findings suggest that cathodal tDCS applied to specifically target the bilateral rostral temporal cortices has potential as an adjuvant for speech language therapy directed at recovery or maintenance of lexico-semantic abilities in the context of neurological injury or disease.

B21 Category-specific verb deficits in Alzheimer's: Thematic structure effects in naming and sentence production with dynamic scenes

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Several studies have found category-specific semantic deficits in Alzheimer's disease (AD) (e.g., Silveri, Daniele, Giustolisi & Gainotti, 1991; Zannino, Perri, Carlesimo, Pasqualetti, & Caltagirone, 2002). However, the range of categories that might be selectively affected as well as the principles underlying the organization of semantic knowledge are still open questions—with most cases showing a classical superordinate living/nonliving dissociation (but see de Almeida, 1999; Laws et al., 2007). Thus far, relatively few studies have investigated verb semantic deficits in Alzheimer's, many of which differ considerably both in terms of verb classes investigated and methods employed. For instance, Kim and Thompson (2004) found that pAD patients had more difficulty naming and producing two-argument verbs (catch) than one-argument verbs (snore). However, this argument structure effect was not consistent, as patients had less difficulty with three-argument verbs (give) than with two-argument verbs. In their study, pAD patients also showed marked difficulty with verbs packing more semantic features, suggesting that verbs are represented in a decompositional form, akin to semantic templates or definitions. Other studies have found that pAD patients have greater difficulty with verbs that assign the Experiencer role--psychological verbs such as fear and frighten, in particular when the Experiencer role is assigned to the argument in the object position (Manouilidou, de Almeida, Schwartz, & Nair, 2009). In the present study, we investigated how different syntactic and semantic classes of verbs might be affected in individuals with pAD. We varied verb classes along three dimensions: argument structure (number of arguments), thematic roles (the roles assigned to the arguments) and internal semantic properties of verbs--so called semantic templates (Jackendoff, 1990; Levin & Rappaport-Hovav, 2005). Verbs belonging to the class of lexical causatives (peel), which is hypothesized to be semantically complex (multiple internal predicates: [x CAUSE [y BECOME <peeled>]]) and structurally complex (two arguments) were contrasted with verbs of perception (hear), which are structurally complex (two arguments) but semantically simplex (one predicate: [x PERCEIVE y]), and with verbs of motion (walk) which are semantically and structurally simplex ([x MOVE]; one argument). These verbs also differ with regards to thematic roles assigned to arguments, with perception verbs having the least canonical thematic structure because they lack an Agent role (de Almeida & Manouilidou, 2015). Probable AD patients (N=13) and healthy controls (N=18) named events and states depicted in short video clips. In addition, they generated sentences related to the depicted events and states. Results indicate a category-specific deficit along two dimensions of verb knowledge: argument structure and thematic roles. Probable AD individuals show greater impairment for naming perception verbs, which arguably assign the Experiencer role to the subject position. In addition, patients show greater difficulty generating sentences for verbs classes with complex argument structures--causatives and perception, in contrast to movement verbs. We suggest that verbs are affected selectively in AD due argument structure and thematic assignment, not semantic-template complexity. Moreover, we suggest that verb meaning is represented in the brain by their argument structures together with their typical roles--not by semantic templates containing covert predicates.

B22 Semantic memory performance following left vs. right anterior temporal lobe resection

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Introduction Surgical resection of the anterior temporal lobes (ATL) is a well-recognised treatment for medically intractable temporal lobe epilepsy (TLE). Problems with episodic memory are often reported following surgery; with material specific memory impairments associated with the side of surgery (i.e., verbal memory is often more impaired following left ATL resection and non-verbal memory after right sided resection). ATL resection also produces mild semantic memory impairments; which follows from convergent evidence implicating the ATLs in the representation of multimodal semantic knowledge. The functions of left vs. right ATL in semantic memory is now becoming an area of intense debate and differences in left vs. right ATL resection on semantic memory have been reported. However, these reports are often in the context of single case-studies or small group comparisons; the aim of the present study, therefore, was to conduct a large scale case-series to explore the effects of left vs. right ATL resection on semantic memory. Method A neuropsychological battery to test semantic memory was developed. Based on predictions from the literature, tests were included which show relatively greater impairments following left ATL resection (e.g., picture naming, lexical decision), or right ATL resection (e.g., famous face recognition, emotion

recognition). The battery also included tests of episodic memory and general cognitive function. Measures of accuracy and reaction time were collected for all tests. Here we report the data from 20 left TLE and 20 right TLE patients. Data were compared to 20 age and education matched control participants. Results Our results replicated previous findings by showing that left TLE patients had decreased accuracy on both the Specific Item Picture Naming and Famous Face Naming tasks, compared to right TLE patients and controls. However, both the left and right TLE groups showed increased reaction times compared to controls. The results from the "right-lateralised" tests (e.g., face recognition, emotion recognition) failed to replicate a selective decrease in accuracy for the right TLE patients. Instead, both the left and right TLE patients showed an equivalent decrease in accuracy compared to controls. Again, reaction times in both patient groups were increased compared to controls. Conclusion This study replicated previous findings by showing a mild semantic impairment in TLE patients who had undergone ATL resection. Predictions of specialisation in left vs. right ATL functions were not fully supported by the current study. Our data replicated well reported findings of a more pronounced anomia following left ATL resection, although both TLE groups were slower to respond compared to control participants. However, on tests predicted to be right ATL lateralised, both TLE groups showed decreased accuracy. These results support a bilateral view of ATL function in semantic knowledge, whereby both ATLs are important for normal semantic function. The advantage of a bilateral system is that unilateral damage, either by atrophy or surgical resection, can be accommodated by the remaining ATL. However, gradations within this bilateral system are possible whereby one ATL becomes relatively specialised for some functions; these relative specialisations may be driven by differential patterns of connectivity.

B23 Integration of verbal object descriptions recruits ventral stream including perirhinal cortex

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Humans make inferences about objects in our surroundings without conscious effort. For example, a half-chewed shoe and muddy paw prints may immediately give away the neighbour's dog and his visit to your house. However, the neural bases of such process where indirect information is used to deduce object identity are not well-understood. Research on visual objects has implicated the ventral stream and particularly its anterior apex, the perirhinal cortex (PRC), in integrating perceptual and semantic features into a conceptual representation. However, it is not known to what extent the same system is involved in integrating non-pictorial semantic input. Here, we set out to identify brain regions that are involved in integrating verbal object descriptions into conceptual representations. The target concepts were never directly presented to the participants, but hinted using verbal cues, thus allowing us to optimally tap feature integration. Moreover, this method allowed us to test whether it is possible to identify neural activation patterns associated with unpresented target concepts. We used functional magnetic resonance imaging (fMRI) and multivariate pattern analysis. The sample consisted of 17 healthy participants (mean age=21.2y; SD=3.4y; 10 females). The participants performed a behavioral task in a Siemens 3T Skyra Magnetom MRI scanner in two sessions. In the task inspired by a childhood guessing game, the participants were presented with three features (i.e. cues) of an object (e.g. 'is small, 'does turn', 'does open locks') and asked to overtly guess the concept they describe (i.e. key). The cues were derived from the CSLB property norm set. In order to map the target concepts' features with neural activation patterns, we used an independent feature set which was a 1.5 billion-token Finnish Internet-derived text corpus by Kanerva and Ginter. Representational similarity analysis (RSA) was used to determine brain regions where the similarity of activation patterns for each item correlated with the similarity of the semantic representations of the same items. A zero-shot learning algorithm was used to test whether it is possible to identify individual target concepts based on their activation patterns in a two-fold cross-validation approach. RSA revealed that activation in the middle and anterior extent of the bilateral ventral stream was related to the semantic structure of the unpresented target concepts. This activation extended to the bilateral PRC consistent with this region's role in the integration of object-features. Other associated regions were bilateral temporo-parieto-occipital junction, retrosplenial cortices, sections of the dorsolateral and orbitofrontal cortices as well as the left angular gyrus. The classification accuracy of individual items based on the respective activation patterns was significantly above chance level in all participants (mean accuracy=82.2%, SD=6.6%). The guessing game paradigm is a naturalistic task which is both easy and engaging for the participants to perform. The present results provide evidence for the role of the ventral temporal cortex in integrating perceptual and semantic information about objects even in the absence of pictorial information. Moreover, these results demonstrate that it is possible to identify neural activation patterns of target concepts whose identity is merely indirectly hinted using cues.

B24 Alpha power reflects prediction differences in learning of nouns and verbs

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Introduction: Academic success is contingent upon the ability to learn new words. Prediction, or the expectation of upcoming information, aids the word learning process because the continual stream of semantic information integrated during sentence processing can be used in an anticipatory manner to determine the most likely meaning of a novel word even before it is encountered (Federmeier, 2007). Studies investigating changes in oscillatory dynamics have identified alpha power changes as having a role in prediction (Bidet-Caulet et al., 2012), but have yet to investigate the role of predictive alpha in word learning. Additionally, studies have investigated semantic retrieval and integration during sentence processing (Schneider et al., 2016), but have yet to determine the role of prediction in semantic retrieval of novel words. The current study addresses this gap in the literature by using electroencephalography (EEG) to investigate how changes in oscillatory dynamics reflect prediction differences in semantic retrieval of nouns and verbs during word learning. Methods: Thirty-eight right-

handed, monolingual, English-speaking adults, ages 18-31 years (10 male; Mage=23.6, SD=4.7) completed a word learning task by reading sentence triplets that replaced the final word with a nonsense word. For the sentence triplets included in this analysis, average cloze probability (CP) increased across the triplet (MCP=4.08%, 41.15%, 81.03%, respectively). Following each triplet participants responded if they thought the nonsense word represented a real word, and if so, what that real word was. Only low CP (i.e. Her parents bought her a pav) and high CP (i.e. The girl goes to sleep in her pav) sentences, correctly responded to, were included in this analysis. Analysis: EEG data were cleaned and epoched using Neuroscan. Throughout the epoch, data were Fourier transformed, magnitude squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline (Delorme & Makeig, 2004). Within EEGLAB, random permutation statistical analysis of the EEG data was performed and p-values for both the time and frequency points for each comparison of interest were computed. Results: During prediction (-200-0 msec), alpha power decreased before the nonsense word onset for verb targets, regardless of CP. During word learning (300-500 msec), theta power increased from low to high CP sentences, regardless of word class; however, nouns demonstrated more widespread theta increases than verbs. Discussion: We interpret predictive changes in alpha as relating to differences in the attentional demands required to anticipate an upcoming novel word. Specifically, verbs require greater attention during prediction than nouns, even while controlling for CP. An increase in theta during word learning for high constraining sentences suggests that this supportive context assists in semantic retrieval and integration of the novel word. Additionally, nouns exhibited greater semantic retrieval and integration than verbs, although this finding was not as robust. These findings establish a necessary standard for understanding the mechanisms required for successful word learning.

B25 Adaptive plasticity in the semantic network: Evidence from combined theta-burst stimulation and functional neuroimaging

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Rapid analysis of the meaning of sound patterns (i.e., semantic processing) is crucial for efficient every-day communication in humans. Previous studies in healthy volunteers have identified the left angular gyrus (AG) and anterior inferior frontal gyrus (aIFG) as key nodes for semantic processing (e.g. Binder et al., 2009; Devlin et al., 2003). However, it remains elusive how the semantic network reorganizes after perturbation to one of these areas. We combined inhibitory continuous theta-burst stimulation (cTBS) with functional MRI in healthy volunteers to investigate short-term plasticity after transient disruption of AG. We expected that cTBS should inhibit task-related activity at the stimulated left AG, which might in turn result in an up-regulation of other important semantic areas or neighboring networks. 15 native healthy right-handed native German speakers received effective or sham cTBS (600 stimuli at 50 Hz for 40 s) over either AG or neighbouring supramarginal gyrus (SMG, control site) in three separate sessions prior to neuroimaging. Subsequently, subjects performed semantic and phonological (control task) decisions during fMRI. The disruptive effects of cTBS over AG were assessed by the comparison of semantic decisions after cTBS over AG vs. cTBS over SMG or sham cTBS ($p<0.05$ FWE corrected, flexible factorial design in SPM12). Additionally, cTBS-induced changes in the effective connectivity in the semantic network were assessed with dynamic causal modelling. We observed a strong task-specific suppression of neural activity during semantic decisions in a large network of semantic regions (including left AG, middle temporal gyrus and aIFG) after cTBS of AG relative to sham cTBS or cTBS of SMG, but no significant disruption of the mean semantic response speed. In turn, cTBS over AG resulted in a strong compensatory upregulation of the neighbouring phonological network (i.e., SMG and posterior IFG) during semantic decisions that might have helped to maintain task processing. Effective connectivity analyses unravelled the neural mechanism of the disruptive network effect of AG cTBS, demonstrating that after cTBS, AG increased its inhibitory influence on aIFG. Critically, individual semantic response speed was delayed as the inhibitory drive of AG on aIFG increased (correlation analysis, $R2= 0.63$, $p= 0.001$, two-tailed). Our results demonstrate for the first time that temporary perturbation of a key node within the semantic network can induce strong inhibitory modulation on the network level. Moreover, the observed upregulation of phonological areas during the semantic task might indicate some degree of compensation for the perturbation of the semantic network. These effects might represent a generic mechanism for semantic processing on the network level and might inform future models of neural reorganization in the semantic network. References: Binder J.R., Desai R.H., Graves W.W., et al. (2009). Where is the semantic system? A critical review and meta-analysis of 120 functional neuroimaging studies. Cereb Cortex 19, 2767-2796. Devlin J.T., Matthews P.M., Rushworth M.F. (2003). Semantic processing in the left inferior prefrontal cortex: a combined functional magnetic resonance imaging and transcranial magnetic stimulation study. J Cogn Neurosci 15, 71-84.

B26 Explicit retrieval of visual and non-visual properties of concrete entities: Differential involvement of superior temporal sulcus and anterior inferior frontal gyrus

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INTRODUCTION: The representation and the processing of a concept require the activation of a distributed neural system. According to neuropsychological dissociation studies, critical dimensions for the organization of the semantic system are category-specificity (e.g. animate versus inanimate), attribute-specificity (e.g. visual versus nonvisual) and input-modality specificity (e.g. written words versus pictures). Within a same event-related fMRI experiment we determined the effect of each of these dimensions upon brain activity patterns during explicit semantic retrieval. METHODS: 18 healthy subjects participated in this event-related fMRI study. 12 animate (subcategories: mammals, birds, insects) and 12

inanimate entities (subcategories: kitchen tools, clothes, music instruments) from De Deyne et al., 2008, were used. In a prior behavioral experiment, the concept-feature matrix was used to select properties that were distinctly visual and non-visual. Using this matrix as a starting point, 52 properties for each subcategory were evaluated on-line by 11 healthy young volunteers. They were asked to judge the degree to which a property is visual or non-visual on a 1 to 7 rating scale. Next, we selected for each subcategory 4 visual (< 2.6 rating scale) and 4 non-visual (> 5.5 rating scale) properties described in De Deyne at al., 2008. The factorial factors in the event-related fMRI experiment were (1) category (animate versus inanimate), (2) attribute (visual versus non-visual) and (3) input-modality (written word versus picture). The experiment consists of 8 runs. Each run was composed of 60 trials, which lasted 8500ms each. A Philips Achieva dstream 3T equipped with a 32-channel head volume coil provided functional and structural images. During fMRI subjects performed a property verification task in which they were asked to judge whether a given property was applicable to a given entity. Using the General Linear Model, the following contrasts were calculated: Retrieval of visual versus non-visual properties, animate versus inanimate entities and written words versus pictures. Significance level: uncorrected $p<0.001$ combined with a cluster-level corrected $p<0.05$. RESULTS: The 3-way repeated measures ANOVA with reaction times as outcome, showed a main effect of input-modality ($F(1,15)=31.9$; $p=.000$) and property ($F(1,15)=17.60$; $p=.001$). The accuracy of responses was: 70.8%. Retrieval of non-visual compared to visual properties activated the superior temporal sulcus along its posterior-anterior axis, up to the anterior temporal pole (x=-45 y=14 z=-32) as well as the anterior inferior frontal gyrus (x=-45 y=32 z=-2). The anterior temporal and inferior frontal activation was bilateral. The superior frontal gyrus and the posterior cingulate were also more active during retrieval of non-visual compared to visual attributes. The retrieval of visual compared to non-visual properties activated the left fusiform gyrus, left and right lateral occipital cortex, the intraparietal sulcus bilaterally and the left ventromedial occipitotemporal cortex. The contrast between animate and inanimate entities yielded activations of lateral and medial fusiform gyrus respectively. CONCLUSIONS: Properties of concepts are a determinant factor in the representation and processing of concept. While explicit retrieval of visual properties mainly relies on visual processing areas, the anterior temporal pole and anterior inferior frontal gyrus appear to be preferentially involved in retrieval of non-visual properties.

Language Development

B27 Structural brain deficits in Chinese children with English reading impairment

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Introduction: Many people experience particular difficulty in learning English as a second language, especially in reading. They read slowly and have a low reading accuracy. Behavioral studies suggest that low second language reading ability may be caused by first language reading impairment(Downey, Snyder, & Hill, 2000). However, there are still lots of people having a normal first language reading level but an impaired second language reading ability. Previous studies have focused on reading disorder in first language, and a few studies addressed the structural brain deficits of second language reading impairment(You et al., 2011). Here we explored, for the first time, the structural brain deficit of Chinese children suffering English reading impairment. Methods: Two experiments were conducted. The first one is to explore how the brain structurally changed in Chinese children with English reading impairment. We compared the brain structure of two groups. One group (impaired group) includes 17 children with English reading impairment (IR, 11 boys/6 girls, mean age=10 years and 8 month) and the other (control group) includes 17 with age and IQ matched Control readers (CR, 8 boys/9 girls, mean age=10 years and 8 month). In the second experiment, we further explored whether these brain regions showing significant group difference truly contribute to the ability of English reading. We chosed another group with 43 normal English readers (NR, 20boys/23girls, mean age=10 years and 4 month). Regions of interest (ROIs) were defined by experiment 1, and the mean gray matter volume (GMV) of ROI were extracted. Then Pearson correlation analyses were conducted between the GMV of the ROIs and reading ability. Results: In Experiment 1, we found that only one region, the left posterior fusiform gyrus, shows decreased GMV in impaired groups compared to control group. Several regions, including the right inferior frontal gyrus, the left middle temple gyrus, the left cingulate gyrus, and the left parahippocampal gyrus, show increased GMV in impaired groups than control group. In Experiment 2, we found only the GMV in parahippocampal gyrus and fusiform gyrus negatively correlated with English reading ability. The less the GMV in the two regions are, the better the reading performance will be. Combined the findings from two experiments, we suggest that the greater GMV in the left parahippocampal gyrus may have a negative effect on IR reading ability, the less GMV in the left fusiform gyrus may have a positive effect on their reading ability, and the other three regions may not directly contribute to English reading ability. Conclusion: The English reading difficulty in Chinese children may be due to the structural alteration of the left parahippocampal gyrus. The impaired readers showed greater GMV in this region, and the GMV of this region negatively correlated with reading ability in normal readers. We also found decreased GMV in the left fusiform gyrus. However, this region may not be the core structural deficit in impaired children, since less GMV in left fusiform gyrus will actually benefit the reading performance in normal readers.

B28 Using brain rhythms to improve behavioral predictors of reading

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Predicting reading development is a crucial step towards designing timely interventions to prevent life-long consequences of reading difficulties. In the current literature, there's general agreement on three behavioral predictors of reading development, irrespective of the language of study: phonological awareness, letter knowledge and rapid automatized naming (RAN). However, these combined

measures account for up to 60 percent of the variance and have a false alarm rate of at least 10 percent , which potentially results in superfluous interventions that are undesirable in terms of both human and economic resources. Although in recent years new theories into the underlying mechanisms of reading difficulties have been put forward, these have not make its way into the behavioral assessment of reading development. The main claim of these theories is that the precision in the entrainment of oscillatory neural activity to external rhythmic stimuli, such as speech or words, underlies the distinctiveness of phonological representations at the auditory level, and the precise shifting of attention necessary for reading at the visual level. In the present study we aimed at improving the predictive validity of behavioral measures by including novel tasks that tap into evaluating the precision of synchronization in auditory and visual oscillatory activity. The behavioral assessment included: phonological awareness, letter knowledge, RAN, tapping to a beat, dichotic listening, visual entrainment, verbal and non-verbal short-term memory, receptive vocabulary, IQ and reading (decoding). The sample was composed of ~700 Spanish-speaking 5 y.o. prereaders attending kindergarten who were assessed at their schools in 3 sessions distributed in two successive weeks; the overall data collection was completed over a 2 month period. In order to accomplish such a large-scale assessment in a brief time course, a digital screening tool implemented in tablets in a game-like manner was developed. These data collection entails the first phase of a longitudinal study to be completed by the end of 2017. The results at this phase suggest that precision of entrainment to external rhythmic stimuli, behaviorally measured, can explain some of the variance found in phonological awareness tasks, underscoring its role in the specification of phonological representations and in the rapid allocation of attention that underlie reading performance. Furthermore, the results show that neural entrainment can be indirectly measured through behavioral tasks easily implemented in an educational environment, which can lead to improved prediction of early reading difficulties.

B29 Rule Learning is Modulated by Temporal Attention in Childhood

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Speech is a sequence of sounds that unfolds in time.. Orienting of attentional resources to speech in the temporal domain seems necessary to predict forthcoming information. In this vein, many language rules require keeping track of predictive information while ignoring intervening elements (i.e., is reading, has played). This study investigated the involvement of temporal orienting of attention in language rule learning in children. In order to do so, we tested children of three different ages; 4-5 years (n=25), 6-7 years (n=28), 8-9 years (n=26) and a group of adults (n=25). All participants performed a temporal attention task and a language rule-learning task. In the temporal orienting paradigm, participants performed a detection task, in which they had to press a button after a target appeared. The target was preceded by a temporal cue that indicated the onset time of target presentation (i.e., short or long time interval). The task contained trials matching or mismatching the target appearance (early/late) based on the (short/long) cued interval. In the language-learning task, participants were auditory exposed to an artificial language with two non-adjacent rules (e.g. tis badi gor; nal duse bun) during a short period of time (5min). After this period, participants were tested with grammatical (belonging to the previously-exposed language) and ungrammatical (violating the rule of the previously-exposed language) utterances. Participants were asked to indicate whether the stimuli belonged to the previously-exposed language. Results showed significant differences in language performance between groups. The two younger groups (4-5 and 6-7 years) did not discriminate between grammatical and ungrammatical utterances at test. In contrast, the two older groups (7-8 years and adults) discriminated between them. For the correlational analysis we used spearman's rho to correlate rule-learning performance (dprime) with temporal orienting of attention (reaction time until button press after target detection). Dprime was significantly correlated with reaction time for the older group of children both in the orienting of attention in valid trials ($r=-496$, $p < 0.01$) and invalid trials ($r=-508$, $p < 0.01$). No other attention measure was significantly correlated with rule-learning performance. Importantly, no other group showed a significant association between rule learning and attentional scores. These results reveal that, when able to learn the rules (only the older group of children), participants with better performance in temporal attention performed better in the rule-learning task. These findings suggest that flexibility of temporal orienting of attention modulate language rule learning during childhood. This study has implications for our understanding of cognitive processes underlying language learning, offering an integrative approach to explore the role of attention in language development.

B30 Morphological Processing in Chinese-Speaking Children: An Event-Related Potential Study.

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Morphological awareness has been suggested to play a significant role in reading development, and support various skills such as vocabulary and text comprehension. However, evidence on how morphological information is processed in Chinese is limited and has been constrained to behavioural tasks in children with reading difficulties (e.g. Chen et al., 2009; Tong et al., 2009). Using event-related potential (ERP) technique, this study examined whether typically developing children are sensitive to the processing of morphemes during lexical-semantic processing. Children were administered a standardized reading test (Hong Kong Graded Character Naming Test, Leung, Lai & Kwan, 2008), and asked to decide whether a target character corresponds to a syllable in the preceding spoken word in a homophone verification task. The auditorially-presented word and target character pairs varied in congruency (match vs. mismatch) and orthographic similarity (orthographically similar vs. dissimilar to the target character) factorially. Significant orthographic effects were found behaviorally, whereby children responded faster and more accurately to characters paired with visually dissimilar targets, suggesting that they needed more time and were more error prone to reject the target character amongst visually similar competitors. Electrophysiological results at the

N400 component showed a left lateralization effect, and that characters paired with mismatched morphemes elicited a more negative N400 than matched morphemes. Character reading ability was also positively correlated with the amplitude of the N400 morpheme congruency effect in the central region. Importantly, the N400 component is sensitive to morphological processing in children, as more effortful N400 activation was required to inhibit the unrelated target morphemes during lexical-semantic retrieval. Moreover, the findings suggest the potential of applying the homophone verification paradigm, given its additional sensitivity to reading ability, to study morphological processing in less skilled and poor readers.

Grammar: Morphology

B31 A quantitative account of the temporal dynamics of reading morphologically complex words

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Neuroimaging studies of the reading process point to functionally distinct stages in word recognition. Yet, the current understanding of the operations linked to each of the stages is mainly descriptive in nature and computationally vague. Approaches developed in the field of computational linguistics for modeling natural language (NLP) may offer a more quantitative approach for understanding brain dynamics. In the present study, we focus on visual recognition of morphologically complex Finnish words. Our aim was to evaluate whether an NLP-based model of morphology, with well-defined computational principles, can capture the neural dynamics of a given process. The Morfessor model (Creutz and Lagus, 2007), created for unsupervised discovery of morphemes, is based on the minimum description length principle and attempts to find optimal units of representation for complex words (i.e., create a compact and descriptive lexicon of morphs) from a large language corpus in an unsupervised manner. The strength of neural activation may reflect the cost related to processing of a word. In probabilistic language models like Morfessor, the cost can be quantified by self-information. Thus, the model offers a quantitative measure that may be linked to brain activation. In comparison with the Morfessor self-information, we used two common psycholinguistic variables: word length and whole-word frequency. We investigated, using linear regression analyses, how these measures predict brain response strengths recorded with magnetoencephalography (MEG) from 20 healthy participants during a lexical decision task. The neural activation was quantified on the source level for single words, by averaging the activation evoked by each word across participants for four cortical response types that showed temporally, spatially and functionally distinct brain activity during reading (Salmelin, 2007). The temporally detailed MEG results indicated that the different stages of reading are differentially sensitive to the measures studied. Evoked activity in the occipital cortex around 100 ms after word onset was accounted for by word length (R2=0.07), indicating visual feature analysis. Response in the left occipito-temporal area around 150 ms was sensitive to length (R2 = 0.018) and Morfessor cost (R2=0.014). The activation in the temporal cortices around 400 ms was described, in the left hemisphere, by whole-word frequency (R2=0.14) and Morfessor (R2=0.125) while the right-hemisphere response was sensitive to length (R2=0.07) and Morfessor (R2=0.08). For the lexical decision reaction times, Morfessor was the best overall predictor (R2=0.38), surpassing that of length (R2=0.30) and frequency (R2=0.30). All correlations were significant at $p<0.05$. Multiple regressions further indicated that Morfessor added unique predictive power beyond the length and frequency measures for reaction times and temporal-cortex responses. The results show that the word processing costs estimated by Morfessor are relevant for brain dynamics of reading. In sum, the study suggests that a computational model based on a statistical optimization principle can offer a novel way to analyze morphological learning and processing on the neural level.

B32 Morphological structure revealed by microsaccades

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INTRO: Microsaccades are miniature rapid eye movements that occur involuntarily during fixation. Microsaccades are typically inhibited following stimulus onset and are released from inhibition about 300ms post-stimulus (Betta & Turatto, 2006; Rolfs, Kliegl & Engbert, 2008). Microsaccade-inhibition is modulated by visual properties of stimuli, including stimulus contrast and spatial frequency (e.g., Bonneh, Adini & Polat, 2015). The aim of the current study was to assess the sensitivity of microsaccades to higher level linguistic properties, specifically, morphological structure of written words. Morphological decomposition of orthographic stimuli is widely supported by behavioral evidence in paradigms that rely on overt motor responses (i.e., button presses; see Amenta & Crepaldi, 2012 for review). Here, we tested whether the rate and latency of microsaccades are modulated by the presence of a real root morpheme within Hebrew pseudowords. METHODS: We presented participants with real Hebrew words and two types of pseudowords: Real-root pseudowords comprised real roots embedded within real patterns, while invented-root pseudowords comprised invented roots embedded within the same set of real patterns. Pseudoword conditions were carefully matched in their orthographic similarity to real words to avoid known confounds (Balota et al., 2004). Participants (N=16) were asked to maintain fixation and perform an overt word detection task on these stimuli, while their eye movements were recorded (Eyelink 1000 infrared system, SR Research, Ontario, Canada). Importantly, no overt responses were produced during pseudoword trials. Eye tracking data were sampled at 500Hz and analyzed offline using the algorithm introduced by Engbert & Kliegl (2003). Microsaccades and blinks were detected automatically, and their timing was compared between the real-root and invented-root pseudoword conditions. RESULTS: Microsaccade response time (msRT), defined as the latency of the first post-stimulus microsaccade relative to stimulus onset, was 26ms slower following real-root pseudowords, compared to invented-root pseudowords ($p < 0.0001$, nonparametric permutation test). Similar results were obtained for blinks: blinks following real-root pseudowords occurred on average 27ms later compared to invented-root pseudowords ($p < 0.0001$, nonparametric permutation test). Moreover, significant correlations were

found between msRT and measures of orthographic similarity to real words, such that microsaccade-delay increased with the similarity to real words. This correlation was specific to the invented root condition. A possible interpretation is that in the real root condition, msRT may be affected by properties of the root (e.g., root family size, valence, activation of related words). However, in the invented root condition, in the absence of root semantics, orthographic similarity to real words becomes the most prominent factor influencing msRT. CONCLUSION: Taken together, these findings demonstrate, for the first time, the sensitivity of microsaccades to linguistic structure. There are many advantages to using microsaccades as a behavioral measure in psycholinguistic experiments: they are involuntary, not subject to conscious control, and can be measured in the absence of overt response. Our results provide initial evidence that microsaccades can be used as a novel physiological measure in the study of psycholinguistic processes in healthy and clinical populations.

Grammar: Syntax

B33 A common neural hub resolves syntactic and non-syntactic conflict through cooperation with task-specific networks

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Every day, people face situations that require behavioral adjustments to resolve information-conflict. Such 'cognitive control' is important for a range of tasks. For example, during language processing, one important cognitive control function enables readers and listeners to revise temporary misinterpretations of sentence meaning.1 The conflict-control procedures that operate over syntactic material may be general-purpose, engaging the same mechanisms that detect and resolve information-conflict in other domains, including recognition memory (when similar conflict-resolution procedures facilitate target identification despite familiar-but-irrelevant memoranda).2 Alternatively, multiple conflict-control systems may independently support specific types of conflict processing. The findings are mixed: Some studies demonstrate co-localized brain activity for syntactic and non-syntactic cognitive control, suggesting domain-general processes, whereas others show non-overlapping activity.3,4 These discrepancies may lie in functional-anatomical assumptions: Prior research has focused on whether one region commonly engages to resolve conflict broadly, or whether separate brain areas distinctly support conflict-control functions depending on information content. Indeed, these assumptions resemble those in the neuroscience of language (e.g., whether syntactic processing is encapsulated from other cognitive systems and therefore recruits separate neurobiological mechanisms). We propose that such approaches create a false dichotomy: both domain-general and domain-specific neural machinery must coordinate to facilitate complex cognitive processes, including conflict resolution and language comprehension, because some task demands are shared whereas others are not. Using fMRI, we investigated broad and specific brain activation within individual subjects (n=28) who completed four cognitively demanding tasks: Stroop (response inhibition), Recent Probes (item recognition with interference), N-back-with-lures (memory updating with interference), and Syntactic Ambiguity Resolution (revising misinterpretations). Despite each having a condition requiring some form of conflict processing (versus a no-conflict condition), the tasks differed substantially in computational demands, goals, and stimulus characteristics. Furthermore, they have been well-established to tap VLPFC-supported conflict resolution.2,6 Thus, we tested left posterior ventro-lateral prefrontal cortex (VLPFC) as a candidate region for shared conflict resolution2,3,5, then examined functional interconnectivity between VLPFC and other regions depending on information content. We used Stroop, the canonical cognitive control measure, as a functional localizer and identified regions of interest within left VLPFC on a single-subject basis to preserve anatomical heterogeneity and functional specificity.7 Left VLPFC consistently engaged during conflict processing (memory updating: $p<0.001$; item recognition: $p=0.03$; syntactic ambiguity: $p<0.001$), suggesting a multifunctional neurobiological resource for cognitive control. The multiple-demand network, typically involved in cognitive demanding tasks8,9, showed no overlap, suggesting distinct processes for difficulty versus conflict. Moreover, psychophysiological interaction analyses revealed functionally connected networks of brain regions that co-engaged with VLPFC. Interestingly, VLPFC coordinated with disparate networks that hinged on task-specific demands. These results suggest that regions within left VLPFC may function as a domain-general "conflict-resolution hub" that cooperates with specialized neural systems according to information content, allowing for efficient re-characterization of information in language, memory, and other domains of complex cognition.

[1] Novick et al., 2005 [2] Jonides & Nee, 2006 [3] January et al., 2009 [4] Fedorenko et al., 2012. [5] Smith & Jonides, 1999 [6] Carter et al., 1995 [7] Derrfuss et al., 2009 [8] Duncan, 2010 [9] Fedorenko 2014.

B34 Expectation effects on the processing of syntactic structure

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Expectations affect language processing on multiple levels (Kuperberg & Jaeger, 2015). In order to generate expectations, a listener may rely on contextual information but also use language-specific regularities. In German, one such regularity is the prevalence of subject-initial structures compared to object-initial structures, which may lead listeners to expect a subject-initial structure for any upcoming sentence. We were interested in exploring the stability of these prevalence effects, which are consolidated over the years of language experience, by testing whether they can be adapted to a particular speaker. Thirty-two participants were presented with sentences which were spoken by two different speakers. Sentences had either a Subject-Object-Verb (SOV) structure or an Object-Subject-Verb (OSV) structure. Crucially, the two speakers differed with regards to the frequency by which they produced a particular syntactic structure. One of the speakers had a high probability to produce a SOV structure and a low probability to produce an OSV structure (SOV-speaker), and vice versa for the other

speaker (OSV-speaker). The association between speaker and structure was established in a prior training phase. Once this association had been established we hypothesized that speaker identity served as a cue for the upcoming syntactic structure and therefore allowed listeners to generate expectations. EEG was recorded while participants listened to the sentences. In the analysis, ERPs were time-locked to the onset of the first noun-phrase where the syntactic structure of the sentence became clear. The 2-by-2 design with the factors speaker and syntactic structure enabled to compare the processing of SOV- and OSV-structures, when either a SOV- or an OSV-structure was expected. Preliminary results showed a main effect of syntactic structure in an early (300-500 ms) and a late time-window (600-800 ms). In both time-windows OSV structures had a more positive ERP than SOV structures with a posterior scalp-distribution. Additionally, there was a significant interaction of speaker and syntactic structure in the late time-window. For sentences produced by the SOV-speaker (i.e. the speaker where a SOV structure was highly expected) a P600 effect was observed, meaning that the OSV structure elicited a more positive ERP than the SOV structure. Importantly, this P600 effect was diminished when the sentences were produced by the OSV-speaker (i.e. the speaker where an OSV structure was highly expected) due to a decreased positivity of the ERPs elicited by the OSV structure. These data demonstrate that a speaker's specific use of syntactic structures affects expectancy for a particular syntactic structure in the listener. These findings highlight the role of expectations in the processing of higher-order language information. The modulation was present in the P600 window, suggesting that expectations affect processes related to structural reanalysis (Friederici, 2011). Note however, that the effects of expectations seem to be restricted to the OSV structure. This may be due to the special role of the subject-initial structure as the canonical (i.e. most frequently used) sentence structure in everyday language use.

B35 Grammatical constraints on lexical and structural processing strategies: EMEG evidence from Russian morphosyntax

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The grammatical context that develops as a sentence is heard can place strong constraints on the lexical category of upcoming items (e.g., whether they are nouns or verbs) and potentially affect their processing strategies. In this experiment we examined the role and the timing of such constraints during the processing of derived/nominal and inflected/verbal forms. Inflections and derivations encode distinct types of grammatical and lexical information and are analysed via different processing strategies. Inflections carry structurally relevant grammatical information, accessed by decompositional and combinatorial processes that are strongly related to left fronto-temporal activity. Derivations carry primarily lexical information, do not require decomposition and are processed within bilateral temporal areas. Using spatiotemporally resolved combined electro- and magnetoencephalography we tested whether, and how early, the presence of grammatical constraints can activate a word's grammatical and lexical features, thereby inducing an inflectional or a derivational processing strategy. We recorded brain activity while subjects listened to Russian sentences with target words whose grammatical category (noun or verb) was either constrained or unconstrained by the preceding context. The nouns contained derivational suffixes, while the verbs contained inflectional suffixes. Importantly, the noun and verb forms were produced from the same stem, so that in the unconstrained condition the target's morphological form and grammatical category were ambiguous until the onset of the suffix, while in the constrained condition they were predictable from the context. For example, the stem 'rabot-' can take an inflectional suffix to become a verb 'rabot-ayet'/'works' or a derivational suffix to become a noun 'rabot-nik'/'worker'. In 'Misha starij rabotnik'/ 'Michael is an old worker ' the stem 'rabot-' is constrained by the preceding adjective 'starij'/'old' to be a noun ('-nik' suffix) while in ''Misha chasto rabot-ayet' / 'Michael often works', the adverb 'chasto' requires 'rabot-' to take the verbal form ('ayet' suffix). These contrast with unconstrained contexts such as 'Misha rabot-nik na zavode'/'Misha (is a) worker at the factory', where the lexical and structural role of the stem 'rabot-' is ambiguous until the affix is heard. We hypothesised that in the constrained conditions listeners would predict the morphological form of the target word before the disambiguating suffix onset, thereby leading to different word-internal (inflection- or derivation-related) processing strategies. The univariate and multivariate results are consistent with these predictions. Processes related to inflectional/verbal and derivational/nominal processes change as a function of preceding grammatical constraints. These effects are strongest for inflected/verbal forms. When these forms ('rabotayet') are unconstrained by the preceding context they produce distinctive left fronto-temporal activity, with LIFG engagement peaking after the suffix onset. This result is in line with previous findings, suggesting decompositional processing of inflected forms. In constrained contexts, however, inflections are processed earlier in the middle and anterior temporal areas, with no subsequent LIFG involvement. Derivational/nominal processing was less affected by these constraints and generally showed effects in the temporal areas after the suffix onset. This suggests that contextual predictability induced by grammatical constraints facilitates lexical analysis of complex words and potentially reduces associated decompositional demands related to the LIFG function.

B36 Plausibility and Agreement Effects of Adjectives on Noun-Noun Compounds in Icelandic: An ERP Study

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Previous work has indicated that, in sentential contexts, compounds show agreement effects in Icelandic (Whelpton et al., 2014), and plausibility effects in English (Staub et al., 2007). However, the interaction of these two effects remains unclear. The current study examines the interaction of agreement and plausibility effects on the processing of nominal compounds that were preceded by an adjective. Using an auditory ERP paradigm, we presented sentences that varied (i) the agreement (gender match vs. gender mismatch) between the adjective and first constituent (C1) of the compound and (ii) the plausibility of the adjective as a modifier for C1 (plausible vs. implausible). All adjectives agreed in gender with the second constituent (C2) and were thus grammatical sentences. The crucial comparison for the plausibility condition

was between "lumpy cream bottle" where "lumpy cream" is plausible, and "empty cream bottle", where "empty cream" is implausible. Methods: 51 Icelandic speakers heard 70 experimental sentences, with 140 fillers. Visually-presented yes/no comprehension questions followed each sentence. ERPs were recorded with a 32 electrode-cap using a 256Hz sampling rate, .01-40Hz filter, with mastoids as reference. Results at offset of C1: In the 300-650ms window, an ANOVA revealed an interaction of plausibility and anteriority, as well as a main effect of plausibility. Within the anterior region, we found an interaction of plausibility and agreement. In the anterior region, the implausible condition elicited an N400. Results at offset of C2: In the 250-550ms window, ANOVA revealed an interaction of agreement and laterality. Within the left hemisphere, there was an interaction of plausibility and agreement, and a main effect of agreement. Additionally, there was a main effect of plausibility within the agree condition, in which the implausible condition elicited an early N400. Conclusion: Semantic implausibility of an adjective-noun combination incurs a processing cost, even in cases where grammatical gender agreement cues indicate that the noun cannot be the end of the phrase. From this study we infer that, when hearing a sentence, people assess the semantic plausibility of the phrase presented regardless of gender cues. When the parser then encounters C2, though all sentences at that point are grammatical and semantically licit, it is only the condition where C1 was implausible but agreed in gender with the adjective where higher processing costs were observed. We propose that the implausibility of an adjective-noun pairing at C1 will have a processing cost at both C1 and C2, but that information from gender agreement cues, while mitigating processing difficulties, is only able to lower the costs associated with implausibility on C2. These findings are in line with theories of minimal attachment, as it is only in the condition where C1 and the adjective agreed that the parser needed to later repair the implausibility. That is, the parser committed to the implausible interpretation based on syntactic cues that it was possible, and failed to commit when those cues indicated that the phrase was unfinished.

Language Disorders

B37 Meta-analysis of mismatch negativity (MMN) studies on specific language impairment (SLI)

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Children with SLI have various cognitive difficulties, and many of them are not specific to language. Studies on neurocognitive markers of SLI have found several differences between children with SLI and children with typical language development (TD), but findings are inconclusive and difficult to replicate. One of the most used index of neurocognitive auditory perception is MMN, which has been applied in SLI research with various stimulus materials and paradigms. We reviewed all the research reports in which MMN was used to study SLI, published in international peer-reviewed scientific journals. We performed a meta-analysis where we included all studies, which reported their MMN amplitudes and standard deviations for both control and clinical groups. The effect of the most relevant experimental parameters were analyzed further with meta regression. Our meta-analysis showed that children with SLI have diminished MMNs for both non-speech and speech sounds. However, the effect is strongly modulated by the experimental parameters. For example, in non-speech frequency discrimination studies, the group difference between SLI and TD children increased with smaller frequency changes, shorter tones, and more rapid stimulus presentation rates. Syllable discrimination meta-analysis did not show differences between groups for MMNs elicited by vowel changes, whereas consonant contrasts showed systematic effects. Children with SLI have various neurocognitive weaknesses and those can be tracked down with MMN studies. However, the effects depend heavily on stimulus features and experimental parameters. Deeper understanding of neurocognitive processing in SLI enables us to further develop clinical markers that rely on comparing of impaired and unimpaired brain mechanisms.

B38 Spoken language following cardiorespiratory arrest in children

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It is well-established that following cardiac arrest some adult patients suffer impairments in various cognitive domains, with memory and executive functions most commonly affected. It is also commonly found that verbal long term memory is more affected than visual long term memory, suggesting that subtle language impairment might also be present. Cardiac arrest in childhood is rare, and therefore, to-date, there is very little research on the effects of cardiorespiratory arrest in childhood on long-term cognitive outcome. Twenty four patients who suffered a cardiac arrest (9 males, age: 12.5±3.3 years, age of cardiac arrest: 3.4±4.4 years, total arrest time: 10.5±21.1 min), as well as 27 age- and sex-matched healthy children (age: 12.6±3.4 years, 9 males) participated in the study. Participants completed the Expression, Reception and Recall of Narrative Instrument (ERRNI), which measures amount of information given in initial and delayed storytelling, Mean Length of Utterance (MLU) and verbal comprehension. Language subtests from the Wechsler Individual Achievement Test–II (WIAT-II) were also administered, including word reading, spelling and reading comprehension. T1-weighted scans were acquired using a 1.5T Siemens Avanto MRI scanner. Images were segmented, normalised and smoothed (8mm FWHM Gaussian kernel) with DARTEL, using SPM12. As a group, patients were not impaired on the ERRNI (one sample t-test, $p>0.05$ for all). However, a number of individual patients showed impaired performance (>1 STD below the population mean) on the initial (n=2) and second (n=3) storytelling sessions, and on the MLU (n=1) and comprehension (n=4) scores. MLU was negatively correlated with age at testing (Pearson's $r=-0.59$, $p=0.001$), but there were no significant correlations between performance and total arrest time or total time on heart-lung machine, or between test scores and grey or white matter volumes. Lastly, performance on the ERRNI

and the WIAT-II subtests also did not correlate (Bonferroni correction applied, p>0.001). Voxel Based Morphometry (VBM) of smoothed modulated grey matter images, performed on the patient group, showed significant correlation between MLU scores and grey matter volume in a large cluster (978 voxels) in the right cerebellar lobule VIII (x=24, y=-63, z=-65, p=0.011, cluster level FDR). This result was replicated when performing VBM for the entire cohort, where correlation was found between MLU scores and a similar cluster (170 voxels; x=29, y=-56, z=-66; peak level, p<0.001 uncorrected). In this analysis correlation was also found between MLU scores and grey matter volume in the mid temporal-mid occipital junction (73 voxels; x=-35, y=-63, z=11; peak level, p<0.001 uncorrected). In summary, although patients who suffered a cardiorespiratory arrest early in life do not show language impairments as a group, importantly, some individuals do suffer from language deficits later in life. These deficits in spoken language production do not correlate with standardised literacy tests which are commonly used for diagnosis. In addition, the ability to produce longer sentences is suggested to be related to grey matter volumes in areas implicated in accessing semantics during sentence processing (posterior middle temporal gyrus) and verbal working memory (right cerebellar lobule VIII), both functions which are crucial for sentence production.

B39 Effects of early music intervention on neural speech processing in infants at risk for dyslexia

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Developmental dyslexia is a heritable learning disorder that compromises reading and writing abilities despite intact general cognitive skills. It has been associated with neurophysiological deficits in language and auditory processing. Infants with a familial background of dyslexia are at an elevated risk to develop reading impairments, and pioneering findings demonstrate that dyslexia-risk is already visible in the neurophysiology of infant brains. Also, brain responses of pre-reading children to speech sounds may predict later language and reading outcomes. In healthy infants and children as well as aging populations, music practice and music-based interventions have been found to facilitate auditory processing and language- and reading-related skills. It is possible that particularly singing may support language development in infancy, when neural representations of native language speech sounds are formed. In the present longitudinal study on dyslexia and language development starting from birth, a music-based early intervention is administered to newborn babies of dyslexic families. During the first 6 months of the baby's life, families are instructed to play song lists constructed by the researchers to their infants on a regular basis. Dyslexic families are randomly assigned to three groups: intervention group A that receives vocal song lists, intervention group B that receives same song lists as instrumental versions, and a control group C with no intervention material. Additionally, a healthy control group D with no familial dyslexia risk is involved in the follow-up. Event-related potentials (ERPs) to speech sounds and their changes are recorded from the infants prior to (at birth) and after (at 6 months) the intervention. Preliminary data from the 6-month recordings suggest that while infants in all groups demonstrate neural detection of speech sound changes, both the familial dyslexia-risk and effects of the interventions are visible in ERPs to speech stimuli affecting their amplitudes and morphology. Thus, the interventions seem to have an effect on early neural speech processing in infants at risk for dyslexia. The results may have important implications for the development of early intervention programs to prevent or ameliorate future reading deficits in at-risk individuals.

B40 Impaired automatic and controlled semantic retrieval of words in Chinese dyslexic children: Evidence from lexicality effect on N400

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Learning to read is a process of mastering the orthographic rules that map a set of visual symbols onto speeches. A popular misconception is that Chinese is characterized as an ideographic writing system, so Chinese literacy requires memorizing a great number of characters. However, most of Chinese characters are phonograms that are composed of semantic and phonetic radicals with specific configuration. The present study aims to use N400, an event-related potential (ERPs) component to index semantic retrieval and integration, to investigate how children with/without dyslexia process Chinese characters, pseudocharacters, and noncharacters that differ in word-likeness. The ensemble empirical mode decomposition method was used to decompose N400 into two frequency bands. In theta band, typical developing children showed greater N400 for real characters than for both pseudocharacters and noncharacters in central-to-posterior sites. However, this pattern wasn't found in dyslexic children. In delta band, both groups showed greater N400 for pseudocharacters and noncharacters than for real characters in fronto-to-central sites. However, greater N400 for noncharacters than for pseudocharacters was only found in typical developing, but not in dyslexic children. Our data suggested that Chinese dyslexic children showed impaired performance on two aspects of lexical processing, which have been proposed by the neural model for the dual semantic processing of words (Lau et al., 2008), including the automatic lexical retrieval function in the left temporal-parietal regions and the controlled processing of lexical integration and selection in the left frontal regions. The lexicality effects on N400s may server as neural markers of orthographic proficiency.

B41 Less is more: facilitating naming in aphasic patients

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Background. Studies on aphasic patients have shown that picture naming can be behaviourally facilitated by concurrent phonemic cues both as an immediate word retrieval technique, and when practiced repetitively over time as a long-term anomia treatment. Furthermore, the brain systems supporting anomia and spoken language recovery remain unknown,

particularly the role of the non-dominant hemisphere. Here, we investigated the behavioural and neural effects of anomia training based on phonemic cueing in a cohort of chronic aphasic patients. Methods. Eighteen native English speakers with aphasia following left hemisphere stroke (mean time post stroke 85 months) took part. They underwent fMRI and language testing directly before (T1) and after (T2) 6 weeks of anomia training using a phonemic cueing approach. The fMRI task required patients to name black and white pictures of monosyllabic objects as quickly and as accurately as possible. Each picture was concurrently presented with an auditory cue belonging to one of four experimental conditions: i) whole word, ii) initial phoneme, iii) final phoneme, iv) noise control (i.e., uncued items). In the fMRI analysis, 17 conditions of interest (4 cue types x 2 times x 2 treatment levels, plus incorrect responses) were modelled separately as events convolved with a haemodynamic function at the first level, also including movement realignment parameters as covariates of no interest. At the second level, 16 conditions were used (i.e., correct responses only), modelling subjects as a random factor. A statistical threshold of $p<0.05$ FWE-corrected for both cluster extent estimation and multiple comparisons at cluster-level was used throughout. Results. Behavioural results showed significant main effects of time (T2>T1), treatment (treated>untreated) and cueing type (word>initial>final>noise) on accuracy, which were mirrored by reaction time data. There were further significant time x treatment and treatment x cueing interactions. Time x treatment interaction showed that naming of treated items at T2 was more accurate and faster than both untreated items at T2, as well as all items at T1. Treatment x cueing interaction showed that, as compared to untreated items, treated items had greater improvements in accuracy across cueing types: 6% (word), 8% (initial), 11% (final) and 19% (noise). fMRI results showed a significant neural priming effect of naming (i.e., reduced BOLD response in cued as compared to uncued items) in the right insula, inferior frontal cortex (IFC) and bilateral premotor cortices (PMC), plus in the dorsal anterior cingulate cortex and supplementary motor area. As a consequence of treatment, a further reduction in BOLD response was found for treated as compared to untreated items within the right IFC/insula and PMC. Conclusions. Our results from a group of chronic aphasic stroke patients illustrate that anomia training using a phonemic cueing approach resulted in significant treatment-specific effects, as indexed by both behavioural improvements and neural priming effects. Activation in two brain regions (IFC, PMC) in the right hemisphere was significantly modulated by these effects. Further analyses will detail the role these right hemisphere regions play at the chronic stage post-stroke in anomia treatment and spoken language function.

B42 Functional ROI activation may predict functional communication and demonstrate post-therapy intervention in post-stroke expressive aphasia

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Clinical, hypothesis-driven study of the functional neural components associated with baseline severity, therapy-induced intervention and prognosis in post-stroke chronic aphasia will contribute to better prediction of response post-therapy and contribute to individual assessment of therapy needs. Both domain-specific and domain-general neural regions have been implicated in aphasia intervention. This study investigated functional neural regions of interest (ROIs) predicting spoken language in post-stroke aphasia. Six patients with expressive aphasia following left hemisphere middle cerebral artery territory stroke, age 45-71 years, 12-72 months post-stroke were analysed. They were enrolled in a crossover therapy design (Stark & Warburton, 2016). ROIs were specified from three peaks of activation during an fMRI button-press paradigm: language-specific left inferior frontal gyrus (IFG) BA 44 (n=5) and domain-general left precuneus BA7 (n=6) and right IFG BA44 (n=6). Contrast values were extracted (using MarsBaR in SPM12) from four conditions of interest: correct and incorrect judgments of a visual word rhyme judgment using inner (covert) speech, and correct and incorrect judgments of a visual symbol sameness judgment. Condition activation in each ROI was used in linear regression and correlation with spoken language measurements: spoken picture description from the Comprehensive Aphasia Test and content unit (CU) production from the Cookie Theft Picture Description. CU production severity at baseline was best predicted by activation during correct covert rhyme judgment decisions in the right IFG ($p=0.04$, $R2=0.7$, $S=5.92$). Even though a correct decision of rhyme using covert speech was made, greater activation during this decision correlated with more severe performance of spoken language. This may suggest a maladaptive, or over-compensatory, role of the right IFG. Prognosis was also investigated. CU post-therapy improvement was predicted by activation during incorrect covert rhyme judgment in the left precuneus at baseline ($p=0.05$, $R2=0.67$, $S=0.10$), where less engagement of the precuneus during a covert speech decision error predicted greater improvement on CUs post-therapy. CU improvement was also predicted by correct symbol judgment in the right IFG ($p=0.03$, $R2=0.75$, $S=0.09$), where activation at baseline on this correct non-language judgment predicted greater improvement on CUs post-therapy. These results indicate a role for language and cognitive-based decision components in predicting CU improvement. Finally, the functional neural effect of therapy was investigated. Exclusive to the left IFG, activation during correct covert rhyme decisions increased from baseline to post-therapy. This activation increase correlated with improvement post-therapy on the spoken picture description task ($\tau=0.8$, $p=0.05$), suggesting that therapy may have a role in successfully modulating left IFG activation which in turn contributes to spoken language improvement. In conclusion, activation produced during covert rhyme and symbol sameness judgments in language-specific and domain-general functional ROIs may predict severity, prognosis and describe effect of intervention. This proof of concept study indicated that functional ROI activation may have the ability to inform clinical decisions regarding therapy in post-stroke aphasia. This study encourages extrapolation in a larger population.

B43 Patients with central alexia rely on direct top-down control of visual cortex from left IFG when reading single words

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Introduction: Central alexia is a reading disorder co-occurring with a generalised language deficit. We conducted a connectivity analysis to investigate differences in the surviving reading network of participants with central alexia compared to healthy controls. Previous work has suggested that feedback from the left inferior frontal gyrus (IFG) occurs within the first 200ms of word reading. In patients with pure alexia the left IFG feeds back to the left occipital cortex (OCC) 1. Conversely in healthy controls the left IFG feeds back to the left ventral occipitotemporal cortex (vOT) 2. Using dynamic causal modelling (DCM) analysis of magnetoencephalography (MEG) data obtained while subjects read real words and false fonts, we directly compared the reading networks of patients with central alexia and healthy controls to investigate differences in the anatomy of top-down control of reading. Methods: 19 participants with chronic central alexia caused by left hemisphere stroke and 10 age-matched healthy controls participated. Patients' lesions were within the left middle cerebral artery territory. During the MEG scan, participants viewed words and 'false font' symbol strings. False fonts were chosen as a baseline condition as they require low-level, non-linguistic processing. To ensure that participants attended to all stimuli, common names (e.g. "Jenny") were presented infrequently, which participants responded to by button press. These catch trials were removed from the analysis. Based on a model of word reading identified in previous research 2, the network contained six sources: left and right OCC, vOT and IFG. Activity in these regions at the M170 peak was identified in a subject-specific manner using Variational Bayes Equivalent Current Dipole source localisation. DCM 3 was used to model differences in effective connectivity between words and false fonts in the first 300ms of word processing. 512 DCM models were estimated, each containing different combinations of connections between the 6 brain regions. A random effects Bayesian Model Averaging 4 analysis was conducted to identify significantly modulated connection strengths. Results: In line with our predictions, patients with central alexia showed significantly stronger feedback from left IFG to left OCC for words than false fonts. This feedback was significantly stronger for patients than healthy controls. By comparison, healthy controls showed significantly stronger feedback from left IFG to left vOT for words than false fonts. This feedback was significantly stronger than for healthy controls than patients with central alexia. Discussion: These findings suggest that patients rely on top down feedback from the left IFG to the left OCC when reading words, whereas healthy controls use an indirect pathway via the vOT. 1. Woodhead, Z. V. J. et al. Reading therapy strengthens top-down connectivity in patients with pure alexia. Brain 136, 2579–91 (2013). 2. Woodhead, Z. V. J. et al. Reading front to back: MEG evidence for early feedback effects during word recognition. Cereb. Cortex 24, 817–25 (2014). 3. Friston, K. J., Harrison, L. & Penny, W. Dynamic causal modelling. Neuroimage 19, 1273–1302 (2003). 4. Penny, W. D. et al. Comparing families of dynamic causal models. PLoS Comput. Biol. 6, e1000709 (2010).

B44 Transcranial direct current stimulation effects on neural processing in post-stroke aphasia

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Non-invasive transcranial direct current stimulation (tDCS) can enhance recovery after stroke. However, fundamental knowledge about how tDCS impacts neural processing in the lesioned brain is currently lacking. This was investigated for the first time in a group of patients with post-stroke language impairment (aphasia). In a cross-over, randomized trial, sixteen patients with chronic aphasia named pictures during functional magnetic resonance imaging (fMRI); concurrently, excitatory (anodal-) or sham-tDCS was administered to the primary motor cortex, a montage with demonstrated potential to improve language and communication in aphasia. This allowed us to assess how tDCS interacts with the patients' residual language network, thereby exploring acute tDCS-effects as they would be present during therapy. Univariate fMRI data analysis revealed reduced activity in domain-general regions mediating high-level cognitive control during anodal-tDCS. Independent component functional network analyses demonstrated selectively increased language network activity and an inter-correlated shift from higher to lower frequency bands, indicative of increased within-network communication. Compared to healthy controls, anodal-tDCS resulted in overall "normalization" of brain function in the patients. This is the first study that provides direct evidence of how tDCS impacts neural processing in the lesioned brain. Such information is crucial to assure that behavioral treatments targeting specific neural circuits overlap with regions that are modulated by tDCS, thereby maximizing stimulation effects during therapy.

B45 Stimulating reading: Behavioural and neural correlates of left-lateralising tDCS to temporal parietal cortex in adults with developmental dyslexia

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Reading difficulties in developmental dyslexia are manifest in a bilateral distribution of the N170, an EEG component associated with orthographic processing. This study used left lateralising transcranial direct current stimulation (tDCs) over the temporo-parietal cortex (TPC) during reading, using EEG to assess underlying brain changes. 20 adult developmental dyslexics and 20 normal readers were asked to read aloud 100 words and 100 nonwords. Then while reading another set of words and nonwords, half of the participants received sham stimulation and the other half received simultaneous anodal stimulation to left TPC and cathodal stimulation to right TPC. Reading performance was then reassessed with new sets of words and nonwords after a short washout period and again a week later. Active stimulation increased nonword reading accuracy for normal ($F(2,36)=7.65$;$p=.002$;partial $\eta^2=0.30$), and dyslexic readers ($F(2, 36)=7.71$;$p=.002$;partial $\eta^2=0.30$), but this effect was larger for dyslexics ($F(1, 18)=4.41$;$p=.050$;partial $\eta^2=0.20$). No significant EEG changes were observed for normal readers or dyslexics receiving sham stimulation. Dyslexics in the active condition showed a reduction in P1 amplitude over left posterior electrodes for nonwords ($T=5.41$;$p=.001$;129ms) and a reduction in right hemisphere N170 for nonwords ($T=4.59$;$p=.024$; 219ms), indicating that stimulation had increased left lateralisation.

B46 Comparison of voxel-based lesion symptom maps for measures of speech fluency in chronic left-hemisphere stroke

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Speech fluency figures prominently in the systematic study of aphasia, and clinically, speech fluency measures help to determine the need for speech and language intervention. Various metrics for quantifying speech fluency are available, including the fluency subtest of the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2007), a widely used test to assess language function. The relationship between neuropathology post-stroke and listener impressions of fluency obtained from the WAB has been well documented in the aphasia literature. However, the relationship between neuropathology and other objective measures of fluency (e.g. speech rate) that are also frequently used for clinical and research purposes have received little attention. Therefore, this study sought to determine the lesion sites associated with speech fluency and the degree of overlap or extent to which multiple measures of speech fluency yield similar results using voxel-based lesion symptom mapping (VLSM). Fifty-five participants with chronic left-hemisphere stroke were selected from a larger dataset for study (19 women; mean age 59±10.37 years). All participants were administered the WAB and underwent high-resolution MRIs. Speech fluency was quantified according to the WAB Fluency Scale, and descriptions of the picnic scene were used to generate four quantitative measures of speech fluency: 1) speech rate (SR), 2) articulatory rate (AR), 3) total number of words per minute (WPM), and 4) different words produced per minute (DWPM). Standard acoustic criteria were applied to segment samples into speech runs and pauses to obtain speech rate (including pauses) and articulatory rate in syllables per second (Tjaden & Wilding, 2004). The Apraxia of Speech Rating Scale (ASRS; Strand et al., 2014) also was used to quantify apraxic errors and severity. Univariate VLSM analyses were run for each speech measure; the resulting-thresholded statistical maps were overlaid on a standard brain template (JHU). Then, we computed the percentage of the statistically significant voxels that fell within a given brain region. Left precentral gyrus (PrCG) contained a relatively large percentage of voxels that were significantly predictive of SR (18%), AR (34%), WPM (19.%), DWPM (17%) and ASRS apraxia (34%) measures. Statistically significant lesion overlap across different speech measures was found mostly in PrCG for combined AR and ASRS apraxia measures (46%) as well as SR, WPM and WAB fluency measures (20%) that may best reflect speech execution and global fluency, respectively. When WAB speech fluency was controlled for WPM, thus exploring word production without the speed component, lesions in the left supramarginal gyrus (SMG) best predicted speech fluency (41% of significant voxels within SMG). In conclusion, damage to PrCG was associated with individual and combined measures of speech fluency while damage to SMG, a region implicated in Broca's aphasia was associated with WAB speech fluency scores controlling for WPM. Although lesions in other brain regions contributed to poorer fluency scores, all speech fluency measures were sensitive to PrCG involvement. Thus, PrCG may be crucial in subserving the underlying constructs of speech fluency not only for word production, but also speed and articulatory processes. These results have implications for the management of fluency impairments post-stroke.

Meaning: Combinatorial Semantics

B47 Different high-level language regions integrate information over the same time-window

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Linguistic processing recruits a language-selective network of left frontal and temporal regions (Fedorenko et-al., 2011). Across numerous fMRI studies, the functional profiles of these regions look similar (e.g., Fedorenko et-al., 2012; Blank et-al., 2016). Additionally, they exhibit highly synchronized activity during naturalistic cognition (Blank et-al., 2014), suggesting that they support similar computations. Nonetheless, it has been proposed that different language regions integrate linguistic information differently (Lerner et-al., 2011): (i) mid-posterior temporal regions integrate sub-lexical information over brief windows; (ii) surrounding regions compose constructions over sentence-length windows, unable to reliably process streams of unrelated words; and (iii) inferior frontal regions integrate over paragraph-length windows, unable to process streams of unrelated sentences (or words). Integration windows can be measured by exposing subjects to stories scrambled at different scales, where a region's tracking of each scrambled stimulus is measured via the reliability of its activity time-course across subjects (inter-subject correlation, ISC; Hasson et-al., 2004). We suggest that this integration hierarchy might be an illusory effect resulting from group analyses that cannot accommodate inter-individual variability in functional-to-anatomical mapping (e.g., Frost & Goebel, 2012). Namely, high ISCs (suggesting narrow windows) occur in locations where language regions overlap across participants; and low ISCs (suggesting wider windows) occur in locations housing distinct networks across subjects. Further, this hierarchy has not been validated via direct region-by-condition interaction tests (Nieuwenhuis et-al., 2011). Therefore, we performed a sensitive, explicit test for an integration hierarchy across language regions. Four temporal and three frontal language regions were functionally localized individually (Nieto-Castañón & Fedorenko, 2012) in each of 13 subjects using a reading task (sentences vs. nonwords; this localizer has been extensively validated; Fedorenko et-al., 2010). Subjects then listened to materials from the original integration hierarchy study: a narrated story, three scrambled versions of it (paragraph-level sentence-level, word-level) and its reverse soundwave. For each region and condition, ISCs were computed and tested for significance via time-course phase randomization (Lerner et-al., 2011). Region-by-condition interactions were tested next, by comparing region pairs for the contrast of each condition against (i) its more coherent neighbor; or (ii) the intact story. ISCs were also computed for two low-level auditory, anatomical regions bilaterally. All multiple comparisons were FDR-corrected. All language regions significantly tracked all scrambled stimuli (to different extents), and some tracked the reverse story. Overall, ISC(intact) and ISC(paragraphs), but not ISC(sentences), were higher than ISC(words); the latter was higher than ISC(reverse). In each auditory region all ISCs were indistinguishably high regardless of scrambling, as is expected of a sensory region,

with no conditions contrasted across region pairs surviving FDR-correction. The contrasts testing for the critical language-region × condition interaction all failed to survive FDR-correction. These effects were similar in size to the (null) auditory-region effects; the only stronger effects distinguished the middle frontal gyrus from the remaining language regions: it showed stronger ISC(intact)>ISC(paragraphs) effects, suggestive of a wider integration window. Therefore, we find that all temporal and inferior frontal language regions share a single integration window, perhaps constituting a unique stage within a broader cortical integration hierarchy.

B48 If so many are "few", how few are "many"? Intact semantic learning but failure to generalize in bvFTD patients with frontal atrophy

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The processing of quantifiers such as "many" or "few" is a complex operation involving the estimation of the numerosities of objects, their comparison to a reference amount, and semantic evaluation of that comparison. This series of processing steps is supported by a fronto-parietal network predominantly in the left hemisphere. The criterion that defines a number of objects as e.g. "many" depends on the context (many pandas vs. many ants) and on personal experience ("many miles" for a long-distance runner vs. a person using crutches with a broken leg). We found that this internal criterion can be modified in the course of a learning paradigm in which healthy young subjects can be trained to adapt their judgement of "many" from 60% to 40% of all circles. Most interestingly, changing the criterion for the quantifier "many" also leads to a change in the criterion for the untrained quantifier "few" (which contracts to about 25%). We demonstrated that Broca's region in the left inferior frontal cortex is essential for this learning effect and the generalization. This led to the question of performance in patients with the behavioral variant of fronto-temporal dementia (bvFTD) who suffer from atrophy of their frontal cortices: Are they impaired in their semantic generalization capacity tested with this paradigm. To this end, 11 bvFTD patients and 12 elderly healthy controls took part in this experiment. In a first baseline block, each individual's criterion for "many" and "few" was assessed. In block 2, subjects received feedback about their decisions. Contrary to their initial notion, a proportion of 40% yellow circles was reinforced as "many". In block 3, the effect of this training on their judgments of "many" and "few" was re-assessed. The healthy controls learned the new criterion for "many", and this also affected their criterion for "few" even though the criterion for "few" had not been trained. In contrast, the bvFTD patients also showed a learning effect for the new criterion trained for the quantifier "many," but failed to generalize this criterion shift to the other quantifier "few". In line with the previous studies, these findings point at the central role of the left frontal cortex for semantic generalization. Since the patients were still able to perform the task and showed learning of "many" to direct feedback, the data suggest that the left frontal cortex is relevant for generalization of the meaning of semantic categories as an instance of cognitive flexibility. This generalization process, rather than initial learning, seems much more vulnerable to frontal degeneration.

B49 Fine-Grained Semantic Coding in White Matter Connections

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Introduction. Past research has identified a set of white-matter (WM) tracts that are crucial object semantic processing, such that their damage leads to semantic deficits (Han et al., 2013; Fang et al., 2015). Whether these WM tracts are involved in some general processes commonly to all types of semantic processing or indeed play a role in the semantic representations remains open. We applied the multi-voxel pattern analysis (MVPA) and the representational similarity analysis (RSA) approaches developed in the fMRI research to the lesion and behavior data of 80 brain-damaged patients to test WM can code fine-grained object semantic information. Methods. MRI (structural and diffusion) imaging data from 80 patients with brain damage and 40 healthy subjects that were age- and education-matched with the patients. Each patient completed an oral picture naming task containing 100 items evenly from five categories: animals, fruit & vegetables, tools, non-tool manipulable and large non-manipulable objects. A semantic distance matrix of the 100 items was constructed using the object picture arranging procedure with 20 additional healthy subjects. The main procedure of analysis included the following steps: 1) Building a WM tract template, where a whole brain WM network was built by conducting tractography using diffusion imaging data across 90 cortical and subcortical regions in the healthy participants. 2) Obtaining the lesion-accuracy prediction matrix across items, where an SVM classifier was trained by the naming accuracy of one item (e.g. hammer) and voxel-wise lesion patterns in each WM tract in 79 patients, and used to predict the accuracy of another item (e.g. spanner), using the lesion pattern of a new patient subject who was not included in the training set, in a leave-one-out validation fashion. 3) Representation similarity analysis, where we correlated the semantic distance matrix with the lesion-accuracy prediction matrix the in each tract. 4) Validation, where we controlled for the object shape similarity by computing a partial correlation between the semantic similarity matrix and the lesion-accuracy prediction matrix while including the shape similarity matrix as a covariate. Results. Fifty left-hemispheric WM tracts were observed to yield significant results in the RSA, such that lesion-accuracy prediction matrix in patients significantly correlated with the semantic distance across items ($r = 0.05 - 0.16$, Bonferroni correct $p < 0.05$; partial R after controlling for the shape similarity matrix = 0.02 - 0.11). That is, in these tracts, the semantically closer a pair of item is, the more accurate in the using the lesion-naming model built from one item to predict the other. The majority of edges were connected from the occipital and partial to temporal cortex. Five hub regions that are most densely connected these 50 semantic distance-represented WM tracts: the precuneus, the hippocampus (included perirhinal cortex), the lingual, the middle temporal gyrus and the superior temporal gyrus. Conclusion. These results revealed the critical roles of white-matter connections among precuneus, the hippocampus (included perirhinal

cortex), the lingual, the middle temporal gyrus and the superior temporal gyrus in fine-grained semantic information of objects that respect semantic distance properties.

B50 Hippocampal engagement in online, high-level linguistic processing

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The hippocampus relates elements of an experience to each other, generating relational memories (Cohen et-al., 1999). Whereas its role has traditionally been linked to long-term memories (Cohen & Squire, 1980), recent neuropsychological and neuroimaging evidence suggests that working-memory relational representations are also hippocampus-dependent (Hannula et-al., 2006; Ranganath & D'Esposito, 2001). Therefore, hippocampal contributions to language may extend beyond initial encoding of vocabulary prior to neocortical consolidation: it may incrementally bind together multiple information sources during online processing. Indeed, patients with hippocampal amnesia struggle when language processing requires unusually flexible relational binding (Duff & Brown-Schmidt, 2012). Do these deficits reflect domain-general impairments in relational binding or, instead, suggest that parts of the hippocampus are specifically engaged in relational language processing? To address this question, here we use fMRI to functionally characterize hippocampal responses to language processing in healthy individuals. Putative "language" regions of interest (ROIs) in both hippocampi were defined individually (Fedorenko et-al., 2010) in each of 152 subjects by contrasting reading with higher (sentences) vs. lower (nonwords) relational demands (this localizer reliably engages the fronto-temporal language network across changes in materials and tasks). To test whether these ROIs were functionally distinct within the hippocampal milieu, we localized control ROIs in both hippocampi using a non-linguistic, working-memory task that requires processing spatial relations (and reliably engages the fronto-parietal task-positive network; Fedorenko et-al., 2013). To functionally characterize these four ROIs, we tested: (i) responses to the localizer tasks (in independent runs; n=93); (ii) responses to reading word-lists (lexico-semantic processing without relational composition) and jabberwocky sentences (syntactic composition without lexical-semantics) (n=31; Fedorenko et-al., 2012); (iii) responses to non-linguistic, working-memory tasks: arithmetic, converting sequentially-presented number-words into a single-number, nonverbal and verbal multi-source interference, and Stroop (n=11-15; Fedorenko et-al., 2013); and (iv) correlations, during both rest (n=85) and story comprehension (n=17), between activity time-courses in these ROIs and in neocortical language regions (excluding the anterior temporal region close to the hippocampus) or fronto-parietal task-positive regions (both networks localized as described above). Region-by-condition interaction tests (FDR-corrected) directly compared results across ROIs and task conditions. We found that language ROIs were consistently localized in the anterior hippocampus. They reliably responded to reading, showing a Sentences>Nonword effect that was stronger than in control ROIs and biased to the left (language-dominant) hemisphere. They were particularly sensitive to relational demands in semantic composition, showing left-biased Sentences>Jabberwocky and Sentences>Word-lists effects, with jabberwocky and word-lists indistinguishable from nonwords. Control ROIs, however, did not differentiate between sentences, word-lists and jabberwocky. Language ROIs were domain-specific, either not responding or deactivating to the spatial and other non-linguistic tasks (despite possible relational demands), but control ROIs differed and did not deactivate. During rest and story-comprehension, activity in language ROIs correlated with activity in neocortical language regions. These correlations were stronger than the non-significant correlations between (i) control ROIs and neocortical language regions; and (ii) language ROIs and neocortical task-positive regions. These findings identify a left-biased, language-selective hippocampal sub-region that is reliably recruited during online language processing and is functionally synchronized with the neocortical language network.

Meaning: Discourse and Pragmatics

B51 Neuropragmatic Speech-Language Deficits Specific To Speech Act Type Following Left-Hemispheric Lesion

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Introduction: Aphasia and other language deficits are frequently seen as structural-linguistic impairments affecting speech sounds, vocabulary and syntax. In contrast, pragmatic-linguistic functions such as the ability to use linguistic materials in order to perform linguistic actions, i.e. speech acts, are attributed to the right, non-dominant hemisphere. However, anecdotal reports have long suggested that the ability to use and understand a linguistic form may strongly depend on context and communicative purpose, as, for example, in Baillarger's case of a woman who could not 'name' her daughter but had no problem to express her regret by saying: 'My dear little Jacqueline, I even don't know your name anymore.' Methods: We tested 30 patients with post-stroke aphasia due to left-perisylvian lesions using a new test (Action Communication Test, ACT), which contrasts the abilities to use words and phrases for confrontation naming of objects and for requesting objects from a partner. Word and picture materials were matched for physical, psycholinguistic and psychological features between naming and requesting conditions and counterbalanced across subjects. Results: 17 patients tended to perform better for one of the speech act types compared with the other. 7 patients showed pronounced and significant performance differences between speech act categories (3 naming > requesting; 4 requesting > naming). The double dissociation between assertive naming and directive requesting was unrelated to target objects, linguistic materials or socio-economic features of the patients. Lesion maps showed overall larger lesions in the patients with predominant naming deficit compared with the request-focused group, but no clear anatomical dissociation. Conclusions: Embedding of language structures in action and communicative interaction contexts significantly influence language performance in a subset of

aphasic patients. The observed double dissociation in the ability to perform assertive (naming) and directive speech acts (requesting) calls for a revision of current concepts of aphasia as a structural deficit. The speech-act specific impairments make it evident that linguistic-pragmatic analysis of left-hemispheric language deficits is important for obtaining a more complete picture of the nature of aphasia and for improved planning of therapy of speech, language and communication.

B52 Knowing vs. thinking: does factivity matter for event structure processing?

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Introduction: Presuppositions specify that the content of a sentence should be taken for granted and considered uncontroversial. They are reliably associated with particular linguistic expressions. Recent psycholinguistic evidence suggests that some of these expressions trigger presuppositions during online comprehension (e.g., Romoli et al., 2015). The present study focused on a class of verbs called 'factives' such as know, which, in contrast to non-factive verbs such as believe, presuppose the truth of their complements (Kiparsky & Kiparsky, 1970). For example, in Example (1), the verb "realized", but not "speculated", presupposes that the dogs are vicious. We used ERPs to ask whether the presuppositions triggered by factives lead comprehenders to predict upcoming events that presuppose the truth of the preceding event(s) conveyed by the context, and, if so, what the neural consequences are of violating these predictions. There is growing ERP evidence that violations of event structure predictions can trigger prolonged neural processing, as reflected by the late posterior positivity P600 component (Kuperberg, 2013). Thus, if comprehenders are able to use factives to generate high certainty predictions about upcoming event structures, then incoming words that violate the presupposition, and therefore these predictions, should evoke a larger P600 than incoming words that do not violate the presupposition. (1) Charlie got three new dogs. He realized/speculated that they were really vicious/harmless. They invariably attacked anyone they encountered. Methods: We used a 2X2 design in which Verb Class (factive/nonfactive) was crossed with Information Expectation (confirmed/disconfirmed) to create four conditions of three-sentence scenarios (e.g. Example (1)). The second sentence included a factive or a non-factive verb. The final sentence, which was identical across the four conditions, contained a sentence-medial critical word that confirmed or disconfirmed the information conveyed by the second sentence. The first and second sentences were each presented as a whole, whereas the third sentence was presented word by word. Twenty-four participants read 152 experimental scenarios (counterbalanced across the four conditions) and 70 fillers, and made plausibility judgments at the end of each scenario. ERPs were time-locked to critical words. Results: There was a significant interaction between Verb Class and Information Expectation between 500-700ms over parietal and occipital electrode sites. This interaction was driven by a larger late positivity (P600) to critical words that disconfirmed versus confirmed the complements of the factive verbs, but no such effect following the non-factive verbs. There were no differences across the four conditions on the N400 evoked by critical words (between 300-500ms). Discussion: Comprehenders are able to use factivity as a contextual cue to predict upcoming events that convey the truth of the information given by the context. If the integration of new bottom-up input violates these presupposition-based predictions, this triggers prolonged neural processing. The absence of N400 modulation, however, suggests that these higher-level event structure predictions did not lead to differential pre-activation at the level of semantic features. This study therefore adds to increasing evidence that the P600 effect can be evoked in the absence of an N400 effect to certain types of event structure violations.

B53 A neural oscillatory signature of reference

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The ability to use linguistic representations to refer to the world is a vital mechanism that gives human language its communicative power. In particular, the anaphoric use of words to refer to previously mentioned concepts (antecedents) is what allows dialogue to be coherent and meaningful. Psycholinguistic theory posits that anaphor comprehension involves reactivating an episodic memory representation of the antecedent [1-2]. Whereas this implies the involvement of memory structures, the neural processes for reference resolution are largely unknown. Here, we report time-frequency analysis of four EEG experiments [3-6], revealing the increased coupling of functional neural systems associated with coherent referring expressions compared to referentially ambiguous expressions. We performed time-frequency analysis on data from four experiments in which referentially ambiguous expressions elicited a sustained negativity in the ERP waveform compared to coherent expressions. In Experiment 1, 32 participants read 120 correct Dutch sentences with coherent or ambiguous pronouns. In Experiment 2, 31 participants listened to 90 naturally spoken Dutch mini-stories containing coherent or ambiguous NP anaphora. In Experiment 3, 22 participants each read 60 Spanish sentences with a coherent or ambiguous ellipsis determiner. In Experiment 4, 19 participants each read 180 grammatically correct English sentences containing coherent or ambiguous pronouns. Analysis was performed with Fieldtrip [7], separately for low frequency (2-30 Hz) and high frequency (25-90 Hz) activity. Power-changes per trial were computed as a relative change from a pre-CW baseline interval, average power changes were computed per subject for coherent and ambiguous conditions separately. Statistical tests used cluster-based random permutation [8]. Despite varying in modality, language and type of expression, all experiments showed larger gamma-band power around 80 Hz for coherence compared to ambiguity, within a similar time range. No differences were observed in low frequencies. In high-density EEG Experiment 4, an additional short-duration gamma-increase was observed around 40 Hz, around 300-500 ms after pronoun-onset, which was localised using Beamformer analysis [9] to left posterior parietal cortex (PPC). The 80 Hz power increase around 600-1200 ms after word onset was localised to left inferior frontal-temporal cortex. We argue that the observed gamma-band power increases reflect successful referential binding and resolution, linking incoming information to previously encountered concepts and integrates

that information into the unfolding discourse representation. Specifically, we argue that this involves antecedent reactivation in the PPC episodic memory network [10-11], interacting with unification processes in the frontal-temporal language network [12]. Based on these results, and on results of patient [13] and fMRI [14] research on pronoun comprehension, we propose an initial neurobiological account of reference, by bridging the psycholinguistics of anaphora with the neurobiology of language and of episodic memory. [1] Dell et al., 1983 [2] Gerrig & McKoon, 1998 [3] Nieuwland & Van Berkum, 2006 [4] Nieuwland et al., 2007a [5] Martin et al., 2012 [6] Nieuwland, 2014 [7] Oostenveld et al., 2011 [8] Maris & Oostenveld, 2007 [9] Gross et al., 2001 [10] Shannon & Buckner, 2004 [11] Wager et al., 2005 [12] Hagoort & Indefrey, 2014 [13] Kurczek et al., 2013 [14] Nieuwland et al., 2007b

Perception: Orthographic and Other Visual Processes

B54 Processing of lexical category and argument structure information in deverbal adjectives: An MEG study on Greek

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Previous research found that morphological complexity evokes two spatiotemporally distinct neural responses: a response peaking at ~300-400ms post-stimulus onset in the left Superior and Middle Temporal Gyrus (STG/MTG) associated with lexical access and later with semantic well-formedness [1, 2, 3], and a response peaking at ~400ms post-stimulus onset related to semantic coherence and located in the orbitofrontal (OF) cortex. A study comparing the processing of prefixed novel words which violate either grammatical category (cat. viol) or argument-structure (arg.str.viol) restrictions of the stem confirms the role of the OF areas in assessing complex words' coherence and shows significant differences in activation in the STG between cat.viol and arg.str.viol items [3]. The present study provides MEG data on the lexical access of suffixed words in Greek by comparing the processing of grammatical and ungrammatical deverbal word formations. We used three different adjectival suffixes, i.e. -simos, -tos and –menos, to create novel words with cat.viol and arg.str.viol. All three suffixes require verbal stems with an internal argument to create grammatical forms. Cat.viol items contained noun stems instead of verbal stems (e.g. *zarkadi-tos, deer-able), and arg.str.viol items contained intransitive verbs instead of transitive (e.g. *rohalis-tos, snore-able). MEG activity and lexical decision responses were collected from 20 Greek native speakers (9 male, mean age 32.3) on 225 test items. RT: Cat. viol items were rejected faster than arg.str.viol items, both within each suffix and across all suffixes (for all comparisons, $p < 0.01$), replicating the results in [4]. MEG: In a spatiotemporal cluster analysis correcting for multiple comparisons across time and space we compared the different types of items within each suffix, and across suffixes. Left STG/MTG: We found a significant amplitude difference between grammatical and violation items, between 290-450ms ($p=0.012$). No differences were found in the within-suffix analyses between the two types of violations (cf. [3]). OF: We found a significant difference between grammatical and violation items, between 250-450ms, in four different clusters ($p=0.019$, $p<0.01$, $p<0.01$, $p=0.031$), replicating [3]. Additionally, we found significant differences between grammatical and cat.viol items in the across-suffixes analysis in three different clusters between 270-500ms ($p=0.01$, $p=0.02$, $p=0.01$) and in the within-prefix analyses for –simos between 380-500ms ($p=0.020$) and –menos between 305-500ms ($p=0.040$). We also found a marginally significant difference between cat.viol and arg.str.viol items between 430-500ms ($p=0.084$) in the across-prefixes analysis, and a significant difference for –menos between 380-495ms ($p=0.043$) in the within-suffixes analysis. No statistically significant differences were found between grammatical and arg.str.viol items. The results suggest that Greek suffixed words also elicit the M350 response, but unlike English, this effect shows minimal sensitivity to the type of violation for the suffixes under investigation. The responses in the orbitofrontal region further support the involvement of this area in the assessment of semantic well-formedness. References

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B55 Comparing and validating methods of reading instruction using behavioural and neural findings in an artificial orthography

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There is intense debate over whether reading instruction should focus on the relationship between letters and sounds (as embedded in phonics programmes) or on the relationship between printed words and their meanings (as proposed by whole-language approaches). We frame this question within computational models of reading – asking whether training focused on the sub-word pathway from print-to-sound-to-meaning, or on the whole-word pathway from print-to-meaning, best facilitates reading comprehension. 24 English-speaking adults learned to read two sets of 24 novel words (e.g., /buv/, /sig/), written in two different unfamiliar orthographies, over eight days. Each novel word had an associated English meaning (e.g., camel, tractor). For one orthography, adults completed tasks focusing on systematic print–sound mappings three times per day and tasks focusing on arbitrary print–meaning mappings once per day (print–sound focus language); for the other orthography the reverse was true (print–meaning focus language). A pre-training MRI scan measured neural activity whilst adults learned to read aloud the print–sound focus language and learned to say the meanings of the print–meaning focus language. A post-training MRI scan measured neural activity when adults were highly accurate in reading aloud and saying the meanings of words from both languages. Behavioural data revealed clear benefits of print–sound focused training for reading aloud, generalisation to reading aloud new words, and, most strikingly, reading comprehension, as compared to print–meaning focused training. Univariate analyses of pre-training fMRI data demonstrated that learning print–sound mappings engaged dorsal pathway regions (e.g.,

left inferior parietal sulcus, inferior frontal gyrus opercularis), whereas learning print–meaning mappings engaged ventral pathway regions (e.g., left anterior fusiform, inferior frontal gyrus orbitalis). This confirmed that the different instructional methods tapped into distinct reading pathways. Post-training, dorsal pathway regions showed increased activity during reading aloud following print–meaning relative to print–sound focused training, reflecting increased sub-word processing effort. Conversely, activity in ventral pathway regions involved in reading comprehension was equivalent following print–meaning relative to print–sound training. Therefore, reliance on the two reading pathways for generating word meanings was equivalent for the two languages. Multivariate analyses revealed high similarity in the spatial distribution of activity during artificial and English word reading, validating our artificial language approach. In particular, voxels more active for English pseudoword than word reading (e.g., in left posterior occipitotemporal cortex, inferior parietal sulcus, inferior frontal gyrus) were also more active for untrained than trained artificial orthography items. Conversely, voxels more active for word than pseudoword reading (e.g., in bilateral middle temporal and angular gyri) were also more active for trained than untrained artificial orthography items. Thus, participants trained to read artificial orthographies used largely the same neural resources as they used in reading English words and pseudowords. Our findings demonstrate that learning focused on the arbitrary associations between print and meaning does not promote whole-word learning, but instead hinders learning of sub-word print-to-sound relationships. Therefore, interventions aiming to improve reading aloud and/or comprehension accuracy in the early stages of learning to read alphabetic writing systems should focus on these systematic print-to-sound relationships.

B56 Context- and knowledge-based predictions in visual word recognition: A MEG study investigating the interaction of pseudoword familiarization and repetition

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Introduction. The predictive coding framework assumes that efficient neuronal processing is realized by predicting upcoming sensory information from context or prior knowledge. As a consequence only the residual (i.e. not predicted) sensory information is processed and, therefore, a negative correlation of predictability and neuronal responses is assumed (i.e. un-predictable sensory events evoke higher neuronal responses than predictable sensory events). In the present magnetoencephalography (MEG) study we investigate the influence of context- vs. knowledge-based predictions on visual word recognition. Method. Knowledge-based predictions were realized by a controlled increase in orthographic expertise for a group of previously unfamiliar pseudowords. Pseudworods were familiarized on the two days prior to the MEG measurement: In four familiarization sessions, participants read a list of pseudowords out loud and then performed a recognition task. During the MEG measurement, words, familiarized pseudowords, and novel pseudowords (matched on orthographic Levenshtein distance) were presented for 800 ms. Context-based predictions were realized by repeating 80% of presented letter strings after an 800 ms delay. Participants were instructed to silently read all presented letter strings and respond to catch trials. Results. The MEG results revealed a reliable knowledge effect at the M170 showing larger event related fields (ERFs) for familiarized pseudowords in contrast to novel pseudowords at left-temporo-parietal sensors. This is a first indication for knowledge-based processing of familiarized pseudowords, as the M/N170 amplitude has previously been associated with orthographic expertise. Interestingly, in repetition trials, the M170 was drastically reduced for familiarized pseudowords in contrast to novel pseudowords (significant interaction at a cluster spanning from right-temporal to bilateral-frontal sensors). Words did not differ significantly from the two pseudoword conditions. In addition, a context effect was found from 200-400 ms at bilateral-fronto-temporal sensors. Here, ERFs in repetition trials for all letter strings were reduced for the second presentation in contrast to the first presentation. Discussion. First, we could replicate the orthographic expertise effect on the M170 component, which was only present in the contrast between familiarized and novel pseudowords. For words and novel pseudowords, the matched orthographic familiarity prevented a significant effect, which is in line with the expertise hypothesis. Second, both the interaction of knowledge and repetition as well as the general repetition effects are in line with the concept of predictive coding. In both cases, brain responses were reduced for more predictable sensory events. The rather early time window in which significant activation reductions were found might indicate that low-level, sensory information processing is directly optimized by both context- and knowledge-based predictions.

B57 Visual information aids statistical and rule-based learning of syllable triplets: evidence from ERPs

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Humans can use transitional probabilities to segment nonsense words from a continuous stream of sounds (Saffran et al., 1996, 1999) and can also extract abstract rules from a stimulus (Marcus et al., 1999). While statistical learning is not limited to the linguistic or auditory domain (Abla & Okanoya, 2009), rule learning in domains other than language seems to be more difficult (Johnson et al., 2008). In light of the differential findings across domains, some have argued the two mechanisms are functionally segregated (De Diego Balaguer et al., 2007; Endress & Bonatti, 2015), while others have argued that statistical and rule learning are one mechanism with different applications across contexts (Aslin & Newport, 2014; Frost & Monaghan, 2016). Here, we assess whether statistical and rule learning of syllable triplets in the auditory, visual, and multimodal domain proceed differently. Based on previous behavioral findings, we predict rule learning to be superior in the auditory domain. For both types of learning, we expect the multimodal condition to yield a stronger response than either unimodal condition. Forty-six participants were exposed to 80 ABB triplets, in one of three conditions: auditory (e.g. dekoko, with random synchronous visual stimuli), visual (e.g. circle-triangle-triangle, with random synchronous auditory

stimuli), multimodal (congruent auditory and visual stimuli). Subsequently, ERPs were elicited in an oddball paradigm. The standards were ABB (n=450); the rule deviant was ABA (violating the rule that the third syllable is identical to the second; n=50); the statistical deviant was BAA (violating the transitional probability since triplets never start with a B; n=50). To assess training effects throughout the experiment, we measured N1 in the training phase and compared it to N1 in successive oddball blocks (the first, the middle, and the last 80 standards). In the oddball stimuli we also measured P3a and N400. Repeated-measures ANOVAs were conducted per ERP component. The dependent measure was the amplitude of each component measured at 27 channels, defined by the within-subjects factors laterality and anteriority (3 and 9 levels). The other within-subjects factors were stimulus type (N1: standard from training, from first, middle, and last oddball-block; P3a and N400: rule deviant, transition deviant) and syllable (first, second, third); the between-subjects factor was condition. For N1, there was a main effect of stimulus type (p=.014): standards from all oddball blocks yielded larger N1 than standard from training, and the last oddball block yielded smaller N1 than the middle and the first. For P3a, there was a significant interaction of stimulus type, syllable, and condition (p=.03). Rule deviant yielded largest P3a in the multimodal condition (on the third syllable). Transition deviant yielded smallest P3a in the auditory condition (on the first syllable). The results indicate that learning/habituation was observed for standards, irrespective of domain. However, while rule learning was more robust under congruent visual and auditory information, statistical learning benefited from the sole availability of visual information (with or without congruent auditory information). Taken together, our findings suggest that visual information in general facilitates both the statistical and the rule learning mechanism.

Language Disorders

B58 Listen-In: The development and testing of a tablet-based therapy application for patients with impaired speech comprehension caused by stroke. Phase 1: Development and consultation.

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Introduction: The Listen-In project is investigating the clinical efficacy of a novel therapeutic digital application targeting auditory comprehension impairments in people with post-stroke aphasia, using both structural imaging and behavioural measures. Most aphasia rehabilitation has not provided sufficient dose to allow for a reliable critique of its effectiveness, both in scientific research1,2 and clinical practice3. We have utilized gamification to help maximize dose delivery. The novelty of gamification in the field of aphasia therapy necessitates the involvement of patients in its development. Methods: Six focus groups were held with people with post-stroke aphasia, recruited through opportunity sampling (Brady, 2006). The groups were split into two smaller groups to support communication. The researchers did not participate in the session in order to reduce bias in feedback. Sessions included playtime, directed questioning in both small and larger groups. Three interim blocks of extended playtime were completed at home between focus group sessions. Thematic analysis was carried out to describe and analyse our qualitative data. Sessions were video recorded and transcribed in full, followed by coding of all data. A predetermined coding framework was updated and refined iteratively as and when researchers encountered new areas of feedback in the transcriptions. Results: Some key themes emerged from focus groups; we have summarised these, and then included our recommendations for the next iteration of Listen-In: 1. Usability of the hardware; 2. Therapeutic elements; 3. Audio problems; 4. Gaps in user feedback; 5. Understanding of gaming elements and 6. Social interaction. Several small usability factors were identified as potential barriers for some individuals, which allowed for clear recommendations. However, other barriers were less clear cut. The most challenging barrier from the research teams' perspective was the pervasive finding that participants did not understand the object of the game. Discussion Whilst challenges were highlighted in involving people with aphasia, our data suggests that the information acquired through ensuring this process is integrated into the research is both informative and an invaluable addition to the design process. This process has led to a better, more user-friendly product which is likely to best maximize player participation and therefore engagement with therapy. This should provide us with the best chance of ensuring an adequate dose is delivered and therefore that the best therapeutic outcome for patients participating in our clinical trial is achieved.

Phonology and Phonological Working Memory

B59 Neural development of phonological working memory from childhood to adulthood

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Goals: Phonological working memory (PWM), the ability to maintain and manipulate sequence of speech sounds, plays a crucial role in online sentence comprehension and speech production in both adults and children. Significant associations have been observed between PWM skills and children's language development. Severe deficits in PWM, often measured by non-word repetition tasks, are characteristic of neurodevelopmental disorders of language. Despite the wealth of behavioral evidence, development of the neural architecture underlying PWM remains largely unknown. The current study investigates the developmental changes of neural responses to increasing demands of PWM load in a non-word repetition task. Methods: 59 typically developing children (Age range: 5;8 – 17;11 years; Median: 9;6) and 23 healthy adults (Age range: 18 – 34 years) participated in the study. Participants performed a non-word repetition task in a sparse-sampling fMRI design (TR = 6 sec, TA = 2 sec) in order to allow accurate speech perception and production in the absence of acoustic scanner noise. Participants listened to and repeated 96 non-words varying in length ranging from two to five syllables over three experimental runs. Participants' voice responses

were coded offline for repetition accuracy. 16 children were removed from the fMRI analysis due to excessive motion. Age was entered as a continuous regressor for whole-brain correlation analysis, while controlling for gender and non-verbal IQ. Children were further divided by median-split into older and younger groups for group comparisons. All group-level statistics were thresholded voxel-wise at two-sided $p < 0.05$ and cluster-wise at $pFDR < 0.05$. Results: Participants' repetition accuracy decreased significantly as syllable length increased. Age is positively associated with participants' overall performance. However, as age increased, the growth of performance plateaued at around 10 years old. Older children and adults do not differ significantly in task performance. Increasing syllable length also resulted in a greater activation at areas dedicated to sensory perception (bilateral superior temporal region (STG/STS), middle temporal gyri (MTG), and posterior inferior temporal gyri (pITG)), sustained attention (bilateral prefrontal cortices (PFC) and superior parietal lobule (SPL), and anterior cingulate gyrus (ACC)), articulation coordination (supplementary motor area (SMA)), information gating (basal ganglia) and long-term memory (hippocampus). The parametric effect of increasing phonological working memory load at bilateral superior temporal sulci (STS) and temporo-parietal junction was positively associated with age. Both adults and older children groups showed greater parametric effect in bilateral STS and reduced parametric effect in hippocampus than younger children. Nevertheless, compared with older children, adults showed greater activation only in left STS. Conclusion: The maturation of the neural architecture underlying phonological working memory exhibits a long-lasting continuity from childhood to adulthood. As age increases, brain areas dedicated to transient sensory information processing are increasingly involved in phonological working memory. However, the involvement of long-term memory system reduces with age, possibly due to the growth of working memory capacity. Even though children's performance of the non-word repetition task reaches plateau before early adolescence, the specialty of speech processing in the left hemisphere continues to develop through early adulthood.

B60 Sequential encoding of acoustic features in EEG responses to continuous speech

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When listening to speech, humans have the ability to simultaneously extract both the content of the speech and the identity of the speaker. This is due to a multitude of cues encoded in the acoustic signal, including distinctive features of phonemic categories that carry meaning, and identifiable features of the speaker such as pitch, prosody and accent. Recent findings from invasive human electrophysiology studies have shown the role of phonetic features in organizing the representation of speech sounds at higher level speech cortices. However, it remains unclear how the neural representation of acoustic features unfolds over time as the speech sounds propagate through the auditory pathway, and how linguistic and non-linguistic information are jointly encoded in the brain. We recorded EEG data from 22 native speakers of American English. Participants listened to simple stories comprised of alternating sentences uttered by two speakers (one male, one female). We applied a novel analysis to electroencephalography (EEG) signals in response to continuous speech to characterize the neural representation of acoustic features and the progression of responses over time. By averaging the time-aligned neural responses to phoneme instances, we calculated the phoneme-related potential (PRP) and studied the joint representation of linguistic (phonetic) and non-linguistic (speaker) information in the PRPs. We observed four sequential time intervals during which the PRPs are organized by the acoustic similarity of phonetic categories, appearing approximately at 50 ms, 120 ms, 230 ms, and 400 ms relative to the phoneme onset. The responses are primarily organized by phonetic feature, while subtler speaker variations appear within manner groups. This is consistent with previous studies that have shown a larger role for phonetic over speaker characteristics in shaping the acoustic properties of phones. Additionally, the different scalp distributions at each time interval suggest a different underlying pattern of neural activity for each component. Moreover, by establishing a direct connection between the acoustic properties of distinct speech sounds and their corresponding neural representation in EEG, we provide evidence for a sequential neural transformation of sound as it propagates through the auditory pathway. A major difference between our study and previous work is that it provides a direct link between the organization of neural responses and the acoustic properties of speech sounds. Therefore, this study lays the groundwork for several research directions where explicit changes in the representational properties of speech can be examined in speech development, as a listener learns new acoustic distinctions, second language acquisition, and through varying task demands.

Signed Language and Gesture

B61 How do signers process spatial anaphora? – An ERP analysis of German Sign Language

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Sign languages make use of the three-dimensional signing space to express various morphosyntactic, semantic and pragmatic functions. Discourse referents (DRs) are, for instance, introduced and referred back to by means of referential locations (R-loci), i.e. regions in the horizontal plane of the signing space, which are identified either by overt grammatical (manual or non-manual) localization strategies or by covert default strategies. However, the question whether the assignment of DRs to R-loci follows a particular pattern, has not been investigated in detail so far. Previous studies (Capek et al., 2009; Hänel-Faulhaber et al., 2014; Hosemann et al., 2013; Kutas, Neville & Holcomb, 1987) revealed that neurophysiological correlates attested in spoken language processing are also observed in the processing of sign languages. The present event-related potential (ERP) study on German Sign Language (DGS) investigates the hypothesis that signers assign distinct and contrastive R-loci to different DRs even in the absence of any overt localization strategy (Steinbach & Onea, 2015). By using a mismatch-design, we constructed sentence sets (see example 1) containing two DRs without overt localization in the first sentence (i.e. covert default strategy) and a pronoun (INDEX) at the beginning

of the second sentence followed by a description clearly identifying the first DR. According to our expectation, example (1a) shows a felicitous sentence set while in (1b) there is a mismatch caused by the pronoun, which implements an anaphoric link to the second referent MANN ('man') but the following description still refers to the first referent FRAU ('woman'). Thus, the two conditions are expected to show different effects on the sentence-final description SCHWESTER ('sister') in the second sentence. (1) a. FRAU(R) MANN(L) HEIRAT. INDEX-R POSS1 SCHWESTER. 'A woman marries a man. She is my sister.' b. FRAU(R) MANN(L) HEIRAT. INDEX-L POSS1 SCHWESTER. 'A woman marries a man. He is my sister.' All stimuli were video-recorded with two right-handed deaf native signers of DGS, cut and processed, however the videos were not modified in any way. Given that even the transition phase between two signs can already provide sufficient information about the next sign to evoke neurophysiological correlates (Hosemann et al., 2013), different points in time of the 'description part' (including the time window before sign onset) were manually determined for the later analysis. We recorded ERPs from right-handed deaf native signers of DGS (N=21, mean age: 33) while they watched the videos and judged the presented sentence sets according to their grammaticality. The analysis of the data shows a difference of the two conditions on the description in the second sentence between 500 and 600 milliseconds over central regions, which is in line with our expectation. Therefore, the data support the hypothesis that signers of DGS assign DRs to contrastive and distinct regions covertly. This study is the first attempt to investigate anaphoric processing in DGS experimentally and contributes to the understanding of discourse processing in sign languages in general.

B62 Neural correlates of variation among lexical items in British Sign Language: a parametric fMRI study

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A number of neuroimaging studies of sign language comprehension reveal highly similar networks to those engaged in spoken language comprehension (e.g. Capek et al., 2004; MacSweeney et al 2002; Neville et al, 1998; Petitto et al., 2000). Such studies have largely focused upon sentence comprehension thus engaging syntactic and lexical processing. In the present study we focus upon lexical processing, presenting a large number of lexical signs in British Sign Language (BSL) that vary in form complexity, usage (as indexed by subjective frequency) and semantics (as indexed by concreteness), to assess the networks engaged in different aspects of processing by the same participants (e.g. Hauk et al., 2008). Sixteen deaf BSL users viewed signs and attended to their meanings: occasionally performing an unpredictable semantic one-back task (respond via button press whether a visually cued sign was semantically related to the previous one). Crucially, signs varied on the basis of their phonological complexity, subjective frequency and concreteness. Participants were deaf native or near native right-handed fluent BSL users. 294 target BSL lexical signs were included; all produced by a native BSL signer. Each participant underwent six functional scans of equal duration. SOA varied exponentially, varying from 4-17sec between video onsets. Results were analysed using SPM8, including phonological complexity, subjective frequency and concreteness as sequentially-entered parametric modulators of the target sign > implicit rest comparison excluding filler events and erroneous button-presses (comparable results were observed in separate models including single parametric modulators). Unsurprisingly, target signs > rest revealed extensive increase in activation incorporating bilateral occipital, middle and superior temporal regions, as well as somewhat left-lateralised activity in inferior/middle frontal regions and superior parietal lobule. For phonological complexity, there was increased activation for the more complex signs in bilateral occipital and postcentral/parietal regions. For subjective frequency, less-frequent signs elicited increased activation in bilateral occipital, superior/middle/inferior temporal, and inferior frontal gyri. For concreteness instead the effect was highly left-lateralised: less concrete signs increased activation in left middle/anterior temporal and inferior parietal and left inferior frontal regions. Hardly any increased activation was observed for less complex, more frequent, or concrete signs. We suggest that all of these factors reveal aspects of processing difficulty that can be attributed to (somewhat) distinct neural systems. Increased form complexity led to increased bilateral activity associated with modality-specific (visuo-motoric) aspects of the materials. Less familiar signs elicited increased activation possibly associated with more general attentional and cognitive demands for those materials experienced less frequently (and far more bilaterally than many studies of frequency effects in speech/writing). For abstract signs, effects were highly left lateralised: consistent with studies from spoken language (e.g. Binder et al. 2005, but see Vigliocco et al., 2014). The lack of increased activation for concrete signs might be attributed to the highly concrete modality: visuo-motor content is present in all signs and thus may obscure or eliminate activation differences related to these domains that are seen in studies of spoken language (e.g. Fernandino et al, 2015).

Speech Motor Control and Sensorimotor Integration

B63 Sensorimotor differences between stuttering and non-stuttering adults before and during fluent speech production recorded in EEG mu rhythms.

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Stuttering is associated with compromised sensorimotor integration during speech production. However, to better understand the nature of this compromise, it is necessary to acquire temporally precise cortical measures of sensorimotor integration free from the state-related confounds occurring in overtly stuttering speech. The electroencaphlographic (EEG) mu rhythm offers a rich source of sensorimotor information that can be measured during speech production tasks and temporally decomposed. 64-channel raw EEG data were obtained from 25 adults who stutter (AWS) and 25 non-stuttering controls (AWNS; matched for age, gender, and handednesss), while they spoke syllable pairs and tri-syllable

nouns or listened to white noise (control condition). Only neural data collected during clearly fluent trials were included in subsequent analyses. Independent component analysis (ICA) was performed on all raw data. 20 and 18 AWS and their matched controls yielded components that contributed to left and right mu clusters, respectively. Criteria for inclusion in the clusters were localization to sensorimotor regions in BA 1, 2, 3 (primary sensorimotor), BA 4 (primary motor), or BA 6 (premotor) and spectra characterized by alpha (8-13 Hz) and beta (15 -25 Hz) peaks. In addition, for each participant that submitted a mu component, a surface electromyographic (sEMG) component that captured muscle activity from the lower and upper lips was identified. Time-frequency analysis of mu and sEMG components was performed via event-related spectral perturbations (ERSP), allowing sensorimotor neural activity to be referenced temporally to muscle movements of speech. ERSP analysis of sEMG components showed muscle movement beginning ~300 ms following the cue to speak (i.e., speech initiation) for both groups. ERSP analysis of left mu clusters in AWNS showed strong alpha and beta event-related desynchronization (ERD) beginning prior to speech onset and lasting throughout utterances. This pattern has been observed before and suggests a normal sensorimotor loop in speech production (Jenson et al., 2014). In contrast, in the AWS, beta ERD was weaker (pFDR <.05) and alpha ERD began earlier than in the AWNS. As beta mu rhythm activity is associated with motor activity (e.g., internal modeling), and alpha mu rhythm activity is associated with sensory feedback, these data provide real-time evidence of weak internal modeling and increased reliance on sensory feedback in AWS even when speech is not overtly stuttered. Similar findings were observed in the right hemisphere, though overall spectral power was weaker and fewer time-frequency voxels showing group-differences were significant than in the left hemisphere. Additionally, the beta peak in the mu rhythm spectra of the AWS was weaker than the AWNS across conditions. This finding again supports a weaker overall capacity for producing internal models. The current data provide real-time oscillatory evidence of senosorimotor differences in speech production between adults who stutter and fluent matched controls even in the absence of overtly stuttered speech. Additionally, data continue to support time-frequency measures of the mu rhythm as a rich source of information about sensorimotor activity in the anterior dorsal (i.e., Premotor / motor) regions.

B64 Motor abilities in people who stutter: Impaired visuomotor adaptation and abnormal response timing

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Stuttering is a disorder in which the fluidity of speech is interrupted by a classic trio of dysfluencies: repetitions, prolongations, and blocks. Unintended movements of the face, head, neck and even limbs often accompany these dysfluencies. Substantial evidence supports basal ganglia and cerebellum disruption in stuttering. Given the role of these structures in movement control generally, we used a battery of tasks to evaluate motor abilities outside the speech domain in people who stutter. Methods: We recruited 19 adults who stutter (AWS, mild to severe stammer) and 18 fluent controls (CON) matched for age, handedness, and sex. The battery included: 1) Visuomotor adaptation - motor learning measure using visual feedback to update internal models and guide movements. Participants moved a cursor from the centre of a computer screen towards targets on the circumference of a circle. In the initial adaptation phase visual feedback was rotated 60° counterclockwise. After a delay, participants completed a second adaptation phase followed by a wash-out phase with no perturbation. The cerebellum is thought to facilitate this form of motor learning. 2) Reinforcement learning - participants learn by trial and error which stimulus in a pair is most likely to be rewarded. Learning of relative hierarchies was tested through recombining stimuli into novel pairs. Performance on this task is sensitive to dopaminergic function of basal ganglia nuclei. 3) Implicit sequence learning - reaction times improve for sequences of finger movements relative to random trials through practice. This form of procedural learning is thought to depend on the function of basal ganglia and higher-order motor regions including premotor cortex. 4) Bimanual coordination – the speed and accuracy of sequence tapping are measured, using both hands separately as well as in and out of phase with one another. This task requires interhemispheric interaction and depends on medial premotor cortex. Results: The primary finding of the study was reduced visuomotor adaptation in AWS relative to CON. All participants compensated for the perturbation by adapting their movements, but AWS showed significantly less error reduction than CON. The AWS were unimpaired relative to CON in the baseline, delayed adaptation, and wash-out phases. AWS and CON did not differ in reaction time, movement duration, or peak velocity during adaptation. The secondary finding of the study is slower self-paced movement reaction times in stuttering. Groups showed no difference in reinforcement learning accuracy, but AWS were slower than CON throughout the task. For the bimanual coordination task, AWS achieved significantly fewer taps than CON during the first sequences of inphase bimanual tapping. During implicit sequence learning, and visuomotor adaptation, both computer-paced, AWS were not slower than CON. Finally, several fluency measures correlated with motor performance. Conclusion: We found relatively poor error reduction during visuomotor adaptation in stuttering, suggesting AWS use sensory feedback to update their internal model more slowly and to a lesser extent than controls. These deficits mirror those seen in cerebellar lesion patients. Thus we provide evidence of cerebellar dysfunction in a developmental disorder in which sensory feedback influences speech fluency.

B65 Assessing error detection and correction abilities in patients with aphasia: MEG and behavioral evidence

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Recent neuroimaging research in healthy speakers suggests that the auditory system constantly monitors its own speech for small deviations from intended speech sounds, and that successful monitoring may drive an unconscious correction of these deviations before they are realized as errors. The current study investigates these processes in patients with aphasia, a disorder caused by damage to language-related brain regions. Eight persons with aphasia took part in a two-phase experiment aimed at assessing auditory feedback use in error detection and correction. The patients were between 50-73 years of age

(mean: 56.6; SD: 7.7), and had chronic aphasia (months post-stroke: mean = 68.6; SD = 28.3) with a mix of aphasia subtypes (Anomic: 4; Broca's: 3, Conduction: 1) and speaking abilities, which were assessed by the Western Aphasia Battery (WAB-R) and repetition subtests from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA). Phase 1 examined the ability of persons with aphasia to correct their speech online. The eight participants completed a behavioral experiment in which they produced 200 repetitions each of three monosyllabic words ("eat", "Ed", "add"). First and second formant trajectories for each vowel were calculated, time-normalized, and compared across productions for a measure of variability across the time course of the syllable. Acoustic variability at syllable onset was greater than previously found in healthy speakers, but in the majority of aphasic speakers, this variability decreased (was corrected) over the course of the syllable. The degree of formant correction was correlated with initial acoustic variability. This suggests that during correct syllable production, online feedback correction mechanisms are at work in at least a subset of persons with aphasia. However, it is unclear whether the same neural mechanisms underlie this correction in persons with aphasia and healthy speakers. The follow-up to phase 1 is a complementary analysis of auditory error detection ability, assessing the auditory cortical responses evoked during the production of deviant syllables. In phase 2, the aphasic patients undergo magnetoencephalographic (MEG) scans while producing and listening to the same syllables from phase 1. We use auditory cortical suppression during more deviant speech, compared with more prototypical speech tokens, as a measure of sensitivity to self-produced acoustic deviations. These complementary analyses will inform theories of error detection and correction in healthy speakers and models of error prevalence in persons with aphasia.

B66 Inner Speech with your own or someone else's voice. Cerebral correlates assessed with fMRI

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Introduction. Our daily experience is often punctuated by a little voice in our head, the inner speech, which plays a central role in human consciousness as an interplay between language and thinking (Morin, 2005). Our first question concerns the sensorimotor nature of inner speech and its relation with overt speech. The second question deals with the agency concept related to various inner speech perspectives such as imitating other people's voice, imagining conversations with other people and using the other's voice. Overall, we evaluated cerebral substrates involved in inner speech related to self and related to others. Methods. Participants: 24 right handed healthy participants (10 males, 29 years old ±10) native French speakers. MR Acquisition: Each subject completed two fMRI sessions, each including blocks testing 4 different tasks: inner speech production with self voice (ISS), inner speech with other's voice (ISO), imagining other speaking to us (IMA), speech perception of other (SP). Experiments were performed in a whole-body 3T MR scanner (Philips Achieva; gradient-echo/T2* weighted EPI). Data analysis. Functional MRI data analysis was performed using the general linear model (Friston et al., 1999) for block designs, as implemented in SPM12 (Welcome Department of Imaging Neuroscience, London, UK, www.fil.ion.ucl.ac.uk/spm). After preprocessing, the 4 tasks were modeled as 4 regressors convolved with a HRF function. We evaluated task-related cerebral networks using pairwise task contrasts computed with one sample t-tests (K=5, $p<0.05$ FWE corrected). Results. Contrasts between inner speech (ISS and ISO) vs. speech perception (SP) revealed greater left hemisphere activation within the inferior frontal, supplementary motor area, cingulate and prefrontal cortices during inner speech and greater activation of bilateral auditory cortices during SP. The contrast between auditory verbal imagery (IMA) and SP revealed a similar although less pronounced pattern. The comparison ISS vs. ISO did not reveal significant differences. However, at a lower threshold, this contrast induced greater activation within the left prefrontal gyrus in ISS and of the right thalamus in ISO. The comparison IMA vs. ISO revealed greater activation of the bilateral precuneus, right temporo-parietal junction and middle frontal gyrus. Discussion and Conclusions. Our findings, indicating stronger involvement of frontal regions and limited recruitment of temporal regions during inner speech, argues in favour of inner speech as a mental simulation of overt speech production. Shifting from self to the other's voice in terms of inner speech, revealed possible recruitment of the right thalamus, typically linked to empathy and evaluation of other's state. Shifting from self (ISS/ISO) to other's perspective (IMA) revealed a greater activation of the right temporo-parietal region, usually associated with processes distinguishing between self vs. other (Blanke, 2012; Saxe and Kanwisher, 2003). Overall, our results are consistent with the view considering that inner speech is a sensorimotor process involving articulatory and sensory representations, different inner speech modalities recruiting specific regions and processes.

Control, Selection, and Executive Processes

B67 Language deficits induced by topiramate (TPM) administration

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Cognitive impairment is a widely-reported side effect of many commonly-prescribed drugs. One such drug is topiramate (TPM), a second-generation anti-seizure drug that often causes significant speech/language problems. However, the nature of these deficits remains under-characterized, as does the extent to which their severity is dependent on plasma TPM concentration. The aim of the current study is to more accurately characterize TPM-induced language difficulties. Here, we test the hypothesis that TPM selectively impairs verbal working memory, resulting in performance deficits on tasks that assess verbal fluency. Twenty healthy adult subjects participated in a randomized, double-blind, crossover study comparing the effects of a single 100-mg dose of TPM to placebo. One hour after drug administration, subjects'

language abilities were assessed using the following measures: (1) semantic and phonemic fluency (COWA) tasks, (2) a picture description task, and (3) the MCG story-recall task. A single blood sample was drawn post-testing, enabling the examination of TPM concentration-dependent effects on performance (see Marino et al, 2012). Nine subjects had their EEG recorded while they performed a modified Sternberg task (memory loads: 1-3-5) to assess effects of TPM on working memory processes. Results showed that after receiving TPM, participants recalled fewer correct words on the MCG ($p=0.02$) than during their non-drug baseline, and that performance was negatively correlated with TPM concentration levels (Spearman's $\rho= -0.65$ $p=0.002$). On the picture-description task, TPM administration led to an increase in disfluency rate ($p < 0.01$), an effect positively correlated with TPM concentration levels (Spearman's $\rho=0.58$, $p=0.007$). The results from the COWA task also showed a negative effect of TPM on generative phonemic fluency ($p < 0.01$), but no correlation with TPM plasma concentration. Lastly, results from the Sternberg task showed that TPM led to increases in reaction time ($p < 0.01$) and error rates ($p = 0.037$). At memory load 5, TPM was associated with an increase in the amplitude of bilateral fronto-temporal negativity between 300–600 msec., an ERP response traditionally associated with working memory processes. This difference was not observed at lower memory loads. In addition, the average ERP difference (TPM – baseline) between 200–800 msec. correlated with TPM blood concentration and RT in response to the probe stimulus. These ERP results are consistent with the hypothesis that TPM selectively disrupts the verbal working memory system. In sum, the data show that TPM disrupts language at both lexical (COWA) and discourse (picture description) levels. These impairments appear to arise from the drug's negative impact on the working memory system, as participants were slower and less accurate on the Sternberg task, behavioral results that were concomitant with an increase in the amplitude of ERP indices of working memory processes. Taken together, these data elucidate the nature of TPM-induced language deficits. In addition, we have demonstrated the utility of pharmacological studies that employ both behavioral and temporally precise electrophysiological techniques as they have the potential to shed light on the neurobiological underpinnings of language and the manner in which it is processed in real time.

B68 Effects of varying cloze probability on prediction and integration during sentence processing

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Understanding sentences involves identifying single words, integrating those words into the grammatical and semantic structure of the unfolding sentence, and using situational and background knowledge to further comprehend the intended meaning. The interplay of information across these levels shapes online comprehension during sentence processing. Prior eyetracking work has shown rapid effects of sentence context on sentence-final spoken word recognition, with participants making anticipatory eye movements to potential objects following a constraining verb and showing less competition from phonologically similar words that are semantically inconsistent. While the effects of varying contextual constraint have been extensively studied in the ERP literature, existing fMRI studies of context effects on sentence comprehension have focused almost exclusively on activation differences between expected, unexpected, and anomalous sentence-final words in highly constraining sentence contexts. The goal of this study is to examine the effects of varying sentence constraint strength on brain activation during sentence processing, both during the accumulation of sentential information and upon encountering a sentence-final word that is either expected or unexpected given the prior context. Twenty-seven subjects performed an anomaly detection task on the final word of 120 sentences varying in cloze probability from 0 to 1. Sentence final words were expected, unexpected but sensible, or anomalous. Sentences were presented word-by-word, with each word presented centrally for 300ms with a 200ms ISI. A 2-6s delay between the penultimate and final word allowed separation of predictive processing from integration of the sentence-final word. Contextual constraint strength modulated activity during the sentence presentation and delay periods. Previous studies have suggested that left inferior frontal regions may exert top-down influence during sentence processing. Consistent with these results, we find increasing activity in LIFG as sentences become more constraining and predictive processing is more likely. The sentence's cloze probability had no effect on activation for expected words in moderately and highly constraining sentences. Activation during the integration of an unexpected word was affected by cloze probability, with increased activity for unexpected endings of high constraint sentences in left angular gyrus, left inferior and middle frontal gyri, and anterior and posterior portions of the middle temporal gyrus bilaterally. This result is consistent with findings suggesting that temporal lobe areas are propagating error signals to higher levels of processing. Similar frontal activation supports findings suggesting that disconfirmed strong predictions require reactivation of memory representations or other additional processing.

B69 The contribution of executive control to semantic cognition: Insights from semantic aphasia and dysexecutive syndrome

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Semantic cognition involves at least two independent components: (i) automatic spreading activation within conceptual representations, and (ii) controlled retrieval of knowledge to identify non-dominant but currently-relevant aspects of meaning. Semantic aphasia (SA) patients have deficits of semantic control that are correlated with general executive impairment. Neuroimaging studies reveal partial overlap between the 'multi-demand' executive network and areas implicated in semantic control; yet there is a degree of segregation which may permit neuropsychological dissociations. This possibility remains largely untested, since studies of patients with dysexecutive syndrome (DYS) have not previously examined tasks tapping semantic control or compared these impairments to those seen in SA cases. We

explored conceptual processing in 12 DYS patients and 24 SA patients, using a range of multimodal semantic assessments which manipulated control demands. The two patient groups were qualitatively similar on both semantic and domain-general executive tasks – for example, both showed strong effects of distracter strength, cues and miscues and probe-target distance, plus minimal effects of word frequency on comprehension (unlike semantic dementia patients with degradation of conceptual knowledge). However, there were also subtle differences between the groups: SA patients showed poorer semantic performance overall, while DYS patients showed additional evidence of an executive impairment – including more inconsistent performance. These differences reflect the importance of clinical classifications, even in patients with highly-overlapping cognitive deficits. Taken together, these findings support a component process account of semantic cognition in which retrieval is shaped by executive control processes.

Meaning: Prosody, Social and Emotional Processes

B70 Emotion and Spoken Language Generation

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Emotion perception and processing are crucial for everyday communication, as social contexts require the recognition and integration of emotional and social information. Models of spoken language production highlight a stage of "conceptual preparation", whereby a message is generated and formulated, before linguistic processes and overt articulation. Therefore, it is likely that the integration of emotional information occurs during the formulation of a message or conceptual preparation stage. The extent to which the valence and arousal of emotional information might influence conceptual preparation is unknown, however, evidence suggests that humans orient towards negative information and spend longer looking at negative stimuli. We investigated whether 1) subjects would require increased time to think of and generate a message when producing sentences in response to negative pictures compared with positive ones, and 2) whether this effect was independent of the arousal level of the picture. Participants (N=100) aged 18 to 81 years completed a task designed to elicit connected speech in response to 40 emotional pictures. Following a period of "thinking time", or conceptual preparation, a tone sounded as a cue to begin speaking. We measured the response latency for each picture (i.e., time after the tone before speech was produced). The results revealed significantly longer response latencies following negative pictures compared to positive ones. This effect remained significant when statistically controlling for the arousal level of the pictures. The results suggest that the emotional valence of information to which the subject is responding plays a role during conceptual preparation, with more negative information delaying the output of connected speech. The results further indicate that it is the negativity, rather than the arousal, of the pictures that is affecting conceptual preparation processes. This is the first evidence to suggest a role for emotional integration during the conceptual preparation stage of sentence generation.

B71 Early ERPs reflect "inner voice" experience in silent reading of direct versus indirect speech quotations

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Recent research shows that we are more likely to mentally simulate an "inner voice" during silent reading of direct speech quotations (e.g., Mary said: "This dress is lovely") as opposed to indirect speech quotations (e.g., Mary said that the dress was lovely). Such "inner voices" were reflected in increased activations of the temporal voice areas (TVAs; Belin et al., 2000) of the auditory cortex (Brück et al., 2014; Yao et al., 2011) and in modulations of reading speed by story contexts (Stites et al., 2013; Yao & Scheepers, 2011). The current study explored the time course of "inner voice" processing in silent reading of speech quotations using event-related potentials (ERPs). We prepared 120 quadruples of short stories as reading materials. They contained either a direct or an indirect speech quotation (Quoting Style manipulation) and each quotation was preceded by a context and a quotative verb that described either a loud-speaking (e.g., in a busy market; shouted) or a quiet-speaking (in a quiet library; whispered) quoted speaker (Loudness manipulation). Within each item, the quotations were identical between the loud- and quiet-speaking conditions, and were almost identical between the direct and indirect speech conditions (except for tense and pronoun changes). Four stimulus lists with counterbalanced item-condition combinations (30 stories per condition per list) were constructed and randomly assigned to equal numbers of participants. We expected to observe differential ERPs related to the Loudness manipulation in the direct but not indirect speech conditions (a 2-way interaction). In line with auditorily-evoked ERPs, we hypothesised that the loudness effects should appear in early time windows (e.g., N1: Engelien et al., 2000, P2: Jaworska et al., 2012) but not in late time windows (e.g., N400: Kutas & Hillyard, 1980, P600: van Herten et al., 2005) which are known to reflect semantic processing. Thirty-two participants silently read the stories and answered comprehension questions. The context sentences of each story were presented in paragraphs for self-paced reading and the critical quotation was presented word-by-word. ERPs were averaged by condition, time-locked to each word within the critical quotations. We observed significant Quoting Style × Loudness interactions in 225-275 ms and 375-475 ms latency windows. As expected, the ERP differences between loud- vs. quiet-speaking conditions were significantly larger in the direct speech than in the indirect speech conditions in both time windows. The interaction effects were topographically clustered around P2 in the 225-275 ms window which extended to the central channels in the 375-475 ms window. Preliminary source analyses suggest that these effects may originate from the left inferior frontal region (225-275 ms) and spread to the left parieto-temporal junction (375-475 ms). Our ERP data show for the first time that "inner voice" simulations in silent reading of direct speech quotations emerge in early time windows (~250 ms). The source analysis results suggest potential involvement of language production in "inner voice" simulations. Our findings are discussed in relation to ERP components that are known to reflect auditory, phonological and semantic processing.

Methods

B72 A novel neurolinguistic corpus of spontaneous speech production and concurrent electrocorticographic data

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A major aim of neurolinguistic research is to understand the neural basis of non-experimental real-life communication. To this end, a corpus that provides authentic, uninstructed and spontaneous speech data together with aligned neuronal recordings is necessary. Our aim was to test whether it is feasible to build up such a multimodal corpus using simultaneously recorded audio, video, and intracranial electrocorticographic (ECoG) data, which were obtained for pre-neurosurgical diagnostics of epilepsy at the University Medical Center Freiburg. Since ECoG has a high temporal and spatial resolution and is very robust against artefacts, it can reliably capture both the spatial organization and the temporal dynamics of the neuronal signals underlying the communication of the patients during their hospitalization. We pre-selected time periods in which patients with good coverage of language-relevant cortical areas, including Broca's area, the premotor cortex, the temporal lobe, the supplementary motor area, the parietal and the prefrontal cortex, were involved in conversations. On the basis of the audio signal, we transcribed the speech production of the patients with PRAAT according to the established GAT-2 conventions. In a next step, we selected all clauses that contained at least one finite verb and were produced within one intonation phrase and extracted the concurrent ECoG recordings. Based on these data, we conducted several linguistic analyses and included the results obtained from them in our corpus, such as information about the parts of speech, the syntactic constituents and the dependency relations in every selected sentence. Our corpus currently consists of the data of four patients, providing a total of 1700 sentences. Furthermore, the data of four additional patients have partly been processed. Special emphasis was set on the accuracy of transcription, ECoG tagging and linguistic analysis. As application of automatic tools did not always meet this requirement, we performed all processing and analysis steps manually. Due to the time-consuming nature of the process, we had to invest several years of work to reach this point. Dealing with the specific structures of spontaneous language and (in our case) its dialectal coloring posed a special challenge that complicated the application of automatic processing and analyzing tools. To further extend our corpus, an automatization and acceleration of the whole process would be desirable. Currently, we are working on an automatic segmentation of the audio signal into words. In conclusion, we created a multimodal corpus composed of audio, video and ECoG data that provides a unique opportunity to perform linguistically grounded studies on the neural basis of real-life speech production in the human cerebral cortex.

B73 Confound and control in language experiments

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Experimental research on the neurobiology of language depends on stimulus or participant selection where not all characteristics can be fully controlled, even when attempting strict matching. In linguistic stimuli, factors such as word frequency are often correlated with primary factors of interest, such as animacy, or other co-confounds such as word length. In clinical studies, factors such as intelligence or socioeconomic status are often correlated with pathology. Inferential statistics are often used to demonstrate that these confounding covariates do not differ systemantically between groups. For example, if word length is not significantly different for two conditions, they are considered as matched for word length. Such a test has high error rates and is conceptually misguided, both statistically and experimentally, yet is commonly used (67% of papers in a survey of recent Brain and Language issues). Statistically, it reflects a common misunderstanding of statistical tests: interpreting significance not to refer to inference about a particular population parameter, but about 1. the sample in question, 2. the practical relevance of a sample difference (so that a nonsignificant test is taken to indicate evidence for the absence of relevant differences). The correct way to control for this type of confound is to match descriptive statistics (measures of central location such as mean and median, as well as variance) and then include a 'nuisance' covariate in an appropriate statistical model, such as a mixed-effects model. The impact of the confound can be examined both by its associated model parameters and by comparison between models with and without the nuisance covariate. Experimentally, this form of narrow control fails to capture the reality of complex interactions and thus can not adequately discern between different, potentially interacting effects. For example, marked constructions are generally less frequent than unmarked ones, leading to the claim that observed differences in processing are frequency effects. In the traditional method of inferential-test based control, there is still some (hopefully, minimal) variation between experimental conditions that is not modelled. By modelling this frequency effect directly (e.g. with the help of mixed-effects models), we can examine the piecewise contributions from the experimental manipulation and the 'confound'. The (perhaps looser) control based on descriptive statistics is still nonetheless necessary here to minimise collinearity. An interation between an experimental manipulation and frequency thus provides evidence that the manipulation is not merely an artefact of frequency. Beyond these conceptual issues, we provide simulation results that demonstrate the high failure rate of inferential-test based confound control, both failing to detect spurious results arising from confounds and falsely rejecting real effects. Inferential testing is thus inappropriate both pragmatically and philosophically, yet widely applied. Incorporating potential confounds into our statistical models provides an easy alternative, especially in light of the recent trend away from ANOVA and towards mixed-effects and structural-equation models. Finally, the modelling of confounds allows to better examine the complex interactions present in real language use and to better distinguish between competing confounded explanations.

Writing and Spelling

B74 Learning to Read Alters Intrinsic Cortico-Subcortical Cross-Talk in the Low-Level Visual System

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INTRODUCTION fMRI findings have revealed the important insight that literacy-related learning triggers cognitive adaptation mechanisms manifesting themselves in increased BOLD responses during print processing tasks (Brem et al., 2010; Carreiras et al., 2009; Dehaene et al., 2010). It remains elusive, however, if the cortical plasticity effects of reading acquisition also lead to an intrinsic functional reorganization of neural circuits. METHODS Here, we used resting-state fMRI as a measure of domain-specific spontaneous neuronal activity to capture the impact of reading acquisition on the functional connectome (Honey et al., 2007; Lohmann et al., 2010; Raichle et al., 2001). In a controlled longitudinal intervention study, we taught 21 illiterate adults from Northern India for 6 months how to read Hindi scripts and compared their resting-state fMRI data with those acquired from a sample of 9 illiterates, matched for demographic and socioeconomic variables, that did not undergo such instruction. RESULTS Initially, we investigated at the whole-brain level, if the experience of becoming literate modifies network nodes of spontaneous hemodynamic activity. Therefore, we compared training-related differences in the degree centrality of BOLD signals between the groups (Zuo et al., 2012). A significant group by time interaction ($t_{max} = 4.17$, $p < 0.005$, corrected for cluster size) was found in a cluster extending from the right superior colliculus of the brainstem (+6, -30, -3) to the bilateral pulvinar nuclei of the thalamus (+6, -18, -3; -6, -21, -3). This interaction was characterized by a significant mean degree centrality increase in the trained group ($t(1,20) = 8.55$, $p < 0.001$) that did not appear in the untrained group which remained at its base level ($t(1,8) = 0.14$, $p = 0.893$). The cluster obtained from the degree centrality analysis was then used as a seed region in a voxel-wise functional connectivity analysis (Biswal et al., 1995). A significant group by time interaction ($t_{max} = 4.45$, $p < 0.005$, corrected for cluster size) emerged in the right occipital cortex (+24, -81, +15; +24, -93, +12; +33, -90, +3). The cortico-subcortical mean functional connectivity got significantly stronger in the group that took part in the reading program ($z = 3.77$, $p < 0.001$) but not in the group that remained illiterate ($z = 0.77$, $p = 0.441$). Individual slopes of cortico-subcortical connectivity were significantly associated with the improvement in letter knowledge ($r = 0.40$, $p = 0.014$) and with the improvement word reading ability ($r = 0.38$, $p = 0.018$). CONCLUSION Intrinsic hemodynamic activity changes driven by literacy occurred in subcortical low-level relay stations of the visual pathway and their functional connections to the occipital cortex. Accordingly, the visual system of beginning readers appears to go through fundamental modulations at earlier processing stages than suggested by previous event-related fMRI experiments. Our results add a new dimension to current concepts of the brain basis of reading and raise novel questions regarding the neural origin of developmental dyslexia.

Poster Session C

Perception: Auditory

C1 Cortical encoding of speech intonation on human superior temporal gyrus

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Speech intonation plays a crucial linguistic role in human vocal communication, conveying information that is not explicit in word choice or syntax. For example, in English, rising pitch at the end of an utterance can turn a statement into a question (e.g. "Anna likes oranges" vs. "Anna likes oranges?"). Local changes in pitch, called pitch accents, can also change sentence semantics through emphasis. For example, "ANNA likes oranges" answers the question "Who likes oranges?", while "Anna likes ORANGES" answers the question "What does Anna like?". In each case, changing only the pitch trajectory causes the same sequence of words to have different meaning. Despite the importance of intonation in language comprehension, we have only a limited understanding of how different intonation contours are represented in human auditory cortex and how intonation affects the neural encoding of phonetic content. To investigate these questions, we created a set of sentences with linguistically distinct pitch contours from four sentences matched for syllable duration and overall intensity. The intonation conditions were Neutral, Question (rising pitch on last word), Emphasis 1 (pitch accent on the first word), and Emphasis 3 (pitch accent on the third word). Baseline pitch and formant values for each sentence were manipulated to create three speakers (two female, one male). Using electrocorticography, we recorded neural activity (high-gamma, 70-150Hz, analytic amplitude of the local field potential) from the cortical surface of human participants as they listened to these sentences. We found that local neural populations on the superior temporal gyrus (STG) showed activity that differentiated intonation contours regardless of phonetic content or speaker identity. These populations were spatially distinct from regions that encoded phonetic content or speaker identity. In addition, intonation did not affect the representation of phonetic features, such that phonetically selective electrodes had the same response to phonetically identical sentences with different intonation contours. This result points to a possible neurophysiological origin for the dissociability of clinical aphasia and aprosodia. Because neural activity patterns on intonation electrodes were similar in response to speakers with different baseline pitch values, the results cannot be attributed exclusively to differences in absolute pitch level between intonation conditions. However, they could still be explained by encoding of relative pitch, which is normalized by speaker. Using a separate speech corpus (TIMIT) containing sentences spoken by hundreds of male and female speakers, we fit temporal receptive field models that predicted neural activity from absolute and relative pitch values simultaneously. We found that neural discriminability of intonation contours on single electrodes was significantly correlated with relative pitch encoding, while discriminability of speakers was associated with absolute pitch encoding. Our results indicate that the cortical representation of speech intonation is locally encoded in STG, is phoneme and speaker invariant, and is associated with the encoding of relative pitch, a more abstract feature than absolute pitch. This invariant representation of intonation provides a neurobiological basis for a listener's ability to recognize phonologically identical pitch contours despite variation between speakers and sentences with different verbal content.

C2 Online Modulation of Neural Pitch Encoding in Tone Language Speakers at Subcortical Levels

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We examined Frequency-following responses (FFRs), which reflect phase-locked responses from neural ensembles within the auditory system, to assess the extent to which neural encoding of lexical tone, pitch patterns that differentiate lexical meaning in tone languages, is modulated by different patterns of listening context. Specifically, we compared neural pitch encoding of a lexical tone when it is 1) unpredictable in a variable context, 2) predictable in a repetition context, and 3) predictable in a patterned context. The availability of context is a fundamental property of language. Co-occurrence of linguistic elements as fundamental as phoneme sequences is seldom random nor repetitive but is structured into linguistic patterns. How human auditory system takes various patterns as context in spoken language processing is a major question in language neuroscience. Yet, not much research has focused on its role at subcortical levels. The recent Predictive Tuning (PT) model postulates that spoken language processing as early as at subcortical levels is sensitive to stimulus patterns through continuous, online modulation of bottom-up signals based on short-term stimulus history. The PT model argues that subcortical context-dependent modulation does not just involve local processes that enhance representation of novel information, but crucially, top-down mechanisms that predict and update incoming stimulus regularities through corticofugal pathways. We thus hypothesised that due to PT, a predictable listening context would enhance online plasticity of the same stimulus compared to when context is unpredictable. However, if predictability is uniform, online plasticity of the stimulus would be weakened when presented as a repeating stimulus rather than a novel stimulus. FFRs were recorded from twenty-four Cantonese speakers listening to Cantonese Tone 4 syllables /ji4/(T4) presented in three context conditions. In the variable condition, T4s were randomly presented within the context of syllable-matched trials of Tone 1 (T1,/ji1/) and Tone 2 (T2,/ji2/). In the repetitive condition, T4s were presented continuously. In the patterned condition, each T4 trial was presented in a patterned sequence of one T1 followed by one T2. We compared event-matched FFRs to T4 from the variable condition with the repetitive condition, and separately, event-matched T4 FFRs from the patterned condition with the repetitive condition. As predicted, results show that neural pitch tracking was more faithful, and phase-locking overall was more efficient (i.e. faster) when listening context was predictable, indicated by higher Stimulus-response-correlation (SRC) ($t(23),-3.086,p=.005$), lower Pitch Error ($t(23),2.964,p=.007$), and earlier FFR onset latency ($t(23),2.116,p=.045$) in repetitive condition relative to variable condition. Results further show that when predictability was constant, neural pitch tracking was more faithful when listening context was not repetitive, indicated by even higher SRC in patterned condition relative

to repetitive condition (t(23),2.21,p=.037), in both conditions T4 occurred with the same probability. These results extend previous findings on context-dependent neural encoding of speech. They suggest robust influence of prior predictable listening context that enhances neural encoding of lexical tone, a dynamic aspect of speech that spans a whole syllable. Together, this study lends further support to the PT model, and sheds light on the role of predictability and patterns in spoken language processing.

C3 Encoding and Organization of Phonemes by Feature in STG

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Recent studies have found evidence for neurons within the superior temporal gyrus (STG) encoding groups of phonemes by phonetic feature (e.g. manner, location, etc.). Though the exact spatial distribution of phonetic feature detectors was unique to each subject, the organization of neurons relative to phonetic similarity was consistent (Mesgarani et al., Science 343:1006-10, 2014; Chang et al., Nat Neurosci 13:1428-32, 2010). These studies examined high gamma responses from cortical-surface electrodes with electrocorticography (ECoG) and lower frequency, theta and gamma band responses from scalp electrodes using electroencephalography (EEG) (Di Liberto et al., Curr Biol, 25:2457-65, 2015). In the present study, we aimed to replicate the previous findings using magnetoencephalography (MEG), analyzing both sensors and (reconstructed) sources. Can we find sensors and sources responding at high gamma frequency at around 100 ms post phoneme onset that are sensitive to distinctive features, and can we replicate the theta-band sensitivity on sensors in the same time window observed in EEG? Three subjects were presented with 498 sentences from the TIMIT corpus (Garofolo et al., Linguistic Data Consortium, 1993), identical to those used in Mesgarani et al. (2014). Each sentence was followed by a word memory task. Data were noise-reduced, downsampled to 500 Hz and z-scored before being processed with MNE-Python. Overlapping analysis epochs were defined relative to the onset of each phoneme, resulting in a matrix of responses to each phoneme for each subject, at each millisecond, for each sensor or reconstructed source for each frequency band under analysis. Data are being processed through an adapted version of the script used in Mesgarani et al. (2014) to compute the phoneme selectivity index (PSI) for sensors as well as for reconstructed sources in the superior temporal areas in each subject. The analysis will be repeated for the high gamma (75-150Hz) band used in Mesgarani et al. (2014) as well as for the theta and gamma bands identified by Di Liberto et al. (2015). In addition, we will replicate the analysis of Di Liberto et al. (2015) by computing the relation between the feature and spectrogram representation of speech sounds (FS) and the evoked MEG response at each sensor and at each of our reconstructed sources in STG, creating a multivariate temporal response function (mTRF). The correlation between the predicted MEG signal given the FS and the actual signal provides an index of sensor/source sensitivity to phoneme identity at particular time windows and can test for the localization of phoneme-sensitive sources in STG at 100 ms+ post-phoneme onset. The results will help determine the feasibility of using MEG to analyze high gamma responses, linking MEG to ECoG and the organization of spike-trains in clusters of neurons. The spatial resolution of MEG as compared to ECoG can be assessed for a known cortical response.

C4 Effects of Speaker and Listener Accent on Speech Perception Measured by Cortical Auditory Evoked Potentials

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Accent differences affect speech recognition, with listeners finding it easier to understand speech spoken with an accent like their own, and more difficulty when the accent is unfamiliar. Most work has examined the role of accent in higher-level linguistic processing (e.g., phonetic categories), but our current work has investigated how the listener's accent influences both early auditory-cortical P1-N1-P2 responses and the later N400. Furthermore, we have explored how neural oscillations are entrained to amplitude envelopes (phase coherence) of attended and unattended speech signals of different accents. In one study, listeners with different English accents (southern British English, Glaswegian, native Spanish speakers) heard random series of concatenated southern British English vowels, and EEG was used to record the cortical auditory evoked potentials in response to each vowel spectral change. There were different patterns of responses for the listener groups, with the non-native English listeners (Spanish) having smaller responses overall to English vowels, and Glaswegian listeners having smaller responses than Southerners only for vowel contrasts that are realised differently between the two accents (e.g., beat-bit). However, there were fewer accent related differences for the N400 or phase coherence data. The results thus add to the evidence that language experience can have effects at early levels of auditory processing rather than only affecting linguistic categorisation.

Perception: Speech Perception and Audiovisual Integration

C5 Auditory Bubbles: A tool for measuring perceptual and neural representations of speech acoustics

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A crucial challenge in language neuroscience is to describe the mechanism by which linguistic information is extracted from the acoustic speech signal and represented in the auditory nervous system. This is particularly difficult in light of the fact that acoustic speech features do not map straightforwardly to linguistic representations. Further, neural coding of the likely information-bearing elements of the speech signal – frequency sweeps, amplitude modulations, etc. – has been described largely in terms of the neural response to simple synthetic stimuli, rather than the speech signal itself. We describe a paradigm, Auditory Bubbles (aBub), that uses a single representational space – the spectrotemporal modulation domain – to link linguistically relevant aspects of speech acoustics to perceptual and neural representations of speech. Spectrotemporal modulations (STMs) are fluctuations in speech energy across time and frequency that are known to convey linguistic information. Additionally, the receptive fields of auditory neurons can be described in terms of a preferred response to particular STMs. Briefly, aBub is a classification

procedure designed to identify the particular STMs that support accurate speech perception and/or maximally drive the neural response to speech. The procedure works by filtering STMs from the speech signal at random over many experimental trials and relating the filter pattern to an outcome measure – e.g., word recognition performance or amplitude of neural activation – in order to measure which STMs drive differences in the outcome measure. In previous work we have used this procedure to demonstrate that temporal modulations < 15 Hz and spectral modulations < 3 cyc/kHz contribute maximally to speech intelligibility. Here, we present two new applications of aBub: (1) classification of the STMs that support 2-AFC emotion identification of jabberwocky sentences spoken with happy vs. sad emotional prosody; (2) classification of the STMs that maximally drive single-trial activation of fMRI voxels in the auditory cortex during sentence comprehension. Focusing primarily on (2), we show that the receptive fields of many auditory cortical voxels are significantly tuned to particular STMs. In particular, these "modulation receptive fields" are maximally tuned to the relatively slow STMs that support intelligibility. However, other STMs are also emphasized – namely, STMs related to vocal pitch (faster spectral modulation rates) and STMs potentially related to phoneme segmentation (temporal modulation rates > 30 Hz). We further show that modulation receptive fields vary across regions of the auditory cortex (e.g., Heschl's gyrus vs. the STS). We propose that aBub provides a methodological framework in which linguistically relevant aspects of speech acoustics can be linked to perceptual and neural representations via STMs.

C6 Timing predictions in speech can be based on phoneme- or word-onset

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Human speech processing benefits from predictive processes that can be based on information about speech sound identity or timing. In electrophysiological research, predictive processing can be probed by the omission of speech sounds embedded in words, resulting in an automatic change detection response, termed "omission mismatch negativity" (OMMN). Previous studies have shown that the amplitude of the OMMN increases with predictability of the identity of the omitted speech sound. The role of temporal predictability in speech-related OMMN experiments has not yet been examined. Timing predictions can either be generated at the word-level, i.e. when words are presented at a regular rate (fixed stimulus onset asynchrony [SOA]), or at the phoneme level, i.e. when speech sounds within a word follow each other in regular intervals (fixed phoneme onset asynchrony [POA]). To study those two possibilities, we manipulated both SOA and POA in a passive oddball paradigm, where the German noun Lachs ([laks], 'salmon') occurred as frequent standard, and the fragment La– (with the omission of the consonant cluster [ks]) occurred as rare deviant. We also provided conditions with standard-deviant reversal in order to be able to calculate the OMMN on the basis of the same physical stimulus (so-called identity MMN). In a 2-by-2 design, levels of SOA and POA were either fixed or variable (in 16 equi-probable steps corresponding to 2% of the center durations). We entertained the following three hypotheses: (1) OMMN amplitudes are reduced by variable SOA (i.e., word onset temporally unpredictable); (2) OMMN amplitudes are reduced by variable POA (i.e., phoneme onset temporally unpredictable); (3) OMMN amplitudes show an interaction of the effects of SOA and POA. Standard-deviant trains were presented to 19 native German speakers while their brain electric response was registered by 64 active electrodes. Across all four conditions, standard and deviant responses significantly differed between 110 and 160 ms post deviance onset, i.e. after the point in time when full-word standards differed from deviant fragments. The OMMN was measured within this time frame; it showed a typical fronto-central topography and sources in left superior temporal gyrus. Mean OMMN amplitudes in the four conditions were subjected to a repeated-measures analysis of variance (ANOVA) with the 2-level factors POA and SOA. Results revealed an interaction of POA and SOA that was due to significantly lower OMMN amplitudes for stimuli with variable POA and variable SOA than for stimuli in any of the other three conditions. This lends support to hypothesis (3) and suggests that timing predictions can be made (and hence OMMN amplitude is retained) at the word- or phoneme-level, but not when predictability is missing at both levels. Entirely unpredictable timing of phonemes apparently generates a weaker speech sound prediction whose violation is less severe, as indexed by an attenuated OMMN response that can be considered the reflection of a reduced prediction error. The pattern of results supports the view that temporal predictions in speech processing operate both on a phoneme- and a word-level.

C7 Multi-level representations in speech processing in brain and machine: Evidence from EMEG and RSA

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Introduction. Human speech comprehension is an important test case for examining the relationship between the neurobiological systems supporting human cognition and emerging computational systems capable of emulating these capacities. Human listeners can accurately identify words in a continuous, noisy speech input, but there is only limited neurocomputational understanding of how this is achieved. Machine-based automatic speech recognition (ASR) systems are approaching human levels of accuracy. These systems are built strictly on engineering principles but provide a computationally specific model of successful speech-to-lexicon mapping. Here we ask whether ASR-derived models of speech recognition can be linked to the human solution. To do so we relate dynamic brain states in the human listener to dynamic machine states in a candidate ASR system. Simultaneous electro- and magneto-encephalography provides high-resolution recording of real-time neural activity. Multivariate representational similarity analysis (RSA) makes it possible to compare brain and machine responses at the appropriate level of abstraction [1,2]. Low-level perceptual representations

of speech are transformed in bilateral superior temporal cortex into a set of non-perceptual features [3,4], providing an intermediate representation of speech for mapping onto lexical representations. Here we use an ASR system to generate a comparable intermediate representation, and test the fit of this model to human brain responses in temporal cortex. We contrast this with a lower-level model capturing the basic acoustic-phonetic properties of speech. Methods. We produced two dynamic test models derived from the deep neural network (DNN) component of HTK, an ASR system. The DNN reads mel-frequency cepstral coefficients (MFCCs) at its input layer, and has five fully-connected 1000-node hidden layers, followed by a 26-node "bottleneck" layer. The bottleneck layer compresses the speech representation to a low-dimensional code for input to a phonetic output layer. We used the MFCCs to create models representing low-level acoustic properties of speech, and the bottleneck code to create models of an intermediate-level representation. Each of these models was tested incrementally against brain data representations in bilateral superior temporal cortex. Results. The MFCC and bottleneck models each showed significant fit to neural response patterns in non-overlapping regions of left temporal cortex. The MFCC model generated fit in Heschl's gyrus from word onset until +120ms. The bottleneck model showed more extensive fit in superior temporal gyrus, from +40ms to +110ms. These regions have frequency-selective and phonetic-feature-sensitive properties [2–4]. Conclusions. Early auditory processing is a key step in speech comprehension. The two models tested relate to the low-level perceptual features of the speech and to a higher-level ASR-based abstracted encoding set. While the low-dimensional space of the bottleneck layer is based on engineering considerations, it is suggestive of a similarly low-dimensional representation of speech in the brain, warranting further investigation. Multivariate pattern analysis techniques allow the comparison of information representations from different modalities. Through them, we have demonstrated that human and machine responses can be directly compared in the auditory domain. References. [1] Su et al. PRNI, IEEE (2012). [2] Su et al. FrontNeurosci (2014). [3] Mesgarani et al. Science (2014). [4] Wingfield et al. OHBM (2016).

C8 Intracranial recordings reveal modulation of high gamma activity in primary auditory cortex during speech pop-out

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INTRODUCTION: Speech comprehension under adverse listening conditions can be enhanced by speaker familiarity, semantic context, and concurrent visual information (Miller et al., J Exp Psychol 41:329-35, 1951; Nygaard & Pisoni, Percept Psychophys 60:355-76, 1998; Sumby & Pollack, J Acoust Soc Am 26:212-5, 1954). In the case of noise-vocoded sentences that lack much of the fine spectrotemporal detail present in clear speech, matching written text can facilitate perceptual "pop-out" of the impoverished signal (Sohoglu et al., J. Neurosci 32:8443-53, 2012; Wild et al., Neuroimage 60:1490-502, 2012). In these cases, sentences are reported as less noisy than when heard alongside non-matching text. fMRI work has shown that the haemodynamic response in primary auditory cortex is elevated when noise-vocoded sentences are heard with matching compared to non-matching text, suggesting that early cortical stages of auditory processing can be modulated by non-auditory information in support of speech comprehension (Wild et al., 2012). In the current study, we analysed a more direct measure of neural activity during perceptual pop-out. METHOD: Intracranial recordings were made from a 33 year old male patient undergoing monitoring to establish the sources of epileptic activity. Coverage included depth electrodes implanted in Heschl's gyri (HG) of both hemispheres. In each trial, lasting around 13 s, the subject was presented with an auditory sentence (clear or 3-channel noise-vocoded), then with written text, followed by a repeat of the auditory stimulus. In the clear speech case, the written text always matched the auditory sentence; in the noise-vocoded cases, written text could be matching or consist of meaningless consonant strings. To ensure visual and auditory attention were engaged throughout, the subject was asked to detect occasional capital letters in the written text, and was warned that memory for the sentences would be tested at the end of the experiment. At each recording site, changes in event-related (evoked and induced) power in the high gamma (75-150 Hz) range were computed over the first 500 ms of the neural response to each of the auditory presentations, relative to a pre-stimulus baseline, and compared by auditory/visual condition and presentation number. RESULTS: Neural responses varied considerably across recording sites in magnitude and in sensitivity to whether the speech was clear or noise-vocoded. High gamma responses to noise-vocoded speech were averaged over the six contacts in postero-medial HG (two in the left hemisphere, four in the right hemisphere), most likely to be recording from primary auditory cortex. A mixed-model ANOVA revealed a significant cross-over interaction between text type and presentation number. This reflected an increase in high gamma power from the first to the second presentation when the written text matched the auditory stimulus, compared to a decrease when the text was non-matching. CONCLUSIONS: Provision of informative written text resulted in increased high frequency neural activity within primary auditory cortex that may underlie perceptual pop-out of degraded speech. The stimuli and experimental design rule out these effects being driven by acoustic differences or mere repetition. The findings may have implications for predictive accounts of perception and its neural underpinnings.

C9 Interactions between oscillatory power in fronto-parietal regions and prosodic entrainment in auditory areas

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The timing of slow auditory cortical activity aligns to the rhythmic fluctuations in speech. This entrainment is considered as a marker of the prosodic and syllabic encoding of speech, and has been shown to correlate with intelligibility. Yet, whether and how auditory entrainment is influenced by the activity in other speech–relevant areas remains unknown. We analysed MEG data of 23 participants who listened to a 7-min long story, and computed auditory delta- and theta-entrainment using mutual information. We then quantified the dependency of auditory entrainment on the oscillatory activity in seven frequency bands (delta to gamma) in fronto-parietal regions,

parcellated using the AAL atlas. We found that auditory delta-speech tracking (i.e., prosodic entrainment) interacted with three distinct networks. First, entrainment in the left anterior superior temporal gyrus (STG) was modulated by beta power in orbitofrontal areas, likely reflecting top-down predictive modulations of auditory encoding. Second, entrainment in the left Heschl's Gyrus and anterior STG was dependent on alpha power in central areas, in line with the importance of motor structures for phonological analysis. And third, entrainment in the right posterior STG modulated theta power in parietal areas, consistent with the engagement of memory processes during challenging listening moments. These results illustrate the topographical network-interactions of prosodic entrainment and reveal distinct cross-frequency mechanisms by which auditory delta-entrainment interacts with cognitive functions related to predictions, rhythm, and memory.

C10 MEG oscillation of auditory mismatch responses to changes in phonemes and f0 contours

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Introduction: In studies of speech perception, the mismatch response is a substantial index measured by contrasting EEG/MEG activities of hearing deviant sounds with that of hearing standard sounds. Studies have analyzed EEG/MEG oscillations and demonstrated that the mismatch response is associated with increased activities in the theta and alpha bands, regardless that deviant stimuli are different from standard stimuli by manipulating voice-onset times, types of vowels, or the contour of f0. These findings seem to be counterintuitive with respect to the multi-timescale model which has suggested different processes for multiple units of speech sounds. Specifically, this model suggests that oscillation activities in beta and gamma bands would be relevant to the processing of phoneme-based units, and oscillation activities in delta and theta bands would be relevant to the processing of syllable-based units. The present study aims to evaluate whether the multi-timescale model would account for the oscillation of the mismatch responses. Methods: Brain activity was recorded continuously by a 157-channel MEG system while thirteen native Mandarin speakers passively listened to speech sounds in a multiple-deviant oddball paradigm. The standard stimulus was a syllable "pu" pronounced in the low-dipping tone (pu3) and the deviant stimuli were the consonant-deviant (ku3), the rime-deviant (pi3), and two types of tone-deviant (pu1, the high-level tone; pu2, the raising tone). Tone-deviant stimuli were further defined as large tone-deviant (pu1) and small tone-deviant (pu2) as their f0 contours are dissimilar and similar to the f0 contour of "pu3", respectively. The duration of each stimulus was 250 ms. Time-frequency (TF) spectra were estimated using signals from each sensor for each trial. Then, the averaged TF spectra were calculated for each stimulus type for each participant. The cluster-based nonparametric statistical analyses were performed by contrasting TF spectra (0 to 40 Hz for 0 to 500 ms after onsets of stimuli) of standard stimuli with that of each type of deviant stimuli. Results: All deviant stimuli yielded significant clusters with increased activities in the theta bands and alpha bands, which replicated previous results of MMN studies. In high frequency bands, the onset-deviant yielded increased gamma activities (30-40 Hz) during 0-100 ms after onsets of stimuli in the posterior-central scalp. For rime-deviant, it also elicited decreased activities in low beta (12-Hz) and high beta (20-30 Hz) bands during 100-500 ms across the scalp, and decreased gamma activities during 100-500 ms in the frontal-central scalp. For tone-deviant, large tone-deviant yielded decreased high-beta activities during 100-500 ms in the right posterior scalp. For small tone-deviant, it yielded decreased low-beta activity during 100-200 ms in the right frontal scalp and decreased high-beta activity during 100-200 ms in the bilateral frontal scalp. Conclusion: The results demonstrated that changes in phoneme-based units yielded mismatch responses in beta and gamma bands. On the other hand, the mismatch responses to changes in f0 contours were mainly associated with the beta band activities in the right hemisphere. These findings suggest that assumptions of the multi-timescale model might account for the processing of acoustic change detection.

C11 How language experiences influence the cognitive and neural oscillatory mechanisms of predictive language processing

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It's well established that predictive processing plays a very important role in language comprehension. The language processing system not only needs to integrate the current predicted/unpredicted word into its preceding context (integration-stage) but also generates hypothesized representation of this word before it appears (anticipation-stage). Although numerous psycholinguistic studies have examined the integration-stage of predictive processing, there is also more need to be learned about the anticipation-stage of predictive processing. This EEG (electroencephalograph) study aimed to investigate the cognitive-neural mechanisms underlying the anticipatory-stage of predictive language processing, and more importantly, to investigate the effect of language experiences on anticipatory language processing. Mandarin Chinese spoken sentences were used as stimuli. On the one hand, the sentences have a strongly or weakly constraining context (high-prediction vs. low-prediction), with the critical nouns in the sentences being highly or lowly predictable. Importantly, the critical noun in each sentence is preceded by two words (a critical verb + an adjective); the critical verb plays an important role in triggering the generating of the incoming critical noun. Therefore, the period from the onset of the critical verb to the onset of the critical noun reflects the anticipation-stage of predictive processing, and the period after the critical noun appearing reflects the integration-stage of predictive processing. On the other hand, the sentences were spoken with native dialect (NA-dialect), non-native dialect that the participants are familiar with (NNF-dialect), or non-native dialect that the participants are not familiar with (NNN-dialect). The results time-locked to the critical nouns (integration-stage) showed that, as compared to the low-prediction condition, the high-prediction condition elicited a reduced negativity (N400) under all of the dialect circumstances (NA-dialect, NNF-dialect, and NNN-dialect) and additional reduced N1 and decreased theta power (4-7 Hz) under the NA-dialect condition, which indicated that the facilitating effect of prediction on the

integration-stage of processing is more pronounced under the native dialect circumstances. More importantly, the results time-locked to the critical verbs (anticipation-stage) revealed that, under the NA-dialect circumstances, the high-prediction condition (as compared to the low-prediction) still elicited a reduced N400 and decreased theta power, which suggested that strongly constraining context also has a facilitating effect on anticipatory processing when listeners are confronted with their native dialect; in contrast, the high-prediction condition elicited an enhanced sustained anterior negativity under the NNF-dialect circumstances and enhanced beta power (19-25 Hz) under the NNN-dialect circumstances, which suggested that listeners might be using more cognitive resources to maintain the already generated hypotheses when confronted with non-native but familiar dialect, and be recruiting more neural resources to generate hypotheses when confronted with non-native and unfamiliar dialect. In summary, language experiences modulate the cognitive and neural mechanisms underlying predictive language processing, especial the anticipation-stage of predictive processing, where the native dialect speakers can generate prediction automatically, while, the non-native dialect speakers must use more cognitive and neural resources. That is, the cognitive mechanisms and neural oscillatory signature of anticipatory language prediction change dynamically as the long-term language experiences changes. Key words: predictive language processing; sentence comprehension; brain oscillations; anticipation

Multilingualism

C12 Tracking syntactic conflict between languages over the course of L2 acquisition: A cross-sectional ERP study

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One particularly difficult aspect of learning a foreign language (L2) in adulthood is the mastery of L2 syntactic structures that are in direct conflict with those of one's native language (L1). This may be especially the case for L1-L2 combinations of highly related languages, for which cross-language transfer is not only an obvious, but also a generally successful strategy. As an instance of such a syntactic conflict between highly similar languages, we investigated how German learners of Dutch processed sentence-final double infinitives as in "Ik heb de vaas laten vallen" (literally 'I have the vase let fall'), for which in German the two infinitives would be in reversed order ("…fallen lassen"). Additionally, we tested in a cross-sectional fashion how processing of these structures develops over the L2 acquisition process. To this end, we presented correct ("…laten vallen") and incorrect, but 'German-like' ("... vallen laten") versions of these sentences to three groups of German learners of Dutch. The first group (N = 18) had just completed an intensive five-week language course; the other two groups had been immersed in Dutch for six (N = 23) or 18 months (N= 20) respectively. A control group of native speakers of Dutch (N = 23) was also tested. Participants read Dutch sentences and made grammaticality judgments while EEG measurements were recorded. Even though accuracy in the grammaticality judgments was native-like and comparable between all L2 groups, the observed ERP patterns changed as a function of length of immersion. While beginners showed a broad and extended N400-like effect and no P600 to incorrect sentences, this pattern changed towards a reduced N400 and a larger, earlier, but not quite native-like P600 in the more advanced groups. ERP effects were native-like in the two advanced groups for a control structure that is implemented the same in Dutch and German (subordinate clause inversion). The beginner group, in contrast, also showed an N400-like effect in the control condition. Results indicate that conflicts between word order rules in L1 and L2 do indeed remain an obstacle to native-like processing, even in advanced L2 learners and when behavioral performance is already native-like. Additionally, our findings indicate that beginning learners employ different neurocognitive mechanisms in L2 syntactic processing in general, regardless of the structural similarity of L1 and L2.

C13 The role of uncertainty in electrophysiological correlates of error detection and feedback processing during second language learning

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Humans monitor their behaviour to optimize performance, but when stable representations of correct responses are not available, self-monitoring of errors can go awry. During second language (L2) learning, stable representations have yet to be formed while knowledge of the native language can interfere with learning, yielding uncertainty. Not having access to or being uncertain about a representation can result in a failure to detect errors internally, reflected by the absence of an Error Related Negativity (ERN) for errors. Instead, learners rely on external feedback for error detection, which elicits a Feedback Related Negativity (FRN). The present study considers how feedback shapes internal error detection and learning in a learning situation where confident error detection is a process in development and certainty regarding response correctness is low. We therefore examined if error responses of L2 learners show signs of error detection before and after receiving feedback and whether the size of the FRN can predict an improvement in subsequent behavioural performance. These questions were addressed by testing the assignment of grammatical gender in German L2 learners of Dutch. Participants performed a 2AFC task in which they decided on the correct determiner ('de'/'het') for Dutch nouns while their EEG was measured; targets were Dutch-German cognates whose gender is incongruent between the two languages that are known to generate many errors. Every response was followed by feedback and the same nouns were repeated in three rounds, such that participants had a chance to improve their performance. Behavioural accuracy showed improved performance after every round of feedback, while the EEG data demonstrated FRN and P3 effects in response to unexpected feedback across all three rounds. Feedback-locked data furthermore tentatively suggest that behavioural learning can be predicted by the size of neural responses to feedback in the previous round. Moreover, the EEG indicated increasing signatures of error detection in the form of a small ERN in the course of learning. Yet, the occurrence of a persistent and large Correct Related Negativity component (CRN) following behavioural improvement suggests that learners experienced great difficulty regarding correct use of

determiners. These results indicate that persistent errors can be corrected rapidly, accompanied by ERP signatures that point to internal error detection during learning. The findings do stress such monitoring is subject to uncertainty during learning, which may explain why previous studies found little evidence for internal error detection during L2 acquisition. In a follow up study, we currently examine whether the occurrence of a large CRN during learning is a reflection of uncertainty while representations are unstable.

C14 The linguistic relativity of time

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The Linguistic Relativity Hypothesis (LRH), formulated in the wake of Whorf's ideas (1956), proposes that the language one speaks shapes the way one thinks. Languages refer to time in different ways. For example, whilst temporal information is mandatorily provided by tense in English, such information is not necessarily provided in Chinese (Smith 1991). Here we set out to test whether cross-linguistic differences between Chinese and English would influence their sensitivity to temporal sequence violations in written statements (time clashes). To refer to events from the past, speakers of English can use the past perfect, the simple past, the present perfect or even the future perfect depending on the relationship between the time at which the statement in made or Speech Time (ST), the time serving as a reference point or Reference Time (RT) and the time at which the event took place, or Event Time (ET). In contrast, native speakers of Chinese use time adverbials, modal auxiliaries or context to distinguish between these different situations (Duff & Li, 2002; Simith 1991). We used event-related potentials to test late Chinese–English bilinguals' ability to detect a present-past time clash between events, as in: a.* After the director of the school has resigned from the university, he worked for a multinational. (Present Perfect + Simple Past); We asked participants to judge whether or not sentences presented word-by-word made sense upon seeing the last words. The control condition featured sentences without a time clash between the events described in the two clauses, as in: b. After the director of the school had resigned from the university, he worked for a multinational. (Past Perfect + Simple Past); In addition, we also tested a future-past time clash as in: c. * After the director of the school will have resigned from the university, he worked for a multinational. (Future Perfect + Simple Past); and we used a semantic violation condition to direct participants' attention towards semantic processing rather than subtle syntactic differences between sentences. Despite their inability to explicitly detect violations in conditions a and c, native speakers of English displayed increased N400 mean amplitude between 1100–1250 ms after the occurrence of a time clash. Chinese-English bilinguals, in contrast, showed no explicit or implicit detection of time-clashes conveyed by syntax. We conclude that time information conveyed by syntax is processed differently in bilinguals when time reference operates differently in the second language, probably leading to confusion in comprehension regarding temporal organisation and strategies in production over-relying on adverbials and context as in their native language.

C15 Early classroom-based foreign language learning in children: vocabulary gains despite unchanged neural sensitivities in auditory MMN and visual word N1

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In many countries, children learn English as a foreign language in early school grades, under the assumption that brain processes can easily tune to properties of a new language at a young age. While changes in neural sensitivity to basic language properties, such as speech sounds, has been investigated for immersive learning, little is known in the case of classroom-based foreign language learning. Here, we investigated 89 Swiss children immediately before learning English at the end of first grade (mean age: 7.5 years) and followed them up after one year of learning English in school at the beginning of third grade (mean age: 8.9 years; 2 hours English per week). As a control group we tested 19 children from another region who did not receive any early English teaching. We tested English vocabulary and sentence comprehension skills behaviorally in third grade, and recorded EEG measures of automatic speech sound processing and visual word processing longitudinally in first and third grade. Speech sound processing was assessed using a mismatch negativity (MMN) paradigm with a standard ("da") and one deviant ("ta") being familiar from the native German language, and one deviant ("tha") that is common in English, but not in German. Mismatch analyses were conducted by subtracting the deviant ERPs from the standard ERP and by focusing on the MMN. Visual word processing was assessed using a repetition detection task that contained German words, English words, Pseudowords, and false-font strings. Coarse print tuning was indexed as the N1 difference between German words and false-font strings. N1 Lexicality effects were computed for the first language (German words – pseudowords) and for the second language (English words – pseudowords). The results showed increases in English vocabulary and sentence comprehension at the behavioral level. At the neural level, however, no significant changes from pre- to post-tests could be detected that were specific for the newly learned English language (MMN, N1 lexicality effects). The results indicate that vocabulary gains at the behavioral level were achieved, even though basic neural language processing mechanisms seem to have remained unchanged. Thus, children may use specialized speech sound processes and print tuning from their first language to process the corresponding aspects of the new foreign language in order to extract meaning. The results also suggest that two hours of classroom-based foreign language learning may not be sufficiently intensive to drive neural changes in basic-level language processes such as speech sound processing or print tuning of a new language.

C16 Immersive late bilingualism reshapes the core of the brain

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An increasing number of studies have suggested that speaking more than one languages affects the structure on several cortical areas of the brain, as well as white matter tracts, which are usually related to some aspect of linguistic processing (García-Pentón et al., 2015). Conversely, there is little evidence for any effects of bilingualism on subcortical structures such as the basal ganglia, who are equally important in language processing, and are particularly relevant for the acquisition of phonology and for controlling among several language alternatives (Green & Abutalebi, 2013). Following up on a recent study that showed changes in the shape of the basal ganglia as a result of simultaneous bilingualism (Burgaleta et al., 2016), we compared the subcortical structure of 20 late immersed bilinguals to 25 age- and education-matched monolinguals. Our bilinguals spoke English as their L2 (mean age of acquisition: 10 years), were highly proficient in English and had lived in the UK for an average of 91 months. Vertex analysis with FSL revealed several subcortical shape changes for our late bilinguals, compared to monolinguals, including effects in bilateral putamen and globus pallidus and the right thalamus. Interestingly, this pattern is comparable to the pattern presented for simultaneous bilinguals in Burgaleta et al. Importantly, the changes in the right globus pallidus for the bilinguals were positively correlated to their amount of immersion in a bilingual environment. All these structures have been suggested to be critical to various aspect of phonological acquisition and processing, as well as language production and selection between available languages in bilinguals. Therefore, the present effects suggest that the acquisition of an additional language, and the additional demands this puts on the phonological and language control system, expresses itself as a reshaping of these structures; additionally, these affects appear to be common between early and late bilinguals, as long as the latter ones are active users of both their languages. This is further corroborated by the positive correlation between the degree of reshaping of the globus pallidus and the amount of bilingual immersion, an effect which possibly reflects the gradual acquisition of L2 phonology. Taken together, these effects challenge the assumption that there are critical periods in the phonological acquisition of a second language; instead, phonological acquisition emerges as dynamic procedure that is independent of critical periods, but highly related to the amount of immersion in a bilingual environment. In other words, structural effects pertinent to simultaneous bilinguals, as well as the cognitive effects they may convey, are applicable to late bilinguals, as long as language acquisition and use is active and takes place in an immersive environment. Burgaleta, M., et al. (2016). NeuroImage, 125, 437–445. http://doi.org/10.1016/j.neuroimage.2015.09.073 García-Pentón, L., et al. (2015). Language, Cognition and Neuroscience, 3798, 1–25. http://doi.org/http://doi.org/10.1080/23273798.2015.1068944 Green, D. W., & Abutalebi, J. (2013). Journal of Cognitive Psychology, 25(5), 515–530. http://doi.org/10.1080/20445911.2013.796377

C17 Neural Correlates of Language Therapy Effects in a Bilingual with Nonfluent Aphasia

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Introduction. Providing aphasia therapy to bilingual individuals raises numerous questions, including whether to focus on one of the languages or treat both, and whether treatment of one will result in cross-linguistic transfer. The exploration of the neural mechanisms underlying treatment effects in bilinguals might provide a way of resolving some of these questions. In the present fMRI study, we examined treatment-induced neural changes in a bilingual who received therapy aimed to improve inflectional morphology performance. Methods. The participant was a 71-year-old native speaker of Hebrew who acquired English in late childhood. He sustained an ischemic CVA 6 years ago, resulting in an extensive left-hemisphere fronto-parietal lesion and a non-fluent aphasia characterized by anomia and agrammatism. He reported high premorbid proficiency in both languages, with slightly higher self-ratings for Hebrew. At the time of testing, impairments were more pronounced in English. The treatment comprised 17 two-hour sessions that focused on verb retrieval and inflection in English. The participant practiced production of 48 verbs in three grammatical tenses: past simple, present simple and future. Each session also included probing and work on verb use in conversation. Prior to and following treatment, the participant underwent behavioral testing and an fMRI scan where both English and Hebrew were assessed. The behavioral testing specifically evaluated the participant's verb retrieval, conjugation and verb use in sentences and narratives. fMRI was used to assess recruitment of language regions during reading and verb inflection (Sahin, Pinker & Halgren, 2006). The participant was given an unconjugated word followed by a carrier phrase and asked to respond covertly. Separately for each language, activation observed during inflection was contrasted with that during simple reading and then compared pre- vs post-treatment. Results. Behavioral tests revealed improvement in the participant's ability to conjugate verbs in the present and past tense in English (the treated language) (from 1 to 29 and from 8 to 18, respectively); evidence of an improvement in Hebrew was more limited (from 2 to 1 and from 12 to 20, respectively). Minimal change was observed in verb use and verb conjugation in connected language production. The behavioral changes might be associated with changes in brain activation patterns following treatment that were, indeed, confined to the treated language. Specifically, preliminary analyses suggest that post-treatment there was greater activation of anterior temporal cortex during verb inflection, as contrasted against reading. Conclusion. The present findings suggest treatment-induced differential recovery in areas involved in verb inflection processing (i.e., the anterior temporal lobe; Holland & Lambon Ralph, 2010). There was limited evidence of transfer of treatment benefits to the untreated language, which may be related to language

acquisition history and the linguistic distance between the languages. References Sahin, N.T., Pinker, S., & Halgren, E. (2006). Abstract grammatical processing of nouns and verbs in Broca's area: Evidence from fMRI. Cortex, 42, 540-562. Holland, R. & Lambon Ralph, M.A. (2010). The anterior temporal lobe semantic hub is a part of the language neural network: Selective disruption of irregular past tense verbs by rTMS. Cerebral Cortex, 20, 2771-2775.

Meaning: Lexical Semantics

C18 The Representation of Taxonomic and Thematic Knowledge in the Human Brain

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Introduction. For a given entity, we know about what categories it belongs to (e.g., an animal or a tool) and in what context or place it often presents (e.g., in a sport setting or a medical setting). How these aspects of conceptual knowledge is represented in the brain is controversial: different but inconsistent brain regions associated with these different types of knowledge have been observed in some studies (e.g. Kotz et al., 2002; Sachs et al., 2008, 2011; Kalenine et al., 2009; Sass et al., 2009; Schwartz et al., 2011; Lewis et al., 2015; Geng & Schnur, 2016), whereas others attribute them to similar brain regions (e.g. Jackson et al., 2015). Such controversies are difficult to be resolved using traditional paradigms (e.g. semantic priming and word or picture association) because of the potential confounding factors engaged. We here employ a representation similarity analysis (RSA) approach in a set of stimuli whose taxonomic and thematic relationships are orthogonally manipulated to test the neural underpinnings of these different aspects of knowledge. Methods. In an ER-designed fMRI study (N = 20), we used the searchlight-based RSA (Kriegeskorte et al., 2006) to detect neural substrates where the voxel-wised activation pattern is correlated with two kinds of semantic knowledge. Forty-five printed words belonging to 9 conditions [3 themes (school study, medical care and sports meeting) × 3 taxonomies (people, objects and location)] were pseudo-randomly presented once in each run. Participants made taxonomic judgements in half of the 10 runs and thematic judgements in the other half to explicit access the meaning of words along both dimensions. Results. The following regions were found to represented taxonomic knowledge, such that the neural response patterns to words are significantly predicted by their taxonomic grouping and not their thematic grouping: the left inferior frontal gyrus, the left transverse occipital sulcus, the left posterior temporal gyrus, the left parahippocampal gyrus, the bilateral retrosplenial cortices and the left anterior superior temporal cortex. We did not find any brain regions representing only thematic knowledge. Intriguingly, within the taxonomic-related brain regions, some presented additional representation to the interaction of taxonomic and thematic knowledge, such that their response patterns are better explained by groupings that considered both taxonomic and thematic relationships, including the ventral temporal cortex, the retrosplenial cortex and the inferior frontal gyrus. Conclusion. Our results indicate that taxonomic and thematic knowledge is represented in neither fully dissociate nor fully similar manner. While taxonomic knowledge is captured by category-specific regions, the thematic information embedded into taxonomic knowledge and is partially represented within the category-specific regions.

C19 Serving two Masters: Electrophysiological Evidence for Parallel Idiom Processing

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Event-related potentials (ERPs) revealed that sentence contexts are not only used to expect specific upcoming words, but also lexical items that are related to highly expected words. For example, a sentence context establishing 'plants in a hotel that should look like a tropical resort' not only yields to largely reduced N400 amplitude for highly expected items ('palms'), but also to somewhat reduced N400 amplitude for unexpected items from the expected category ('pines'), compared to unexpected items from a different semantic category ('tulips'), respectively (Federmeier & Kutas, 1999). Notably, context-dependent prediction of related lexical items did not generalize to the processing of written idioms (Rommers, Dijkstra & Bastiaansen, 2013). This may emphasize that idioms are retrieved as a whole from the lexicon. Here we recorded ERPs for spoken German idioms such as 'Isabell hatte Schmetterlinge im Bauch.' (English: Isabell had butterflies in the stomach). We tested 40 native speakers of German. Participants listened to correct idioms and to manipulated forms. In manipulated conditions, the idiom's last word ('stomach') was replaced by a semantically related item ('arm') or by an unrelated item ('water'). Participants were asked to judge whether or not the sentence was an idiom. As typical for auditory processing, the semantic N400 effect was observable already in an early time window – starting at around 100ms after stimulus onset with a maximum effect over posterior sites. In contrast to the previous study with written materials (Rommers et al., 2013), the present study with spoken materials suggests parallel processing mechanisms. Anterior and right-hemispheric sites showed enhanced N400 amplitudes for both, related and unrelated conditions and no difference between those two conditions. This finding replicates the former results with written materials and indicates that the meaning of individual words within an idiom is not available for the underlying neural network. However, over posterior and left-hemispheric sites a graded effect was observable. N400 amplitudes were largely reduced for the correct item, but also somewhat reduced for the related item compared to the unrelated item. This finding is evidence for a network that decomposes idioms into their constituents. All in all, this pattern suggests separable networks processing linguistic increments of different sizes. While a left-lateralized network appears to follow decomposition at the single word level, a right-lateralized network appears to be specialized to larger units like idioms. Federmeier, K.D., & Kutas, M. (1999). A rose by any other name: Long-term memory structure and sentence processing. Journal of Memory & Language, 41, 469-495. Rommers, J., Dijkstra, T., & Bastiaansen, M. (2013). Context-dependent semantic processing in the human brain: Evidence from idiom comprehension. Journal of Cognitive Neuroscience, 25, 762-776.

C20 Working memory, not language experience, predicts N400 effects to semantically anomalous words during reading

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An important goal for research on language comprehension is to identify how individual differences (IDs) modulate engagement of neural systems supporting language use. For semantic processing, priming studies focusing on the N400 ERP component have found robust effects of language experience (LE), both during early development (measured as vocabulary size: e.g., Borgström et al., 2015) and in literate, university-enrolled adults (measured as comprehension skill: e.g., Landi & Perfetti, 2007), where greater language experience is associated with increases in the N400 effect for semantically unrelated versus related words. In sentence context more research has focused on the role of working memory (WM). Increased WM capacity has been found to modulate the N400 in cases of lexical ambiguity resolution (Gunter et al., 2003) and use of message-level information in discourse (Boudewyn & Swaab, 2013), among other domains. However, recent behavioral research has shown that LE and not WM is related to reading comprehension, measured by semantic interference effects in a dual-task reading paradigm (Van Dyke et al., 2014). Nonetheless, little research has directly compared how IDs related to both WM and LE in stable adult populations impact the N400 effect, which is related to semantic memory retrieval (Kutas & Federmeier, 2011). Moreover, many studies focusing on WM capacity have used single measures of WM, such as reading or listening span. Single measures may not adequately measure broad underlying constructs like WM, and language-related WM measures like reading and listening span may show correlations with language processing measures because both of these tasks also probe language experience (MacDonald & Christiansen, 2002). To identify the relative contributions of LE and WM to the N400 effect in sentence context, we used a latent variable approach to identify ID factors, and regressed these on to N400 effect amplitudes elicited during sentence reading. Monolingual university-enrolled native English speakers (N=64) read well-formed sentences and sentences containing semantically unexpected words ("The driver delivered the package/*tumor…") while EEG was recorded. Grand mean analyses showed the expected large N400 effects to unexpected words. Participants also completed a battery of ID measures related to LE (Peabody Picture Vocabulary Test, North American Adult Reading Test, Author Recognition Test) and WM (Operation Span, Letter-Number Sequencing, Letter 2-back). Note that although our WM tasks tapped verbal WM, none was specifically a reading measure. Principal components analysis of the ID measures yielded two clear components, with one corresponding to LE and one to WM; factor scores for individuals were computed for each individual and regressed onto individuals' N400 effect amplitudes. Multiple regression analyses showed that WM capacity predicted N400 effect sizes over centro-parietal and posterior electrode sites (β=.32, t=2.64), such that greater WM capacity was associated with larger N400 effects. LE, however, did not (β=.07, t=.53). Although there were clear IDs related to LE even among our literate adult population, these did not modulate N400s during real-time sentence comprehension. Instead, our findings suggest an important role for cognitive capacity related to attention and memory updating in managing semantic and lexical expectations during reading.

C21 The role of the left and right anterior temporal lobes in pictures and names semantic processing

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The ability to recognize a famous person requires semantic processing. Previous neuroimaging studies have shown that the anterior temporal lobes (ATLs) are involved in the knowledge of famous people. However, it is still a matter of debate whether the left and right ATLs contribute differentially depending on the modality of stimulus presentation. Some studies suggest a specific contribution of the left and right ATLs, depending on the modality of stimulus presentation (verbal vs. pictorial, respectively). Other studies show the ATLs is as a modality-independent convergence region. The aim of the present study was to verify whether the activation of the ATLs was modulated by the modality of the stimulus presentation (names vs. pictures) during a famous people semantic categorization task. Methods. In this block design fMRI study, 15 healthy young French-speaking adults (mean age = 26 y.o.) were asked to perform a semantic categorization judgement task (i.e., to decide whether the famous person was an actor or a singer) on visually presented pictures and names of famous people (n = 15 each). The control condition was composed of unknown faces (matched by age, sex, and prominent physical attributes with famous stimuli) and names (matched by length). Each block consisted of five stimuli displayed for 2500 ms each, followed by a 1500 ms inter-stimulus interval in which a cross was displayed on the screen. Each block was interleaved with a 20-sec rest period with a black screen. Results. Behaviourally, no accuracy differences were found for famous faces vs. famous names. RTs were significantly slower for famous faces vs. famous names. Neuroimaging findings showed that both the left and right ATLs were recruited in the semantic processing of famous people, regardless of the input modality. The comparison famous faces vs. famous names showed increased activation in the left inferior prefrontal cortex and the fusiform area. Within the ATLs, we failed to find any increased activation in the left or right lateral ATL for this contrast, except for a small cluster of increased activity in the medial portion of the left ATL. The comparison famous names vs. famous faces revealed increased activation in the left lateral ATL, and in more posterior regions including the temporal and parietal lobes. In conclusion, our results for known people knowledge are in line with previous findings obtained with object stimuli, highlighting that semantic knowledge would be sustained by the ATLs bilaterally. Also, our findings are consistent with the theory proposing that verbal semantic processing (e.g., words) would rely more heavily on the left ATL because of its connections with a left-lateralized phonological system.

C22 The influence of semantic associations on sentence production in schizophrenia: An fMRI study

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Neurocognitive research on the localization of the semantic system is making good process. However, localizing the speech production network is an ongoing challenge, particularly with regard to sentence production. The current study focuses on the examination of the neural correlates of associative relations in sentence production. In particular, we compare neural activation of healthy subjects and subjects with schizophrenia during an adapted picture-word-interference (PWI) paradigm. Studies on healthy subjects show an interference effect for associative relations concerning the first noun of the sentence, which suggests incremental processing. That is, the first noun is articulated while the second noun of the sentence is still being processed. So far, there is little evidence on sentence production and its neural basis in schizophrenia. 14 subjects with schizophrenia and 13 healthy subjects performed an adapted PWI paradigm. Two pictures were shown simultaneously, while a written distractor had to be ignored. The subjects had to utter a standardized sentence (e.g. "The car is to the left of the tree.") as fast and as correctly as possible while ignoring the distractor. Stimuli consisted of 192 black-and-white drawings of concrete objects and pairs that were neither phonologically nor semantically related to each other. The distractors were either unrelated (UNREL) or associatively related to the first (REL1) or second noun (REL2) of the sentence. A black frame appearing around one of the two displayed objects indicated the noun that was to be named first. Measurements took place in a 3T fMRI scanner in an event-related design. Audio recordings were filtered post-hoc and trimmed. Errors were discarded from further analyses. Afterwards, speech latencies were measured and an ANOVA and a paired-sample t-test were carried out. The preprocessing of the imaging data with SPM12 included realignment, slice time correction, coregistration, normalization and smoothing. At the first level (single subject analysis), the regressors were combined in a design-matrix and the individual effect of the reaction time was modelled with a canonical hemodynamic response function (HRF), generated by the stimulus-onsets of each condition per session. As a last step of the single-subject level the parameters of the HRF regressors for each condition were estimated. At the second level (group analysis), the two groups (patients and controls) and the three conditions were entered in a two factorial ANOVA. The SPM Anatomy Toolbox was used for the precise localization of the MNI-coordinates. On the neural level, a preliminary analysis of the relatedness effect shows a stronger effect for the patients than for the controls in the right hippocampus and left pars orbitalis (REL1 - UNREL) and a weaker effect in the middle cingulate cortex. These results might contribute to a better understanding of assumed alterations in the semantic network in schizophrenia.

C23 ERP responses to (un)expected spatial and non-spatial prepositional phrases

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It has been argued that prepositions have a central spatial sense which is chained to multiple tertiary, related senses (e.g., Lakoff, 1990; Boroditsky, 2000). In this account, non-spatial (e.g., temporal) uses of prepositions are not idiomatic but cognitively associated with spatial concepts through metaphor. In the current study, event-related potentials (ERPs) were used to examine the processing of spatial and non-spatial phrases consisting of "in" or "on" followed by semantically expected and unexpected nouns (e.g., "in the bowl/plate" and "in the moment/mend"). Conjunction phrases, containing "and", were also included as a control condition. ERPs were recorded from 28 adult participants using a 128-channel electrode net. When time-locked to the onset of the noun, ERPs from prepositional phrases yielded a slow negative drift in occipital-parietal sites as compared to conjunction phrases. However, the semantic expectedness of reference nouns in prepositional phrases had differential effects on ERPs, depending on whether the noun was spatial or non-spatial. Unexpected reference nouns in spatial phrases (e.g., "on the bowl") elicited a significantly large centro-parietal N400 effect, while unexpected reference nouns in non-spatial phrases (e.g., "on the moment") elicited relative positivity in central sites, beginning 700ms post-noun onset. Together, these findings create a complicated picture. On one hand, occipital-parietal slow-wave activity suggests there is a single spatial-image building process used to apply the denotation of a preposition to spatial and non-spatial phrases (Noordzij et al., 2006). On the other hand, the centro-parietal N400 response to unexpected nouns in spatial phrases and the P600 effects to unexpected nouns in non-spatial phrases imply that only non-spatial (abstract) nouns require phrase reanalysis and/or reconstruction. If this is true, non-spatial uses of prepositions may be idiomatic and even stored in the lexicon as phrasal units, casting doubt on accounts claiming that non-spatial uses of prepositions are cognitively and metaphorically linked to their spatial sense.

C24 Expect the unexpected: Speaker reliability shapes online lexical anticipation

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During language comprehension, a word's predictability in context has a robust influence on event-locked neural activity as well as reading behavior. To better understand these anticipatory effects, it is important to investigate both how and when comprehenders generate expectations about upcoming language input (Huettig, 2015). One critical question is whether lexical predictions are generated automatically – as a function of pre-existing associative links in semantic memory – or whether the strength of predictions can be strategically modulated based on the demands of the current comprehension environment (Summerfield, et. al., 2008). For example, does the constraining context "The web was spun by the…" always activate the highly predictable completion "spider" or can this prediction process be curtailed in environments where prior input has been unexpected (Kuperberg & Jaeger, 2016)? In Experiment 1, a group of 36 participants listened to sentences

for comprehension while EEG was recorded from the scalp. Half of these sentences were spoken by a "reliable" speaker, who typically produced predictable sentence continuations ("The parents of the awarded athlete felt very proud"), and half were spoken by an "unreliable" speaker who often produced plausible but unexpected endings ("The parents of the awarded athlete felt very tired"). If comprehenders are sensitive to the success or failure of predictive strategies, we should observe reductions in predictive processing for unreliable speakers, as indexed by the amplitude of the N400 for a set of high and low-cloze critical sentences. Consistent with this hypothesis, we observed a significant interaction between Cloze Probability and Speaker Reliability on the amplitude of the N400. Cloze effects were significantly larger for the reliable speaker (2.6µV) than for the unreliable speaker (1.3µV), and these differences were driven mainly by increases in N400 facilitation for predictable target words. This suggests that listeners generated more robust lexical predictions for reliable speakers. In addition, we also saw significant differences in the timing of the N400 effect. For the reliable speaker, the effects of lexical predictability were observed in an early 100-300ms time-window, while for the unreliable speaker, this cloze effect was delayed until approximately 300ms. This is consistent with previous evidence suggesting that lexically specific predictions can produce pre-activation at early phonological stages (Lau, Holcomb, Kuperberg, 2013; Brothers, Swaab, & Traxler, 2015). In Experiment 2, we replicated this strategic effect using a between-subjects, self-paced reading task (N = 256). As the proportion of predictable sentence completions decreased (87.5%, 50%, 12.5%), we observed significant reductions in the size of the cloze probability effect on reading times (26ms, 18ms, 4ms). Moreover, these effects were not accompanied by differences in comprehension question accuracy or text memory, suggesting that the reliability manipulation had a selective influence on predictive strategies. In sum, the generation of lexical predictions does not appear to be an automatic, stimulus-driven process determined by the preceding semantic context. Instead, comprehenders appear to dynamically adjust their predictive strategies as a function of the environmental validity of predictive cues.

C25 Processing enhancement for conventional metaphors following stimulation of Broca's area

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The left hemisphere of the brain is specialised and dominant for language comprehension and production and patients with left hemisphere damage often display profound language disruption. In contrast, following right hemisphere damage, disruption to language is less perceptible. Current research acknowledges a critical role for the right hemisphere in processing inferred or implied information by maintaining relevant facts and/or suppressing irrelevant ones but the exact role of the right hemisphere and its coordination with the left is still under investigation. The present study investigated the role of Broca's area in the left hemisphere and its homologue in the right hemisphere in the processing of metaphorical language by studying the processing abilities of individuals with depressed or enhanced unilateral brain function produced by transcranial direct current stimulation (tDCS). The study employed an auditory sentence priming paradigm using both novel and conventional metaphors as well as literal sentences, and young healthy participants (N=20) were asked to make semantic judgements. Anodal, cathodal or sham stimulation was applied to electrodes F7/F8 known to tap onto Broca's area and its homologue in the right hemisphere respectively. Significantly enhanced processing abilities for literal meanings and conventional metaphors only were observed after anodal (i.e., excitatory) stimulation of Broca's area in the left hemisphere, while anodal stimulation of Broca's homologue in the right hemisphere resulted in enhancing accuracy across all conditions. The findings are in line with the Fine/Coarse Semantic Coding Hypothesis and corroborate previous research in underlining the distinct roles the left and right hemispheres play in processing literal and non-literal language respectively.

C26 The neuromagnetic time-course of semantic ambiguity resolution in speech comprehension

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Most words in speech are semantically ambiguous and take on different meanings in different contexts. When we encounter ambiguous words in speech we use context and previous experience to make sense of (resolve) these ambiguities: multiple meanings are activated in parallel and compete for selection. If it becomes apparent that an incorrect meaning has been selected (for example following additional contextual information), reinterpretation processes are triggered. Previous research on semantic ambiguity resolution has highlighted the importance of two cortical regions - the left inferior frontal gyrus and the left posterior temporal lobe. However, this evidence comes mainly from fMRI (e.g., Rodd et al. 2011, Vitello et al. 2014), which makes it difficult to tease apart the time course of distinct cognitive operations (selection, reinterpretation etc.). Here we used EMEG to investigate the neurocognitive mechanisms of meaning competition/ selection and reinterpretation during ambiguity resolution. Volunteers (20 native English speakers) listened to spoken sentences (e.g., the couple thought that this JAM/STORM was worse than the one on the other MOTORWAY/TELEVISION) presented in a 2 X 2 design in which we manipulated the presence of an ambiguous word and subsequent disambiguation. An ambiguous word (JAM) should require additional meaning competition/ selection processes relative to a matched control (STORM). A disambiguating sentence-final word (MOTORWAY) resolved the ambiguity to a non-dominant meaning, which should induce additional additional reinterpretation processes compared to a final word (TELEVISION) that is consistent with both meanings. Listeners' task was to judge whether visually-presented probe words were related or unrelated to the preceding spoken (filler) sentence (20% of all trials). Simultaneous MEG/EEG data were recorded (306-channel NeuroMag Elekta MEG system, 70 EEG electrodes). Following ICA-denoising, filtering, and artefact rejection, ERFs/ERPs were measured relative to the offset of target words (assessing responses associated with ambiguity and meaning selection) and sentence-final words (assessing responses associated with reinterpretation). We used non-parametric cluster-based permutation tests on a-priori-defined time windows to test for between-condition differences. Analyses of the MEG data

(between -500 and 1500 ms relative to the sentence-final word offset) revealed a significant interaction between the presence of ambiguity and the sentence-final word (cluster p-values < .05). In the magnetometer data, clusters were of right and left frontal sensors (-152 to 236ms, -148 to 152 ms) and in the gradiometers data (RMS transformed), a single cluster was widespread bilaterally (-204 to 40 ms). These results suggest a neural correlate of reinterpretation processes during ambiguity resolution, the underlying sources of which will be subject to further investigation. Following the EMEG recording, listeners' comprehension of the ambiguous resolved sentences was tested, with most participants understanding most sentences (mean = 94%, range = 84-100%). A Pearson's correlation analysis revealed a significant association between volunteers' comprehension scores and their scores on the Mill Hill vocabulary test (p = .004), but no association with their non-verbal IQ scores on the Cattell 2a test. These results suggest individual differences in ambiguity resolution that will be the subject of further neural analyses.

C27 Left primary motor cortex stimulation affects language comprehension during semantic judgment but not lexical decision task: an online rTMS study of action vs. abstract word processing

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Among various questions pertinent to grounding cognitive functions in a neurobiological substrate, the association between language and the motor cortex is a particularly debated one in neuroscience and psychology. While many studies support a broadly distributed model of language and semantics grounded in basic modality-specific systems (1–3), theories disagree as to whether motor and sensory cortex activity observed during language processing is causally-relevant or epiphenomenal (4,5). TMS (transcranial magnetic stimulation) is a great tool for investigating causal contributions during language processing, because of its non-invasiveness, reversibility, and temporal precision. A handful of previous TMS studies of motor contributions to language available to date have produced inconsistent results, possibly because they did not explicitly compare tasks of different semantic demands (6–8). Moreover, rather than address language comprehension as such, they often measured MEPs (motor evoked potentials). Unfortunately, MEPs merely reflect the status of the motor system and do not provide causal evidence about the putative semantic role of motor cortex in comprehension: they only show that linguistic processing affects motor cortex excitability, which could in principle be a downstream and a semantically shallow effect. To show the reverse, namely, that motor cortex stimulation influences language processing, one must demonstrate direct behavioural effects of TMS on linguistic performance. We set out to assess this question in a systematic fashion and investigated subjects' behavioural responses to different word types using three orthogonally modulated experimental variables: (a) we compared responses to action (e.g., write) vs. abstract (think) words; (b) we modulated the degree of semantic processing by employing explicit semantic judgement vs. lexical decision tasks; (c) we used rTMS to interfere with primary motor cortex function in the left vs. right hemisphere. A total of 28 right-handed healthy native Russian speakers performed both tasks using Russian stimuli carefully matched for their psycholinguistic properties. We found that early rTMS (delivered within 200 ms from word onset) produced a task- and meaning-specific change in reaction speed, inhibiting behavioural responses to action-related, as opposed to abstract words, in the semantic judgement task, but not in the semantically less engaging lexical decision. Furthermore, this effect was only found for the stimulation of the left but not right primary motor cortex. We interpret these data in light of action-perception theory of language - the causal character of the present effect (disturbed semantic processing of action words after TMS) suggests that the role of the motor cortex in comprehension is inherently functional, and that this involvement is evident in semantic contexts where the action-related aspects of words have to be understood. References: 1. Pulvermüller, F. J. Neurolinguistics (2011) 2. Vukovic, N. & Shtyrov, Y. Neuroimage (2014) 3. Glenberg, A. M. & Gallese, V. Cortex (2011) 4. Mahon, B. Z. & Caramazza, A. J. Physiol. Paris (2008) 5. Barsalou, L. W. Annu. Rev. Psychol. (2008) 6. Gianelli, C. & Dalla Volta, R. Front. Psychol. (2015) 7. Papeo, L. et al. Cereb. Cortex (2014) 8. Pulvermüller, F. et al. Eur. J. Neurosci. (2005)

Language Development

C28 Changes in cortical functional and structural organization related to the development of language production skills

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How do brain systems change as people become more proficient and experienced producers of language? Using fMRI, Krishnan et al (2014) showed that the 'naming complexity' of visual objects differentially affected activation in inferior and prefrontal cortex for children and adults. Both groups demonstrated comparable task accuracy, suggesting that the observed differences may represent developmental change in neural/cognitive strategies. We examine three potential hypotheses for these differences: changes in putative cortical myelination, default network connectivity, and variation in language ability and vocabulary size. In order to explore changes in neural organization associated with changes in object naming profiency, and determine what may cause underlying differences, we employed an fMRI object-naming paradigm with multiple layers of linguistic and visual complexity, in conjunction with a set of standardized behavioral tests. We also used multi-parameter mapping methods (MPM) to detect quantitative differences in T1 and MT relaxation rates related to myelination across key cortical regions involved in language processing. Children (7-14 years) and adults (26-30 years) were asked to name different objects during a functional scanning session. The objects were black and white line images drawn from the International Picture Naming Project (Bates et al., 2003), which varied along parameters including contextual diversity of usage, word neighbourhood density, and visual complexity. In the same session, they underwent a set of MPM structural scans. Prior to the session, they engaged in a series

of behavioral tests relating to language abilities, including the TOWRE, PPVT, and ART. Preliminary group-level analysis of the data suggests that children show a greater degree of cortical deactivation during object-naming overall, and much greater ventral temporal activation. Ongoing analyses relating individual multiparameter map differences to those in activation and behavior should shed light on the mechanisms driving change in the functional regionalization and differentiation of language over development.

C29 Age-related N400 delay and reduction during Chinese sentence comprehension

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Age-related language comprehension decline was associated with reduced and/or diminished N400 effect in the older adults relative to the younger adults. In the present study, semantic incongruent and congruent sentences were presented to 16 older and 17 younger adults. The semantic incongruent induced a significant larger N400 effect than the congruent sentences did in both younger and older adults. However, the time window showed N400 difference between the two types of sentences was delayed in the older adults. Specifically, N400 difference was significant through the time window between 300-550ms with 50ms step in the younger adults, but it was significant only in the 400-550ms window with 50ms step in the older adults. Moreover, in 400-450ms, 450-500ms and 500-550ms windows, a significant Region (anterior vs. posterior) by Condition (congruent vs. incongruent) by Group (younger vs. older) interaction was found. Simple main effect revealed significant N400 effect in both anterior and posterior regions in the younger adults while only in posterior regions in the older adults. The present study thus added time course and distribution information for age-related N400 reduction.

C30 Large-scale functional network differences between children and adults during reading

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Introduction: Reading requires the coordination of multiple brain regions. In this study, we explored the whole-brain functional connectivity in children and adults during phonological and orthographic tasks in two language systems. Method: 18 young adults (college students, aged 22-26 years, 7 males) and 18 children (primary-school students, aged 8-10 years, 3 males) took part in the experiment. Both groups are native Chinese speakers, learning English as their second language. During the fMRI scanning, participants performed a Chinese word rhyme-matching task and a Chinese word orthography-matching task in two separate runs. They also performed an English letter rhyme-matching and an English letter orthography-matching task in another two separate runs. A fixation served as a baseline in each run. All of the experimental stimuli were visually presented. Preprocessed fMRI scans were partitioned into 90 regions according to the AAL template, and region-wise timecourses specific to task blocks were extracted and concatenated. Then, Pearson's correlation between the timecourses of each pair of regions was calculated, yielding a 90 X 90 functional connectivity matrix for each participant under each condition. Next, a one-tailed t-test was conducted on each possible edge ($T(34) = 3.34$, $p = 0.001$) to get between-group difference matrices (for adult > child and child > adult separately). Finally, Network Based Statistics (NBS) was applied to correct for multiple comparisons. In this step, participants' gender and mean head movements were included as confounding variables. Results: For the Chinese word rhyme-matching task, we identified a network that was more strongly connected in adults than in children. This network was consisted of connections of the posterior visual regions with inferior frontal regions, connections of the temporal regions with motor and occipital regions, and connections of the parietal regions with inferior frontal and fusiform regions. Most of the edges within this network also showed stronger connectivity in adults than in children under the English letter rhyme-matching task. No network was more strongly connected in children than in adults for the rhyming tasks under either language condition. For the Chinese word orthography-matching task, there was no between-group difference. However, for the English letter orthography-matching task, there were two networks that were more strongly connected in children than in adults. The one network was consisted of connections of the parietal regions with the superior frontal regions and the bilateral fusiform. Another network was consisted of connections between the cingulum and the occipital regions. Conclusion: The absence of group difference in large-scale functional connectivity under the Chinese orthographic task indicates that by the age of about 8 years old, children have developed a comparable functional system as young adults to support orthographic processing of native language. However, compared with adults, children are less able to integrate orthographic information with phonological information, and this disadvantage is present in both the first and second language systems.

C31 The cerebellum's relationship to language function

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A small but growing number of empirical studies suggest that the cerebellum impacts language function and development, and this possibility is bolstered by the known cerebellar-ponto-cerebellar connectivity between the left perisylvian cortex and the right cerebellar hemispheres, especially lateral regions Crus I, Crus II, and VIIb. In an ongoing study of the cerebellum's involvement with language and its development in typical individuals, we have investigated the association between the tissue volumes of manually parcellated sub-regions of the cerebellum in structural MRI, and a battery of receptive and expressive language measures. Our preliminary data on 18 individuals (ages 9-38-years) suggests an association between the volume of lateral cerebellar sub-regions and expressive language. Specifically, we measured the volume of cerebellar sub-regions and created a laterality index across regions. Thus, we measured the volume difference by computing difference = (right-left)/(right + left) for the Crus I, Crus II, and VIIb regions. We related these difference scores to

language outcomes. We found that greater volume of right VIIb predicted better expressive language scores on the Clinical Evaluation of Language Fundamentals (CELF-expressive; $p < .01$), while greater volume of the right Crus I predicted worse performance ($p < .01$). No association was found for the Crus II difference measure ($p > .05$). Although preliminary, these findings have the potential to enhance our understanding of cerebellar function with respect to language, which may inform therapeutic strategies for language recovery following cortical insult.

C32 Developmental Changes of the Functional Near Infrared Spectroscopy (fNIRS) Network Architecture in Emerging Readers

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Learning to read is a challenging task for young children. At the level of brain, reading acquisition requires functional reorganization of the neural networks for language and visual processing systems. To date, it is largely unknown how such functional reorganization occurs over the critical period during which children acquire literacy knowledge. In this study, we explored development of the functional neural networks for speech and reading in two groups of children: a pre-reading group (~ 4 years of age) and an emerging-reader group (~ 6 years of age), using graph theoretical analyses on functional near infrared spectroscopy (fNIRS) measurements. Our whole head Shimadzu system included 58 channels covering prefrontal, frontal, and temporal brain regions, allowing for a systems level analytic approach. The pre-readers listened to spoken words and emerging readers read or listed to written or spoken words during fNIRS scanning; both groups were also scanned while they passively watched a video. We deployed a modularity analysis using a Newman-Girvan algorithm on a 58 × 58 adjacency matrix derived from the correlation between each pair of channels for each task for both groups. Findings revealed left (left inferior parietal lobule and left temporal lobe), middle (left and right prefrontal lobes), and right (right inferior parietal lobule and right temporal lobe) modules for both the spoken word and video tasks in the pre-reading group. For emerging readers we found increasing coherence between the left and right brain regions across the three (video, printed word, spoken word) tasks. In addition, for emerging readers, the printed word processing task revealed a hemispheric synchronization in both frontal-temporal (right inferior frontal gyrus to left and right temporal lobes) and temporal-parietal (left fusiform gyrus to left and right superior temporal gyri and inferior parietal lobule) lobes; while the spoken word processing task produced a left hemispheric advantage in combination with a left-right synchronization in the temporal channels. For the video task, the emerging-reader group had similar left, middle, and right modules with the pre-reading group, except that the left angular gyrus synchronized with the right module. Our results indicate that there is an increasing hemispheric synchronization between the left and right frontal-temporal and temporal-parietal regions at the age when children begin to read, and such synchronization is pronounced in processing printed words. The greater coherence between fusiform gyrus and inferior frontal gyrus to temporal and parietal lobes indicates an emerging reading network. In addition, we also observe greater adult-like left lateralization during processing of spoken words for emerging readers. In the current study, we focus on the functional changes of the frontal-temporal network when children start to read. In ongoing analyses we are exploring the relationship between these functional changes, early language skills, and later reading achievement to identify biomarkers of early risk for reading problems.

Grammar: Syntax

C33 Neural Bases of Chinese Syntactic Representation across both Tasks and Syntactic Constructions

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Previous studies using alphabetic materials have shown that syntax-related manipulation resulted in brain activation while performing implicit syntax tasks. However, it is still an open question as to whether this conclusion can be applied to logographic Chinese, differing drastically from alphabetic languages. For example, in Chinese words do not generally have explicit grammatical markers, and syntax and semantics are relatively closely inter-related. Because previous studies adopting Chinese materials mainly employed violation paradigms to investigate the neural networks of Chinese syntactic, further studies are needed to investigate how the different tasks modulate the neural bases of Chinese syntactic, especially under the implicit syntax tasks. The present study used high spatial resolution fMRI technique to investigate Chinese two-word phrase processing. The factors of syntactic construction and task demand were orthogonally manipulated. Specifically, 120 phrases were constructed and were evenly divided into four syntactic construction types while phrase familiarity, frequency and visual complexity (i.e., number of strokes) were matched across types: 30 noun-adjective argument, 30 verb-noun argument, 30 adjective-noun modification and 30 adjective-adjective parallel constructions. Participants were asked to finish two tasks for each of these phrases, i.e., 1-back syntactic construction task and 1-back word task. For the 1-back syntactic construction task, they should respond if the syntactic construction of the current phrase matched with the previous phrase, and, for the 1-back word task, they should respond if either word in the current phrase matched with a word in the previous phrase. Each task consisted of 3 blocks and the order of the task was counterbalanced across participants. Each trial lasted 10s on average, consisting of fixation cross (0.5s), blank interval (0.3s), phrase (2.2s) and blank interval (3s, 5s, 7s, 9s or 11s). The whole fMRI recording for each participant lasted around 55min. The representation dissimilar matrices (RDM) of syntactic construction was created for representation similar analysis (RSA). The RSA searchlight results of 18 participants revealed that the activity patterns in the left middle frontal

gyrus (LMTG) and left angular gyrus (LAG) were significant correlated with the syntactic construction RDM for the 1-back syntactic construction judgment task. However, for the 1-back word judgment task, no significant similarity with the syntactic construction RDM was found. In addition, the conventional activation-based analysis revealed that the left middle/inferior frontal gyrus (LM/IFG) and the LAG were more activated in the 1-back syntactic construction repetition judgment than in the 1-back word repetition judgment for three syntactic types of phrases (except the adjective-adjective parallel constructions). Altogether, these results demonstrate that a) the brain regions related to the neural representation of Chinese syntactic construction would only be activated in the explicit syntactically related tasks; b) the LM/IFG and the LAG may play important role in Chinese syntactic representation during normal phrase reading.

C34 Automatic detection of morpho-syntactic violations in Dutch: A Mismatch Negativity study

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Introduction: The present study investigated how the serial order of words in spoken language is processed in the brain. In particular, we tested the model of neuronal grammatical sequence detectors (Pulvermüller and Styrov 2003). According to this model, the presentation of one lexical element causes the grammatical sequence detector to prime the next element, thereby relatively reducing the activation level of that second element. Such priming is, however, absent in ungrammatical sequences. In line with this model, Pulvermüller and Styrov found that ungrammatical subject-verb sequences elicit a greater MMN than grammatical ones in English. We investigated the processing of subject-verb sequences in Dutch. Dutch presents an interesting test case because it is inflectionally richer in the verbal paradigm than English and allows relatively more variety (Donaldson 1997), which may reduce the priming effect of the pronoun. Methods: Two Dutch subject-verb sequences were presented auditorily in an odd-ball paradigm to native-speakers of Dutch (n=12). These sequences differed acoustically only in the inflection of the verb, which rendered them either grammatical (wij dansen 'we dance';) or ungrammatical (*we danst 'we dances'). To control for effects of acoustic differences between the sequences, a nonlinguistic control condition was included in which the verbs were preceded by a spectrally similar but unintelligible nonlinguistic sound (filtered noise or fn). In total four blocks of stimuli were created, in which each sequence served once as the deviant and once as the standard in its respective condition (linguistic vs. nonlinguistic). The order of the blocks was partially counterbalanced across participants. Using a 64-channel standard EEG setup, we recorded electrical brain activity with while the participants were watching a silence film. Results: We analyzed the frontal-central recording sites at electrode FCz with the largest MMN in two 40-ms-wide time windows, i.e. 130-170 ms and 330-370 ms after deviance onset, following Pulvermüller and Styrov (2003). The MMNs to the stimuli were averaged in each condition. Paired-samples t-tests (one-tailed) revealed a significantly greater MMN in the linguistic condition than in the nonlinguistic condition only in the late time window ($t(11) = -2.81$, $p < .01$). Additional t-tests were conducted, one for the conditions with wij/fn dansen as the deviant and one for the conditions with wij/fn danst as the deviant. In the early time window, the MMN to the ungrammatical sequence was significantly greater than the MMN to its nonlinguistic counterpart ($t(11) = -1.78$, $p = .051$). Discussion: The results in the late time window suggest that the presentation of 'wij' did not sufficiently prime the occurrence of the correct verb form and reduce the activation level of the verb in Dutch, different from the finding in English. This difference is in line with the difference in inflectionality between the two languages. Notably, the difference found in the early time window between conditions differing in the deviant stimulus suggests that whether the grammatical sequence or the ungrammatical sequence serves as the deviant can affect the brain's response to the difference between the standard stimuli and the deviant stimuli.

C35 Probability, Semantics, Syntax, Memory: Within Subject Comparisons of Late Positive Components

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The P600 – a late, positive going event-related potential (ERP) component – has been linked to syntactic processing, as P600 effects have been seen in response to many different types of syntactic violation as well as during the processing of complex sentence structures. Given a number of important similarities between the P600 and the more general P3b component, some have proposed that the P600 is a P3b, with differences in latency and amplitude simply reflecting the complexity of linguistic structure. Previous work has found that the P600, like the P3b, is response aligned, and is modulated by saliency, task relevance and subjective probability, all of which are also known to modulate the P3b. Researchers have also noted similarities between the P3b and a further ERP component – the late positive complex (LPC) – which is often elicited in memory paradigms and is modulated by the strength of memory. Despite the similarities between these three components, no one has yet made direct comparisons between them when they are elicited within the same person using component-typical tasks. In the current study, therefore, 24 young adult participants were presented with four tasks, each of which has previously been used to elicit one of the components of interest. These included a standard visual oddball (P3b), phrase structure, morphosyntactic, and thematic role violations (syntactic/semantic P600), and a depth of encoding task (LPC). Each of the tasks elicited the desired components and analyses on the resulting waveforms suggest that there are similarities between these components. These findings provide further evidence that these late positive components may be members of the same family.

C36 Left inferior frontal cortex mediates morphosyntactic processing: ERP evidence from left-hemisphere damaged patients

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Neurocognitive models of language comprehension have proposed different mechanisms with different neural substrates mediating human language processing (e.g., Pinker & Ullman,

2002, Ullman et al. 2001, Joanisse & McClelland, 2015). Whether the left inferior frontal gyrus (LIFG) is engaged in (morpho-)syntactic information processing is currently still controversially debated. The present study addresses this issue by examining the processing of irregular verb inflection in real words (e.g., swim>swum>swam) and pseudowords (e.g., frim>frum>fram) by using event-related brain potentials (ERPs) in neurological patients with lesions in the LIFG involving Broca's area as well as healthy controls. Different ERP patterns in response to the grammatical violations were observed in both groups. Patients with LIFG lesions displayed a N400 in response to incorrect verb inflections, whereas controls showed a biphasic negativity-P600 pattern. For incorrect pseudoword inflections, no ERP effects were obtained in patients, while a late positivity was found in controls. These findings of different ERP patterns in both groups strongly indicate an involvement of LIFG in morphosyntactic processing in healthy controls, and compensatory mechanisms presumably engaging the temporal cortex in patients.

C37 ERP Effects of Scrambled/'Floating' Numeral Classifiers in Korean

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This study examines the effects of scrambling either a subject or object associated with 'floating' numeral classifiers (FNCs) in Korean by using the event-related potentials (ERP) paradigm. The experimental materials consisted of 360 sets of 6 items, which vary in terms of three factors such as (i) the grammatical role ((S)ubject vs. (O)bject) that FNCs associate with, (ii) the type of Case/particle marker on FNCs (Case-less vs. (N)om/(A)cc Case-marked vs. (F)ocus-particle-marked), and (iii) the application/non-application of subject or object scrambling, as schematically represented below. i) S-related Case-less FNC: [park-in dog-Nom bread-Acc 2-FNC ate] I heard. ii) S-related N-marked FNC: [park-in dog-Nom bread-Acc 2-FNC-Nom ate] I heard. iii) S-related F-marked FNC: [park-in dog-Nom bread-Acc 2-FNC-Foc ate] I heard. iv) O-related Case-less FNC: [park-in bread-Acc dog-Nom 3-FNC ate] I heard. v) O-related A-marked FNC: [park-in bread-Acc dog-Nom 3-FNC-Acc ate] I heard. vi) O-related F-marked FNC: [park-in bread-Acc dog-Nom 3-FNC-Foc ate] I heard. Using the materials, we investigated the following three questions. First, is there a difference between effects of in-situ and scrambling options on FNCs? Second, is there a contrast between the in-situ and scrambled objects? Third, is there a distinction between the subjects in object-scrambling and object-in-situ sentences? We found that, first, the Case-less FNCs in sentences involving subject or object scrambling elicited P600 in comparison to the corresponding ones in sentences without such scrambling, whereas the Case-marked FNCs in the former case were ERP-wise not significantly different from the corresponding ones in the latter case. By contrast, the F(ocus-particle)-marked FNCs in sentences involving scrambling elicited P600 for subject or N400 for object in comparison to the corresponding ones in sentences without scrambling. We attribute the P600 effects here to a second-pass, revised integration process that now attempts to correctly link the Case-less/F-marked FNC to the relatively more 'distant' scrambled subject or object associated with it. Second, the scrambled objects induced reduced N400 effects relative to the in-situ ones. This result is unexpected, given that the canonical word order in Korean is SOV, predicting that scrambled objects will incur more processing loads. But one crucial feature of Korean is that this language allows pro drop or null subject argument for subjects. Thus, the object-initial sentences were not perceived by the Korean users as marked/exceptional in terms of word order. Third, the subjects after the scrambled objects were not differentiated from the ones before them in terms of ERP responses. Note that the former involve object scrambling, while the latter do not. Since the subjects do not involve scrambling in either type of sentences, no difference between them is an expected result. Overall, we take all the three results above to render neuroelectrophysiological evidence that our mind actively detects scrambling or permutation of word order in the course of sentence-processing FNC-associated scrambled subjects or objects.

C38 Voice mismatch in Korean pseudo-sluicing: An ERP study

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Voice mismatch is impossible in sluicing in English (e.g., *Someone bought roses, but we don't know by who(m)), which is attributed to a syntactic factor (e.g., the size of an elided category; Merchant, 2007) or a non-syntactic factor (e.g., resemblance relations; Kehler, 2000, 2002). The impossibility of voice mismatch in English sluicing has been extensively examined in theoretical linguistics, but little work have provided electrophysiological evidence for ellipsis. Thus, we examined voice mismatch in Korean pseudo-sluicing by conducting both an offline acceptability task and an ERP (event-related brain potential) experiment. The experiment employed Korean elliptical structures with 3 Agent types [such as (i) active sentence with explicit Agent (AE); (ii) passive sentence with explicit Agent (PE); (iii) passive sentence with Implicit Agent (PI)] by 2 (mis)match conditions. Twenty-five right-handed normal functioning Korean native speakers, who had normal or corrected-to-normal vision (7 females, mean age 22.5, range 19-26), participated in the experiment. The descriptive data of the offline 4-scale acceptability task for the 6 conditions are as follows: (Condition A): mat(ched) AE - 3.3; (B): mis(matched) AE - 2.0; (C): mat PE - 3.3; (D) mis PE - 2.0; (E): mat PI - 3.2; (F): mis PI - 1.5 [Mean acceptability scale (1: bad, 4: good)]. The ANOVA results of the offline task showed main effects of Agent type ($F(2,48)=10.39$, $p<0.001$) and voice (mis)match ($F(1,24)=81.74$, $p<0.001$). Korean speakers consistently judged all the three voice mismatch conditions unacceptable, and particularly the mismatch in the implicit Agent condition was rated worst among the conditions. These results were consistent with the ERP results as well. ERPs were measured at the remnant word (plus the Q marker) in the elliptical clause such as nwukwu-i-nci 'who-Cop-Q' and nwukwu-eyuyhayse-i-nci 'who-by-Cop-Q'. When the antecedent clause hosts a correlate to the remnant, voice mismatch (i.e. a switch from active to passive) in condition (B) compared to condition (A) elicited an early left anterior negativity (ELAN) at the 80-180 ms interval, followed by a P450 at posterior regions. Likewise, with a correlate to the remnant, voice mismatch (in this case, a switch from passive to active) in condition (D) compared to condition (C) elicited an N450 at posterior regions. On the other hand, without

a correlate to the remnant, voice mismatch (in this case, a switch from passive to active) in condition (F) compared to condition (E) elicited an N400 at posterior regions. The results indicated that the voice mismatch without a correlate incurs semantic anomaly that cannot be repaired by any syntactic operation. Given that either P450 or N450 is an index of conflict processing (Lansbergen, van Hell, & Kenemans, 2007), P450 or N450 reflects a conflict when the parser processed the remnant whose Case/postposition marker mismatched with that of its correlate. The elicitation of ELAN from condition (B) compared to condition (A) is attributed to the complex form of postposition as a marker of Agent in a passive sentence (-eyuyhayse) relative to the simple form in an active sentence.

Language Disorders

C39 Interfered naming and its improvement in aphasia: A group fMRI study on a novel approach to impaired word processing

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INTRODUCTION. Functional magnetic resonance imaging (fMRI) studies in healthy participants successfully applied picture/word interference paradigms to localize stages of word processing [1]. The interference task distracts picture naming by nearly simultaneous presentation of words, which facilitate naming responses when phonologically related or semantically associated, but hinder responses when semantically competing due to a categorical relation. The latter, in particular, impose high demands on executive control as revealed by fMRI, while all three activate language-related brain networks. We for the first time applied this complex paradigm in diagnostic and therapeutic settings for aphasic patients on the group level. We aimed at investigating the neural and behavioural impact on brain and behaviour exerted by (i) each distractor type to diagnose functional and impaired processing components, (ii) a novel treatment method targeting word access [2] combined with language control by means of interfered naming. METHODS. 19 patients with a mean age of 50 years (range 21-74) and 26 months post-onset (4-63) were included in a diagnostic fMRI study comprising a pure naming test, a picture/word matching test for evaluation of distractor comprehension, and the fMRI interference paradigm with 5 distractor conditions (phonological, associative-semantic, categorical-semantic, unrelated word, unrelated noise) in a 3T Philips scanner. 11 of these patients completed the 4-weeks fMRI therapy study with pure and interfered naming tests post-therapy. fMRI activations within and between assessments were compared at a threshold of MC-corrected $p<.001$, 10 voxels, corresponding to FWE $p<.05$. During therapy, picture naming was distracted by interfering words which were primed by the preceding comprehension task, and directly assisted by increasing semantic and phonological cues. RESULTS. Using interfered naming and comprehension performance as covariates, we found pre-therapy brain activations for semantic associates versus phonological distractors in right fusiform/lingual gyrus, for semantic competitors versus phonological distractors in left precuneus, and for semantic associates versus competitors in wider mostly right-lateralized brain areas. Comparing pre- to post-therapy measurements, brain activations predominantly decreased. The combined treatment of linguistic and executive processing resulted in highly significant improvements both for pure and interfered naming in the therapy group (naming score, Wilcoxon singed ranks test, one-tailed, $p<.001$). Therapy gains in pure and interfered naming were positively correlated with initial distractor comprehension ($rs=.699$ and $.711$, $p<.01$, one-tailed) – but not with language comprehension in general (Aachen Aphasia Test; $p>.10$) –, and with an indicator of rather preserved lexical semantics (semantic connection weight in the Dell model, $p<05$). The pure naming gain affected trained items and generalised to untrained items to a similar extent (Wilcoxon, $p<.001$ each; difference of differences: Mann-Whitney-U, $p>.10$). CONCLUSIONS. Results indicate that the interference paradigm is a useful means for novel aphasia diagnosis and therapy. However, high variability in the population with aphasia regarding lesion size and location, as well as individual patterns of compensatory activations, still pose major challenges to fMRI therapy studies. LITERATURE. [1] Abel et al., The separation of processing stages in a lexical interference fMRI-paradigm, NeuroImage, 44 (2009) 1113-1124. [2] Abel et al., Therapy-induced brain reorganisation patterns in aphasia, Brain, 138 (2015) 1097-1112.

C40 Predicting speech entrainment success using white matter connectivity

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Increased speech fluency is a common behavioral treatment target for persons with non-fluent aphasia. Previous research therefore has sought to understand how brain injury relates to fluency inducing treatments including speech entrainment (SE), a therapeutic strategy requiring an individual to simultaneously produce speech while watching and listening to a video-recorded speech model. Persons with aphasia produce more fluent speech after SE treatment compared with treatments using practice in picture description, particularly for persons with Broca's aphasia with relatively restricted damage to the inferior frontal gyrus (IFG) (Fridriksson et al., 2012; Fridriksson et al., 2015). However, it is still unknown what residual structural neuronal network is necessary to support the successful SE-related sensorimotor transformation of speech. Thirty-six participants with chronic aphasia and 19 participants without aphasia secondary to left hemisphere stroke were selected from a larger treatment project for study (19 female; mean age 59±11 years). All participants underwent high-resolution MRI, were administered the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2007), described three pictures, and completed SE for three audio-visual speech models. The dependent variable was improvement in different words per minute (IDWPM), a measure of speech fluency, calculated by subtracting the average number of different words per minute produced during SE from the average number of different words per minute produced during picture descriptions (Fridriksson et al., 2012). Connections in left select regions of interest were analyzed through linear-kernel Support Vector Machine-based Regression (SVR). A random sampling scheme was used to generate 3 prediction score distributions: 1) an SVR model based on lesion data, 2) an SVR model based on connectivity data, and 3) an ensemble method that averaged

the outputs of the SVR models. A model's prediction score at each iteration of the sampling scheme was calculated as the coefficient of determination (correlation squared) between true and predicted IDWPM. Each of the 3 distributions was compared against a null hypothesis score of 0. This sampling scheme also generated coefficient distributions for each lesion and connection corresponding to model weights. These distributions were analyzed to determine which connections and lesions were associated with fluency improvement. The lesion-based model had a higher average prediction score (Mean 0.45 ±0.22, $t(999)=65$, $p<.05$) than both the connectivity model (Mean 0.20±0.30, $t(999)=21$, $p<.05$) and ensemble method (Mean 0.36±0.001, $t(999)=12{,}290$, $p<.05$). However, the ensemble method was more reliable as evidenced by the lower standard deviation and higher t-value. Probalistic white matter tracts that best predicted positive fluency-inducing response to SE as indexed by IDWPM included relatively preserved connections between left lingual and cingulate gyrus (LG-PCC; $t(999)=178$, $p<.001$), fusiform gyrus and posterior middle temporal gyrus (FuG-PSMG; $t(999)=163$, $p<.001$), and pre-cuneus and cuneus (PrCu-Cu; $t(999)=155$, $p<.001$). In line with our prior findings, participants with damage to IFG ($p<.001$) significantly increased the number of different words produced per minute with SE versus spontaneous speech. Together, these findings support the mounting evidence that white mater connections may be critically necessary to attain the maximum benefit from SE treatment and provide additional evidence for the use of SE to improve speech production.

C41 A DTI study of speech-related white matter tracts in patients with left-hemisphere stroke

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Stroke affects approximately 150,000 people in the UK each year. Speech and language difficulties commonly occur following a stroke affecting the brain's left hemisphere. The aim of this study was to use diffusion MRI to examine the microstructure of language tracts in people with left hemisphere stroke and to relate this to language abilities. We present the analysis of brain images in two groups, one followed longitudinally from the acute (~two weeks) to the chronic phase (~four months) and a group studied four months after the infarct. Structural and diffusion MRI scans were acquired in 24 patients and 24 controls longitudinally. An additional 30 patients were scanned at four months after the stroke. Lesion sizes and locations varied in size and were distributed throughout the left hemisphere. Diffusion data were preprocessed using the FMRIB Diffusion Toolbox (http://www.fmrib.ox.ac.uk/fsl). Images of fractional anisotropy (FA), mean diffusivity (MD), axial and radial diffusivity were calculated for all participants. Probabilistic tractography was used in the controls to reconstruct the following tracts connecting language areas in the left hemisphere: the arcuate fasciculus portion of the superior longitudinal fasciculus (AF), the extreme capsular fasciculus (ECF), the uncinate fasciculus (UF), and the frontal aslant tract (FAT). The cortico-bulbar tract (CBT) and corticospinal (CST) portions of the internal capsule were also tracked and compared. As a control tract not involved in language processing, we tracked the optic radiations (OR). Tracts were reconstructed in both hemispheres in each control and used to construct probabilistic atlases thresholded at 35%. Thresholded masks were applied to the diffusion images in each patient and control to calculate mean FA, MD, axial and radial diffusivity for each tract. Compared with controls, the patients scanned acutely had significantly lower mean FA and higher radial diffusivity in the left AF and FAT. The groups did not differ for any of the other tracts in the left hemisphere and the right-hemisphere tracts were also unaffected. Four months later, mean FA reduced further in the left AF, but not significantly. The thirty additional patients seen at four months had significantly lower mean FA, and significantly higher radial diffusivity and MD compared with controls in the left AF and FAT. In this group, the left ECF and UNC and the right FAT were similarly affected. Furthermore, the lesions in this group extended to affect the integrity of the left CBT and CST as well as the left OR. The lesions in these patients mainly affected the integrity of the dorsal language tracts (FAT and AF). In the group studied four months post stroke, the effects of the lesion were more extensive, and affected ventral tracts (ECF and UF), projection fibres to the brainstem and spinal cord from motor cortex (CBT and CST, respectively) as well as the thalamo-cortical visual projection (OR). Even though the lesions were restricted to the left hemisphere, the right frontal aslant tract was also affected. It is important to understand how these changes relate to and predict language outcomes in these patients.

C42 Intra- and inter-category regions in semantic dementia: Evidence from anti-VLSM and representational similarity analyses

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Semantic category has been documented as an essential organizational dimension of conceptual knowledge, and different semantic domains are supported by separated brain systems (Caramazza & Mahon, 2003). Researches also revealed two kinds of semantic representational facets: item-specific and superordinate category levels (Clarke & Tyler, 2015). Therefore, there are distinctive regions for intra-category (recognizing a given specific level concept from a category) and inter-category (recognizing a given category from others). However, such regions have not been known well. Semantic dementia (SD) is an ideal disease model to address this issue as SD patients present semantic-category-specific deficit and gradual error types from specific level to superordinate category level (Hodges & Patterson, 2007). To reveal the intra- and inter-category regions in SD, we adopted the representational similarity analysis (RSA, Kriegeskorte et al., 2008) to investigate the conceptual relationship among the brain maps of 40 items in object naming. To obtain the brain map of each item, we developed anti voxel-based lesion-symptom (anti-VLSM) analysis. The traditional VLSM (Bates et al., 2003) is to get a task-specific brain map by comparing the behavior (performance of multiple items in a task) between brain lesion types (subjects with and without lesion on each

voxel). The anti-VLSM is to obtain an item-specific brain map by comparing brain lesion degree (e.g., gray-matter volume values on each voxel) between behavior types (subjects performing correctly and wrongly on the item). We recruited 27 patients with SD (13 males, 62±9 years old; Gorno-Tempini et al., 2011) and 20 healthy controls (8 males, 61±4 years old). They orally named 20 animals and 20 tools. The following analyses were conducted. (i) The gray-matter volume value of each voxel was extracted from 3D TI image. (ii) The brain map of each item was obtained using anti-VLSM. (iii) A behavioral semantic similarity matrix across 40 items was created from 20 healthy adults' subjective ratings with a multiple arrangement method (Charest et al., 2014). (iv) A whole-brain searchlight analysis (in a 9-mm sphere) was performed to determine the intra- and inter category areas by correlating behavioral and neural semantic similarity matrixes (i.e., the correlations of anti-VLSM maps in the sphere for each pair of items). The intra-category matrix of a category only contained the pairs within it. However, the inter-category matrix of it included the pairs of it and between-category, in which the behavioral matrix was coded as 1 and 0 for within- and between-category pairs, respectively. For animals, the intra-category regions included the left insula and anterior hippocampus while the inter-category ones had the left inferior temporal gyrus, the right superior temporal gyrus and superior temporal pole (Bonferroni $p < 0.05$). For tools, the intra-category regions mainly involved in the bilateral postcentral gyri, supra-marginal gyri, cuneus, and the left middle temporal gyri, while inter category ones had the right inferior frontal gyrus, precuneus and superior parietal gyrus (uncorrected $p < 0.005$). These findings further clarify the organization of semantic knowledge, which is a distributed brain network along hierarchy level with semantic category.

C43 Lesion correlates of noun and verb processing in post-stroke aphasia: Voxel-Based Correlational Methodology

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There is a debate in the literature concerning the nature of verb and noun processing, and whether there are differences in processing these two word classes and their neural correlates. The debate falls into two broad hypotheses. First, noun and verb processing is segregated in distinct brain regions, with verb-processing engaging left frontal regions and noun-processing engaging left temporal regions. Second, the neural correlates of noun and verb processing are jointly supported in overlapping brain areas involving left frontal, temporal and parietal regions. In this study, we used a lesion-correlation technique to identify brain damage associated with noun and verb processing deficits in chronic post-stoke aphasia. A survey of the materials used in the current literature to investigate noun-verb comprehension and production difference suggests that there is a dearth of comprehension tests for verbs, and that the materials are not sufficiently well controlled in existing naming tests. Therefore, we created a noun-verb set matched simultaneously on imageability, frequency, familiarity, age-of-acquisition and word length. We used these test items to probe production (word naming) and comprehension (picture-to-word matching). Normative data were collected from 25 healthy control participants (Mean age=72.64, SD=5.37), which revealed high accuracy (greater than 97.9% in all tests). Subsequently, we tested 27 chronic post-stroke participants (Mean age=62, SD=12.8), with a range of aphasia types resulting from a single left-hemisphere stroke. A three-way ANOVA revealed no significant differences between nouns and verbs, both on the naming and the picture-to-word matching tasks. A main effect of task was found showing an advantage for picture-to-word matching over naming, and a main effect of group showed the fluent group was more accurate than non-fluent group. We then applied Voxel-Based Correlational Methodology (VBCM) using continuous behavioural and tissue intensity. The naming task showed a large overlapping area spanning the left temporal lobe extending from ventral supramarginal gyrus to anterior temporal pole for both noun and verb naming. In contrast, a direct comparison between noun and verb naming identified the precentral gyrus for verb-naming, with no significant cluster for noun-naming. We repeated the VBCM on the picture-to-word matching task. Again, we found a large overlap between noun and verb comprehension along the left middle temporal gyrus and temporal fusiform cortex. A direct contrast between noun and verb comprehension revealed parts of the left fronto-partial network for verb-comprehension, with no significant clusters for noun-comprehension. The current findings suggest that, using well-matched materials on multiple psycholinguistic features, there is no behavioural differences between verb and noun production and comprehension, and they share overlapping neural correlates within the left temporal lobe. Nevertheless, distinct neural correlates for verbs do appear, in a direct contrast with nouns, which are task dependant. Specifically, frontal lesions in the precentral gyrus seem to adversely affect verb compared to noun production. The motor cortex may be involved due to the perceived action of verbs, or the articulation of morphological markers attached to the verbs. Furthermore, verb-comprehension required an extended executive-control network, which might suggest that verbs place higher attentional processing demands compared to nouns.

C44 Longitudinal changes of resting state functional connectivity during naming recovery after stroke

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Introduction: Resting-state functional MRI (rs-fMRI) could provide crucial information on the neural mechanisms of language recovery in participants with aphasia. Post stroke loss and recovery of functions have been increasingly correlated with alterations in the connectivity of neural networks; however, the relationship between aphasia recovery and changes in functional connectivity of distinct language regions is largely unknown. In this study, we explored the neural correlates of naming recovery in participants with aphasia by investigating longitudinal changes in rs-fMRI of the language network. In addition, we also examined changes in rs-fMRI

in participants that have damage to the 'language cortex' regions of interest (MCA: middle cerebral artery strokes) and participants that do no have damage to the language cortex regions of interest (PCA: posterior cerebral artery strokes). Methods: Participants included 12 individuals with right-handed acute ischemic left hemisphere stroke (mean age: 63.1 years) and 8 healthy controls (mean age: 66.2 years). Six participants had PCA strokes involving the left thalamus or left occipital/fusiform gyrus, and the other six participants had MCA strokes involving the left temporal lobe or the left frontal lobe. All participants had naming deficits acutely and they showed varying degrees of recovery. Stroke participants received detailed language testing and resting-state fMRI at the acute (within 3 days post stroke) and chronic (7-14 months post stroke) time points. Controls were scanned once. Naming performance was assessed using the Boston Naming Test. We investigated the intra-hemispheric and inter-hemispheric connectivity of the language regions of interest (ROI). ROI included regions in the left and right "language cortex": inferior frontal gyrus (IFG, pars opercularis, pars triangularis, and pars orbitalis), superior temporal gyrus (STG), middle temporal gyrus (MTG), inferior temporal gyrus (ITG), supramarginal gyrus (SMG), angular gyrus (AG). Lesion masking was performed and only non-lesioned voxels were included in each ROI for connectivity analyses. Fisher-transformed correlation matrices were obtained for the participants from the resting state data. Resting state connectivity analyses were performed automatically in BrainGPS (https://braingps.anatomyworks.org). Results: For the normal controls there was good inter- and intra-hemisphere connectivity between the language ROIs. At the acute time point, participants with aphasia (both MCA and PCA strokes) had weak inter and intra hemisphere connectivity between the language ROI. Participants with moderate to severe naming deficits had weaker connectivity (low or negative z scores for correlations) compared to participants with mild naming deficits. Functional connectivity increased within and across hemispheres in the chronic phase in participants who showed the most recovery of naming, but neither intra- nor inter-hemispheric connectivity increased in participants who continued to have moderate aphasia. Conclusion: Our findings indicate that recovery of language skills from the acute to the chronic phase is paralleled by an improvement in inter-hemispheric, and often intra-hemispheric, functional connectivity. Irrespective of the whether or not participants have damage to language cortex ROI, what was most important was the restoration of balance between bilateral language networks for language recovery. A better understanding of network mechanisms of language plasticity may lead to new prognostic biomarkers and therapeutic targets.

C45 Association between language functional network and attenuated psychotic symptoms in clinical high-risk psychosis patients in Shanghai

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Goals: The onset of schizophrenia (SZ) occurs during young adulthood. Approximately 30% of patients who display attenuated psychotic symptoms of illness between 15 and 30 years old convert to a psychotic disorder within 3 years. Understanding the neural characteristics related to the clinical high risk (CHR) of SZ allows timely diagnosis and intervention that potentially prevents later manifestation of chronic psychosis. Studying CHR patients who haven't received medication treatment also provides an unprecedented advantage to dissociate the risk markers from drug effect. One of the important symptoms of CHR patients is language dysfunction characterized by impairment of verbal communication and auditory hallucinations. The current study investigates the functional organization of language network in CHR patients and its relationship to SZ symptomatology. Methods: 50 CHR patients from Shanghai Mental Health Center, together with 30 age- and gender-matched healthy controls (HC), underwent a 6-min resting state fMRI scan as well as a high-resolution T1-weighted anatomical scan. The two groups differed significantly in years of education, which was therefore entered as a covariate in all the imaging analysis. SPM and CONN were used to process resting-state fMRI data. Whole-brain connectivity analysis based on the seed regions (Left IFG) was compared between groups and related to CHR symptoms. Results: Compared to HC, the CHR group exhibited enhanced connectivity within the left hemisphere and reduced connectivity between left and right hemispheres. In particular, the CHR group showed hyper-connectivity between left IFG and left posterior STG, as well as left premotor cortex, but hypo-connectivity between left IFG and right IFG. Brain-behavior correlation analysis showed distinct roles of these two biomarkers. The extent of hypo-connectivity between hemispheres marks the severity of the positive symptoms, while the extent of hyper-connectivity between the left frontal and posterior language nodes indexes less severe positive symptoms. Conclusions: Reduced cross-hemispheric frontal connectivity in the CHR group is consistent with previous evidence in chronic schizophrenia patients. The decreased functional communication between hemispheres might reflect impaired inhibition pathways as predisposition to psychosis. However, greater long-distance connectivity between left IFG and left posterior STG, which is crucial for integration of speech sounds and semantics, seems to constitute a protective mechanism for at least a subset of CHR patients. Future studies will relate the longitudinal clinical outcomes with individuals' functional network.

C46 Language brain networks in anomic versus non-anomic early Alzheimer's disease patients

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Language impairments such as anomia are frequent yet heterogeneous in Alzheimer's disease (AD). Previous neuroimaging studies suggest that the left posterior middle temporal gyrus (pMTG) might be hypoactivated during language tasks in AD patients, leading to impaired lexical access. Other studies have associated naming impairments in AD with left anterior temporal lobe (ATL) atrophy, which

may lead to loss of semantic content. Nonetheless, increasing evidence demonstrates that clinical symptoms observed in AD reflect variations within large-scale brain networks. The present magnetic resonance imaging study aims to compare the organization of gray matter structural covariance networks anchored to regions implicated in naming between cognitively unimpaired controls (CTRL), non-anomic and anomic AD patients. 130 CTRLs and 130 AD patients from the ADNI database were included in the study. AD patients were classified as non-anomic when they presented scores on the Boston Naming Test comparable to the CTRLs' mean (n=65), and as anomic when they presented a naming performance of 2 standard deviations below the mean of CTRLs (n=65). Groups were matched on age, gender, and education. Using voxel-based morphometry, we investigated the pattern of structural covariance between the gray matter volume of a 4 mm sphere within a seed brain region (i.e. critical region of the network) and the gray matter volume throughout the entire brain. Based on previous literature, seed regions were placed bilaterally in regions of the semantic network: the pMTG (±66, -42, 3), the ATL (±38, 10, -28) and the inferior prefrontal cortex (iPfC) (±50, 18, 7). Controlling for brain sizes, specific T contrasts were established to map the voxels that expressed a stronger structural association between groups ($p \leq 0.05$ FWE corrected). Networks with seeds within the left hemisphere had equivalent spatial extent (amount of voxels) in all groups, with the exception of the left pMTG network, which was more extended in non-anomic AD patients. Compared to anomic AD and CTRLs, non-anomic AD presented increased structural association between the left pMTG and the left cerebellum. Conversely, all networks with seeds within the right hemisphere showed increased spatial extent in anomic AD versus non-anomic AD and CTRLs (which were equivalent). Compared to non-anomic AD, anomic AD presented increased structural association between the right ATL and the right middle cingulate cortex. Compared to CTRLs, anomic AD presented increased structural association between the right pMTG, the right iPfC and the right ATL. Our results suggest that non-anomic AD patients might rely on stronger structural associations between the left pMTG and other brain regions such as the cerebellum, in order to preserve their naming abilities. Anomic AD patients, in contrast, do not present this adaptive reorganization: the left pMTG is structurally associated with fewer regions in these patients. This could potentially contribute to impaired lexical access. Furthermore, anomic AD patients seem to rely on right-hemisphere language networks. Our findings support previous studies reporting a reorganization of cortical language networks in AD towards the right hemisphere and further suggest that this reorganization is maladaptive.

C47 Abnormal semantic processing of emotional and neutral words in post traumatic stress disorder

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Post traumatic stress disorder (PTSD) is associated with dysfunction of fronto-limbic brain circuits involved in emotional memory and the control of behavioral manifestations of fear. Previous neuroimaging work has demonstrated a relatively elevated and sustained-over-time response in the left amygdala to trauma-related words in subjects with PTSD, and a positive correlation between the level of the amygdala response and PTSD symptom severity (Protopopescu et al., Biological Psychiatry 2005; 57:464-473). The present study focused on the role of the semantic system in mediating the processing of emotional words in subjects with PTSD. Methods: Participants were patients with a primary diagnosis of sexual/physical assault PTSD (N=29; mean age (SD) =35 (9), 25 females) and normal (NL) subjects (N=23; mean age (SD) =29 (8), 11 females). Whole brain blood oxygen level dependent functional magnetic resonance imaging (fMRI) responses were compared in the PTSD and NL subjects during silent reading of words. The words consisted of 24 negative trauma-related (e.g., rape, force), 24 negative non-trauma-related (e.g., cancer, frantic), 48 neutral (e.g., bookcase, rotate), and 48 positive (e.g., gentle, delighted) words, balanced across valence categories for frequency, length, and part of speech. The fMRI activity was compared in the early and late epochs of the scan to assess sensitization and habituation. In the PTSD patients, the fMRI activity was also correlated with symptom severity measured by the Clinician Administered PTSD Scale (CAPS). Results: In a post scan behavioral test, the PTSD and NL subjects rated the trauma words as more negative than the neutral words, and the PTSD subjects rated the trauma words as more negative than the non-trauma words ($p < .001$). The PTSD compared to NL subjects showed a different fMRI pattern in left temporal and left inferior parietal language areas in response to both the trauma and neutral words. In the angular gyrus (AG), fusiform gyrus (FG), and rostral anterior cingulate gyrus (AC), there was reduced deactivation to the trauma words. In the posterior middle temporal gyrus (pMTG), there was elevated activation to the trauma words in the late epoch (i.e., there was less habituation). In the pMTG and AC, the response was also elevated to the neutral words. In PTSD subjects, the level of activation to trauma versus neutral words was positively correlated with PTSD symptom severity in the pMTG in the late epoch, and negatively correlated with AC. Conclusions: The results demonstrate a different time course of habituation and different specificity of left semantic areas in PTSD relative to NL subjects. The areas showing reduced deactivation to the trauma words in PTSD (AG, FG, AC) are part of the default network, in which deactivations have been associated with spontaneous (task-unrelated) cognitive and semantic processing. The left pMTG showing elevated activation in PTSD to both trauma and neutral words is part of the semantic network associated with supramodal integration and concept retrieval. Overall, these results suggest that semantic processing of both trauma-related negative words and neutral words is impaired in PTSD, as reflected by more extensive engagement of the semantic system.

C48 Using fMRI to predict post-stroke aphasia recovery

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BACKGROUND: Recovery from post-stroke aphasia is highly variable. Currently, there is no effective method available to predict how an individual with aphasia will recover, or to guide the type and timing of language therapy offered. This study addresses the lack of knowledge regarding brain mechanisms which underpin aphasia recovery in order to provide much needed specificity in determining the best predictors of recovery for language symptoms targeted in rehabilitation. METHODS: Twelve individuals with post-stroke aphasia and 15 healthy aged-matched controls performed an event-related functional MRI language task and spoken word comprehension assessment (out of scanner) at 2-6 weeks (subacute) and 6 months (chronic) post-stroke. The fMRI task involved lexical decisions on auditory words (abstract, concrete) and pseudowords. RESULTS: Region of interest analyses were conducted to investigate the relationship between brain activity for concrete, abstract, and pseudoword conditions and spoken word comprehension at 6 months. ROIs were selected based on previous meta-analyses of concrete and abstract word processing. At the subacute stage, there was a strong positive correlation between left posterior cingulate activity for pseudowords and improved spoken word comprehension at six months. Negative correlations were also observed between chronic spoken word comprehension and increased subacute left SFG activity for pseudowords. At the chronic time point, activity in left posterior cingulate for both concrete and abstract words was positively correlated with single word comprehension. CONCLUSIONS: These findings demonstrate the potential of this paradigm to elicit language-related neural activity in subacute and chronic aphasia that relates to improved spoken word comprehension. The positive involvement of left posterior cingulate at both time points suggests that this region contributes to improved language comprehension abilities although its function appears to change over the course of recovery with respect to activity elicited for pseudowords (subacute) versus real words (chronic). While this region is commonly associated with the default mode network, it is also frequently engaged during retrieval of semantic information and episodic memory operations. Successful engagement of these semantic retrieval processes while performing lexical decisions appears related to subsequent recovery of spoken word comprehension. The negative relationship between subacute stage left SFG activity and recovery of spoken word comprehension, suggests less capacity for recovery when domain-general regions associated with cognitive control are recruited during lexical decision.

Meaning: Combinatorial Semantics

C49 Quantifier Polarity Processing and Numerical Comparison: fMRI results show striking Modularity

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BACKGROUND: Natural language quantifiers – expressions like many, at-least-5, less-than-½ – are situated at an important cognitive crossroads: they have unique logical, syntactic and semantic properties, and also, denote quantity. This places them at the interface between reasoning, language processing, and numerical cognition. One important property of quantifiers is Polarity: reasoning with positive quantifiers (e.g., many, more-than-half) involves inferences in one direction (1); with negative ones (few, less-than-half), the direction reverses (2): (1) POS: at-least-3 students cooked carrot soup at least 3 students cooked soup (2) NEG: at-most-3 students cooked carrot soup at most 3 students cooked soup Recent experimental results with a Parametric Proportion Paradigm (PPP, Deschamps et al., 2015) indicate that Polarity has a behavioral signature. Exposed to probe-scenario pairs, participants heard sentences with quantifiers, or equivalent non-linguistic probes (with <,>) and verified them against proportion-depicting images. Sentence probes consisted of negative/positive pairs, where meaning, structure, number of words and syllables were kept constant (sentence: more-than-half of the circles are blue, less-than-half of the circles are yellow; image: blue and yellow circles). Similarly, analogous non-linguistic probes (<, >) were used. Sentences with negative quantifiers were processed slower than their positive counterparts; different non-verbal probes had no effect on performance. A Probe type*Polarity interaction was found. These results, together with an initial fMRI test (Heim et al., 2012), guided us in this project. GOALS: 1. To uncover the neural dynamics of numerosity tasks driven by complex linguistic stimuli 2. To find cerebral loci for quantifier processing and study their relation to Numerosity EXPERIMENT: We conducted an fMRI test with the PPP: sentence probe pairs with polar quantifiers, and non-linguistic probe pairs (<,>) were tested against images depicting 5 different proportions. Events divided into a composition part, in which the probe was presented (Phase 1, 2.6sec), and estimation/comparison part (Phase 2, 3.4sec), where an image was presented. A speeded truth-value judgment followed. ANALYSIS: Behavioral - analyses aimed to replicate previous results were performed. fMRI - all time series were pre-processed. For each trial we modeled two different time windows: (1) Phase 1, focusing on the presentation of the auditory or visual probe and (2) Phase 2, focusing on the visual display. Within each phase, we investigated the Probe type*Polarity interaction and the effect of numerical comparison (as a proxy, we used the correlation between RTs and the BOLD signal). RESULTS: Behavioral results were replicated – a quantifier Polarity effect and Probe type by Polarity interaction. For the fMRI data, a Phase 1 and Phase 2 Probe type*Polarity interaction was only found in left anterior insula. A Phase 1 and Phase 2 numerical comparison effect was found mainly in the IFG and IPS, bilaterally. CONCLUSIONS: 1. Quantifier Polarity processing resides in specialized cortical loci, which are silent during Numerical Comparison. 2. Numerical comparison relies on a distinct set of regions, which are insensitive to linguistic processing. 3. The linguistic stimulus activates numerosity regions even before an image is viewed. 4. Critical combinatorial linguistic and numerical abilities constitute distinct neural modules.

C50 Less is more: negative polarity in quantifiers is more difficult to process than negative polarity in adjectives

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INTRODUCTION: The quantifiers “few” and “many” are similar to the adjectives “short” and “high” in the fact that both are polar pairs with a negative and a positive. The negative

poles ("few", "short") denote some small degree relative to a contextual standard: (1) Few students took algebra: the number of the students who took algebra is below some standard. (2) Short students took algebra: the height of the students who took algebra is below some standard. However, only in quantifiers does negative polarity affect reasoning (4 vs. 3; given a fixed standard), while negative adjectives do not have such an effect (6 vs. 5): (3) Many students took algebra. ==> Many students took mathematics. (4) Few students took algebra. □ Few students took mathematics. (5) Tall students took algebra. ==> Tall students took mathematics. (6) Short students took algebra. ==> Short students took mathematics. Given the centrality of reasoning in our mental life, we tried to find processing evidence that would inform us on whether these two sets of pairs have a similar or a different cognitive status. We present two reaction time experiments (verification task) that directly compare negative polarity in adjectives to negative polarity in quantifiers. In the presentation we will also present results from an ongoing fMRI experiment. METHODS: Subjects heard sentences of the structure "X of the circles are blue/yellow", where X is an expression of quantity that contains either a quantifier or an adjective (Type), which is either positive or negative (Polarity). To get even a finer structure, we included a factor of whether the expression X compares to a standard which is a fraction/proportion or not (Standard). This results in a 2×2×2 design. For example, "a small number" is negative, cardinal, adjective; "more than half" is positive, proportional, quantifier. Subjects were instructed to decide as fast and as accurately as they could whether the sentence correctly described a picture that immediately followed it. RTs were measured, and the log of the RTs was used as the dependent variable in a repeated measures ANOVA. RESULTS AND CONCLUSIONS: Replicating previous results, we found a main effect of Polarity ($p<0.001$, $F(1,31)=267.09$). If the impact on reasoning has also an impact on processing, then we should find that the Quantifier Type condition has an overall larger polarity effect (=RT difference between negative and positive) than the Adjective Type condition, namely a statistical interaction of Type×Polarity. As predicted, a significant interaction of Type×Polarity was found ($p<0.001$ $F(1,31)=22.72$). This was found both Standard conditions. We replicated these results in Hebrew (Polarity: $p<0.001$, $F(1,29)=139.13$; Type×Polarity: $p<0.001$). These results suggest that despite the similarity between polarity in adjectives and in quantifiers, they are not processed similarly, and that reasoning is a determinant factor in their processing.

C51 Compositionality and imagination: Assessing the neuronal correlates of indeterminate sentence interpretation

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Sentences such as 'The author started the book' are often called indeterminate because they do not make explicit what the subject (the author) actually started doing with the object (the book). This type of sentence has generated a lot of interest because it represents a case study for a central issue in language representation and processing: compositionality. Thus far there have been at least two proposals for how the meaning of an indeterminate sentence is attained. By far the dominant view assumes that some form of local semantic enrichment takes place—often via what is called "coercion" or "type-shifting" (e.g., Pustejovsky, 1995). Both coercion and type shifting assume that internal analyses of the noun complement—i.e., features or ontological properties—are assessed and retrieved in order to resolve an alleged mismatch between an event-taking verb (begin) and an entity noun (book), yielding an enriched form of compositionality. An alternative view assumes that classical compositionality is enforced, with much of the interpretation of the sentence being the product of (abductive) inferences (e.g., Fodor & Lepore, 2001; de Almeida & Dwivedi, 2008; de Almeida & Lepore, 2016). Most experimental psycholinguistic studies have failed to provide clear support for either theory, even if longer reading times at post-verbal positions are often obtained—an effect that can be accounted for by both theories. Thus far, only three cognitive neuroscience studies have investigated this particular type of construction. An MEG study (Pylkkanen & McElree, 2007) found that, relative to the other conditions, indeterminate sentences produced a unique response in what they called the anterior midline field (AMF), hypothesized to be at the ventromedial prefrontal cortex (vmPFC). However, this study also found an early bilateral temporal activation. An fMRI study (Husband, et al., 2011) found that indeterminate sentences significantly activated the left inferior frontal gyrus (L-IFG; BA45) relative to controls, leading the authors to conclude that this region represents the locus of coercion. No differential activation was found in the vmPFC, contra Pylkkanen and McElree's (2007) AMF result. Yet, another fMRI study (de Almeida et al., 2016) obtained results that are only partially compatible with both previous studies: bilateral activation of the superior temporal gyrus (STG), the right (but not left) IFG, and the anterior cingulate cortex (ACC), more so than control sentences. Because the ACC is anatomically (and, by hypothesis, functionally) connected to the vmPFC (Margulies et al., 2007) it is possible that the MEG effects reflect the spread of activation from ACC into prefrontal areas. If indeed each of these regions participates in the resolution process, this challenges a view of indeterminacy that links indeterminacy resolution uniquely to the L-IFG. This casts doubt on a version of coercion theory that attributes the resolution of these sentences strictly to a semantic coercion operation. Instead, data from two studies are in line with a theory of indeterminacy resolution that takes indeterminate sentences to trigger a search for a resolution—a process of imagination beyond strict sentence compositionality.

C52 Lexical access feeds composition: Temporal modulation of combinatory LATL activity according to lexical access demands

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Introduction. A large literature has identified the left anterior temporal lobe (LATL) as a combinatory hub, and specifically, as a site of conceptual-semantic integration. In light of this functional hypothesis, the timing of LATL effects in combinatory contexts is somewhat surprising: they peak around 200ms (Bemis & Pylkkänen, 2011, 2012), at which time lexical semantic effects are not consistently observed. Here we aimed to distinguish between two hypotheses regarding the temporal aspects of combinatory LATL activity: (i) The

earliness of prior effects is enabled by the fact that in the rapid serial visual presentation designs of prior studies, the context word (e.g. red) has been fully processed before the composing word (e.g. boat) is encountered. Thus, relatively little semantic access is required before composition at the target item proceeds. (ii) The earliness of combinatory LATL effects is due to a hardwired architecture in which the LATL is part of an obligatory processing stream, wherein the signal arrives at the LATL approximately 200ms post-onset. At this time, composition occurs if semantic activation of the composing items has sufficiently unfolded. If, however, the meanings of the composing items have not yet been sufficiently accessed, the LATL cannot compose them (say, later in time). To distinguish between (i) and (ii), we compared modifier-noun composition, where the modifier was presented in a screen prior to a monomorphemic noun (marble fountain), to compounding (bathroom), in which the composing items were presented simultaneously. According to hypothesis (i), compounds should elicit a later LATL combinatory effect than the modifier-noun combinations, since the former require accessing two input items in parallel before composition. In contrast, hypothesis (ii) would predict no LATL combinatory effects for compounds, assuming that the constituent meanings are unlikely to be sufficiently accessed by 200ms. Finally, if the LATL participates in meaning composition, its combinatory effects should not straightforwardly extend to semantically opaque compounds. To test this, opaque compounds (butterfly) were also included. Methods. Monomorphemic, transparent compound, and opaque compound nouns followed either a modifier or consonant string in a magnetoencephalography study. Critical analyses were run on distributed source activity localized to the LATL in twenty-four subjects. Results. When monomorphemic single nouns were compared to their modified versions, an effect of modification started in the LATL at 150ms, with modified nouns eliciting greater activity. When monomorphemic single nouns were compared to semantically transparent compounds, a similar effect was observed for compounds, but this began at 335ms. The comparison between opaque compounds and monomorphemic nouns showed no LATL effects. Conclusion. A clear latency modulation of LATL combinatory activity was observed, with the compound effect trailing the modification effect by 185ms, accountable by the hypothesis that this activity begins once the meanings of the constituents have been sufficiently accessed. We provide evidence against the hypothesis that LATL effects necessarily occur in the 200-250ms time-window, a generalization that was compatible with prior data. Finally, the absence of LATL combinatory effects for opaque compounds agrees with prior reports suggesting a semantic as opposed to morphosyntactic role for this activity.

Meaning: Discourse and Pragmatics

C53 The brain dissociates between different levels of prediction during language comprehension

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Hierarchical generative frameworks of language comprehension propose that comprehenders constantly attempt to infer the underlying message they believe is being communicated. In turn, probabilistic predictions are generated at multiple lower level representations which are compared to the unfolding bottom-up input (Kuperberg & Jaeger, 2015). Here, we asked whether and how predictions at different levels of representation influence neural processing of incoming words. We used a partially-crossed design in which target nouns fulfilled or violated contextual predictions at the level of specific lexical items and/or verb-argument event structure. METHOD: Event-related potentials (ERPs) were collected as participants read and judged the acceptability of five types of discourse scenarios (examples below). Contexts were either lexically constraining (average cloze predictions: 82%) or non-constraining (average cloze predictions: 26%). Following lexically constraining contexts, target nouns were (1) Lexically Expected, (2) Lexically Violating, or (3) Lexically and Animacy Violating (violating the preceding verb's animacy-based selection restrictions). Following non-constraining contexts, target nouns were (4) Lexically Unexpected or (5) Animacy Violating. Target nouns in conditions (2) through (5) were matched on semantic relatedness with their preceding content words. Discourse contexts appeared in full; a third sentence appeared word-by-word. RESULTS: We observed clear dissociable neural signatures of semantic facilitation, lexical prediction violations, and event structure prediction violations in the same participants. (A) Semantic predictions: The amplitude of the N400 was selectively reduced to the Lexically Expected nouns compared to all other conditions. (B) Lexical predictions: A Late Anteriorly-distributed Positivity was selectively enhanced to Lexically Violating nouns following lexically constraining contexts, but was not evoked by lexically violating nouns that additionally violated the animacy constraints of the preceding verb. (C) Event structure predictions: A late Posteriorly-distributed Positivity (the P600 effect) was selectively enhanced to Animacy Violating nouns; its amplitude was larger following lexically constraining than non-constraining contexts. DISCUSSION: Our N400 findings highlight the fact that this waveform primarily reflects the predictability of an incoming word's semantic features, rather then either its lexical predictability or its message-level coherence. Our findings on the late positivities indicate that the brain engages in prolonged neural processing upon encountering words that violate both lexical and event structure prediction, but by engaging distinct but partially interacting neural networks. Taken together, these findings support a hierarchical generative architecture in which unfolding bottom-up evidence that has not already been predicted at a given level of representational level manifests in the brain as distinct spatiotemporal neural signatures. EXAMPLE STIMULI. Constraining: The lifeguards received a report of sharks right near the beach. Their immediate concern was to prevent any incidents in the sea. Hence, they cautioned the (1) swimmers / (2) trainees/ (3) drawer. Non-constraining: Eric and Grant received the news late in the day. They decided it was better to act sooner than later. Hence, they cautioned the (4) trainees / (5) drawer.

C54 The neural difference between Chinese and English in reading and listening stories

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An increasing interest has focused on the universal brain activities across languages/writing systems (Nakamura et al., 2012, PNAS; Rueckl et al., 2015, PNAS). In supporting this view, our previous study has found language-specific regions in word reading disappeared in naturalistic reading (Wang et al., 2015), and concludes that the language-specific areas in previous studies might be due to the demands of the linguistic tasks. To further understand this view, we examined the neural difference between Chinese and English in story comprehension at shared and distinct regions of input modalities (reading and listening). The prediction was that the language difference would only occur at modality-specific regions that can be modulated by tasks. In the current fMRI study, two groups of adults (16 Chinese and 16 English native speakers) with normal vision participated the experiment. Participants performed comprehension task on six fairy tales (by Hans Christian Andersen) in their native language version. A full story was presented in each run and was split into four blocks, two for reading and two for listening task. Reading and listening blocks mixed in each run. Each block was followed by 20s of rest. After each story, a set of four multiple-choice comprehension questions was presented to ensure participants have understood the meaning of the story. First, the GLM contrast was used to identify the language difference on each modality. The results showed that reading stories recruited more activation in bilateral visual areas of the occipital and temporal lobes for Chinese than English group, and that listening stories shared the neural networks for two groups without significant difference. Then, the consensus maps were examined in each group and combined to reveal the language difference in shared and distinct regions on reading and listening modalities. In reading specific areas, Chinese group showed more consistent activity at superior parietal lobule and posterior inferior temporal gyrus than English groups. In listening specific areas, English group showed more consistent activity in left superior temporal gyrus than Chinese group. Whereas in shared regions of reading and listening, Chinese group showed more consistent activities at bilateral IFG and left middle frontal gyrus that might reflect general cognitive processing in story comprehension. As for shared regions along bilateral STS, which function as language comprehension, showed no difference between Chinese and English groups. In summary, our data revealed that the major neural difference between two languages is in regions of modality specific, but not in regions of cross-modality for high-level comprehension processing. The finding confirmed the view that previous language-specific findings was driven by the task demands, and has great theoretical implication on the universal neural network for language processing across writing systems.

C55 Processing affirmation and negation in contexts with unique or multiple alternatives

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Negative sentences have been claimed to be more complex and therefore harder to process than affirmative ones (Just & Carpenter, 1971; Carpenter et al., 1999; Lüdtke et al., 2008). This observation raises the question of how negated concepts are represented and how negation is integrated into the sentence meaning. The Two-Step-Simulation-Hypotheses by Kaup et al. (2006) predicts that negation is integrated into the sentence meaning in two steps. First, the negated state of affairs is simulated, whereas the actual state of affairs is simulated only at a second step. Hence, in order to process a sentence like The door is not open one needs to simulate first the open door before simulating the closed door. However, this theory is not in line with incremental language comprehension, since the processing of negation is postponed to a later stage. Furthermore, polar adjectives such as closed vs. open allow for the identification of the negative of a predicate (not open) through its affirmative opposite (closed). Compared to cases where there is no clear opposite (e.g. red) the processing of the negation of polar adjectives can be facilitated. Measuring ERPs during a sentence-picture-verification paradigm we addressed the question of whether the processing of affirmation and negation is facilitated in cases where the context offers a unique referent relative to those where the context offers multiple referents. We used a 2 x 2 design with the factors: (i) context model (unique vs. multiple referent) and (ii) sentence polarity (affirmative vs. negative). The pictures depicted three different objects out of which either one or two were then marked with a frame. A green picture frame was used to indicate that an object was chosen and hence the unframed one(s) is/are unchosen. A red frame was used to indicate that an object was not chosen and hence the unframed one(s) is/are chosen. The target sentence expressed which object was chosen (affirmative) or was not chosen (negative). In the first experiment the sentence always referred to an unframed object. Thus, in the condition with two out of three objects framed there was only one possible referent (unframed picture), whereas in the condition with one framed object there were multiple referents (unframed pictures). In the second experiment we reversed the frames so that the sentence referred to framed objects in order to make sure our effects are not caused by the framing. In both experiments we observe a clear N400 effect for the multiple conditions compared to the unique ones, which is independent of the sentence polarity. This effect indicates that the processing of the unique referent is facilitated relative to the case when there are multiple referents available in the context model. Whereas the Two-Step-Simulation-Hypothesis predicts that the contrast between multiple and unique cases should be larger for negative than for affirmative sentences, our study does not support this claim. Additionally, we observed a sustained positivity effect for the negative compared to the affirmative conditions, which indicates possible reanalysis mechanisms related to the processing of negation.

Perception: Orthographic and Other Visual Processes

C56 Left inferior longitudinal fasciculus underlies orthographic processing: Evidence from lesion-behavior mapping analysis

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Introduction: Orthography is a pivotal component in language. Previous studies have found that anatomical connectivity supporting orthographic processing might include the left inferior longitudinal fasciculus (ILF) and inferior fronto-occipital fasciculus (Epelbaum et al., 2008; Vandermosten et al., 2012). Zemmoura et al. (2015) further claimed that damage to the posterior (but not anterior) segment of the left ILF led to dyslexia. Albeit informative of these studies, it could not conclude for orthographic anatomical network, because (1) reading task they used includes other processes in addition to orthographic recognition; (2) the findings on the basis of one patient should be validated by a large sample of patients; (3) structural/functional reorganization bias might exist in some studies; (4) only limited white fibers were considered. The present study aims to identify the orthographic-relevant tracts by adopting pure orthographic processing index and considering major white matter tracts across the entire brain in a large sample of patients with short-term brain damage. Methods In 70 patients with brain damage, we correlated the pure orthographic index and white-matter integrity of each of the 20 major tracts across the whole brain. The orthographic index was measured by the mean values of two sets of residuals: orthographic tasks (visual lexical decision, word associative matching) regressing out non-orthographic tasks (auditory lexical decision, visual form perception, picture associative matching). The integrity of white matter tracts was measured by the lesion volume percentage (LVP) and the mean fractional anisotropy (FA) value. The observed effects were further validated through covarying confounding variables (relevant gray matter region, types of brain damage, types of aphasia, and disease duration time). We also separately investigated the effects of anterior and posterior segments of the observed tract. In addition, the functional specificity of the tract was explored by calculating the correlations between the tract integrity and the above non-orthographic control tasks performance. Results The left ILF was found to be the only orthographic-relevant tract, whose integrity values were significantly correlated with the orthographic index (FA: $r = 0.34$, FDR corrected $q < 0.05$; LVP: $r = -0.50$, FDR corrected $q < 0.05$) even after controlling for potential confounding factors (FA: partial rs = 0.27 to 0.35, ps < 0.04; LVP: partial rs = -0.64 to -0.60, ps < 0.0005). Furthermore, the integrity values of posterior and anterior branches were both significantly correlated with orthographic scores (anterior branch: LVP: partial $r = -0.54$, $p < 10\text{-}5$, FA: partial $r = 0.36$, $p < 0.003$; posterior branch: LVP: partial $r = -0.64$, $p < 10\text{-}8$, FA: partial $r = -0.08$, $p > 0.50$). The mean FA values of the tract could also predict the performance of visual form perception (partial $r = 0.24$, $p < 0.05$) and picture associative matching (partial $r = 0.31$, $p < 0.02$). Conclusions The left ILF (both anterior and posterior segments) might play a critical role in orthographic processing, and involves in object primary visual perception.

C57 To gaze – to see – to read: Brain activity beyond orthographic processing

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Developmental reading problems can occur due to a variety of problems: Some children have phonological deficits, whereas others suffer from attentional or visual processing difficulties or problems in gaze control. In order to dissociate neurophysiological processes in the domains of orthography/phonology from nonlinguistic processing demands, the Landolt reading paradigm was established. Replacing all letters in a written sentence by closed Landolt rings and instructing subjects to scan these in a reading-like fashion in search for potential targets, i.e. open Landolt rings, allows investigating abnormal eye movements and their neurofunctional underpinnings without the influence from orthography. In a first paper by Hillen et al. (2013) we demonstrated that Landolt reading recruited no areas for orthographic, semantic, or syntactic processing, but, instead, primarily involved right parietal regions related to attentional orienting. Here, we report a follow-up event-related fMRI study with 39 healthy adults testing whether these parietal activations were driven by the fact that the Landolt reading task involved the detection of potential targets (an open Landolt ring), or rather are characteristic of Landolt reading itself. Furthermore, we separately analysed brain activation during the initial orientation of gaze and attention to the beginning of the line in each trial. The results demonstrate additive effects in the right parietal cortex for the presence vs. absence of targets and of the Landolt vs. orthography conditions. These findings provide a deeper understanding of the nature and utility of the Landolt paradigm: Most importantly, it appears that the task itself relies on higher visual attention and scanning demands and may thus be a useful diagnostic addendum to identify dyslexic readers with visuo-motor rather than phonological reading problems.

C58 Training-induced changes in the neural mechanisms underlying visual word recognition

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Introduction: Previous studies suggest that the efficiency of the visual word recognition system can be improved with training. The current study examined the underlying mechanism responsible for such enhancements in visual word processing. Thus, we employed EEG before and after intensive short-term training using a visual lexical decision task (LDT). We additionally investigated whether changes in processing from the trained task condition transferred to an untrained task condition. Methods: 20 healthy young adults (20-28yrs; 11 males) completed approximately 16 hours of training over 7-10 days. The training employed a visual LDT with word and nonword stimuli presented horizontally. Before and after training the participants completed the LDT during EEG recording, with stimuli presented both horizontally and vertically. Behaviourally, we analysed training-induced changes

in reaction times on the trained (horizontal word processing) and the near-transfer (vertical word processing) task conditions, using repeated measures ANOVAs. To examine neural changes, we performed Partial Least Squares (PLS) analysis on the ERP data for both the trained and near-transfer task conditions. Results: Behaviourally, participants were significantly faster at correctly responding to both horizontal and vertical words following training. Analysis of the ERP waveforms revealed greater negative amplitudes in the N170 component following training, as well as reduced positive amplitudes in the P600 component. These amplitude changes were identified in bilateral occipital-parietal electrodes, for both horizontal and vertical words. Discussion: The results suggest that LDT training improved the efficiency of the visual word recognition system, for both the trained task condition (horizontal word processing) and the near-transfer task condition (vertical word processing). Greater amplitudes in the N170 component suggest that LDT training improved visual processing of letter strings, in line with previous studies examining reading skill. In contrast, decreased amplitudes in the P600 component suggest reduced access to stored representations of words. Taken together, the results suggest that participants relied more on perceptual processing of the stimuli, and less upon the language network following training. Furthermore, this mechanism was also engaged when stimuli were presented in the untrained vertical condition, providing some evidence of near-transfer.

Phonology and Phonological Working Memory

C59 Foreign sound learning and mismatch negativity (MMN): a longitudinal ERP study

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An early component of the auditory event-related potential (ERP), the mismatch negativity (MMN), has been shown to be sensitive to native phonemic language sound contrasts. The potential changes to this neural sensitivity after foreign language learning have only been marginally studied.
The existing research seems to suggest that the MMN can adapt to foreign language sound contrasts with very target-specific training, but whether the effects are long-lasting or generalize to proper foreign language learning is yet to be investigated in a viable longitudinal study design. We recorded electroencephalography (EEG) from two groups of language officer cadets (learning either Arabic or Dari) while they listened to language sound contrasts from both languages. We recorded EEG and behavioral responses four times over the course of 19 months of intensive foreign language training (immediately before they started (T0), after three weeks (T1), after six months (T2), and after 19 months (T3)). Somewhat surprisingly, we did not find any language-specific increases in the cadets' MMN to their target language sound contrasts. We did, however, find an early effect of language learning on the behavioral responses in the group of Dari learners, reflecting stronger categorical perception for the newly learned phonemic category within just three weeks of language training. Furthermore, we elicited statistically reliable MMNs to both language contrasts for both groups at most of the four times of measurement. And we found that the group of Arabic learners' MMN to the Arabic stimuli diminished over time, as well as that the Dari learners' P3a responses to the Arabic stimuli diminished over time. We correlated the cadets' MMNs with their behavioral responses to the language stimuli, and this did not reveal any strong links between behavior and neurophysiology. However, those Dari learners whose MMN to the Dari stimuli increased the most within the first three weeks of language training, also received the highest grades on a listening task after 17 weeks. Hence, we did not observe any neurophysiological effects of foreign sound learning despite 19 months of intensive language training and significant changes in one group's behavioral responses to the same sounds. This may suggest that the link between behavior and the MMN in relation foreign language learning is not as strong as has previously been proposed.

C60 Subcortical involvement in phonological input processing: an electrophysiological registration study

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The involvement of subcortical nuclei in auditory phonological input processing has only been studied by measuring neuromodulation effects on different aspects of auditory comprehension. Direct registration of event-related potentials (ERP) elicited by language paradigms in the deep brain nuclei is only possible in patients recruited for deep brain stimulation (DBS) as treatment for their illness. The current study applied direct electrophysiological registration in thalamus, subthalamic nucleus (STN) and pedunculopontine nucleus (PPN) to determine if they are involved in phoneme discrimination and word recognition. If so, what are the temporal and spatial characteristics and how does it relate to normative data on cortical level? The current study included 20 right-handed Parkinson's disease (PD) patients with STN stimulation (age 45-71; 9 male, 11 female), 2 patients with thalamic stimulation for essential tremor (age 56-73; 1 male, 1 female) and 1 male PD patient with PPN (age 50) stimulation. The imbalanced number of patients corresponds with the prevalence of indications for DBS in the course of 2 years in the centre for Movement Disorders in Ghent University Hospital. The patients were evaluated with (ON) and without (OFF) dopaminergic medication. The first experiment (phoneme discrimination task) consisted of an auditory oddball paradigm both executed in pre-attentive (MMN) and attentive (P300) condition. The second experiment consisted of a word recognition task where pseudowords were implemented as deviant stimuli and real words as standard stimuli. An in-house made interface between the registration device (Neurosoft) and the STN/thalamus/PPN contacts were connected to the bilateral externalised DBS-electrodes. As such, each DBS electrode was connected to four contacts numbered 0 to 3, with 0 as the most distal and 3 as the most proximal contact. Data were collected using a 32-channel SynAmp (Neuroscan) amplifier. Electro-encephalographic analysis was performed using BrainVision Analyzer 2 (Brain Products, Munich, Germany). Within PPN mid-latency auditory potentials were present. Within PPN and

thalamus no phonologically related long-latency potentials could be demonstrated. Within STN a pre-attentive ERP-peak occurred on average in both ON/OFF at 64.26ms and 60.71ms post-stimulus for left and right hemisphere respectively. In the attentive condition a clear ERP-peak was elicited at 241.86ms (left) and 241.15ms (right) post-stimulus. For the word recognition task a clear potential is elicited in ON for real words on 200ms, with higher average amplitude in the left hemisphere (1.42µV<->1.29µV). This ERP-peak was elicited at 172.72ms (left) and 173.72ms (right) post-stimulus onset. In OFF, attenuation of amplitudes at the same latencies was found. The average latencies of STN evoked potentials for both the pre-attentive (left=62ms, right=58.28ms) and attentive ERP (left=224.57ms, right=217.43ms) are shorter than the average latencies for cortical evoked potentials in age-matched normal subjects (pre-attentive=171ms; attentive=417ms) out of the normative data of Aerts et al.(2013). These data suggest an important role of PPN and STN in the spectrotemporal preparation of phonological input processing and a primary role for STN in phonological input processing. In comparison with normative cortical data, this suggests that subcortical phonological components precede cortical phonological processing. Within the thalamus no phonological related potential could be detected.

Signed Language and Gesture

C61 Co-Activation of American Sign Language in Deaf Readers: An ERP Study

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Automatic co-activation of a task-irrelevant language in spoken language bilinguals has previously been investigated using an implicit phonological priming paradigm. In this paradigm, bilinguals make semantic relatedness judgments in response to word pairs in a target language. Unbeknownst to the participants, some of these word pairs have phonologically related translations in the non-target language. In the original study, Thierry and Wu (2007) presented English word pairs to Chinese-English bilinguals. Targets in word pairs that had phonologically related Chinese translations elicited a smaller amplitude N400 than targets in word pairs that had Chinese translations with no such phonological relationship. Behavioral (RT) evidence for this type of cross-language activation in deaf signers reading English has also been reported (e.g., Morford et al., 2011). Here, we extend these findings to show that the electrophysiological effect found for phonologically related translations in two spoken languages holds when the two languages are in different modalities and do not share a phonological system. Native and early-exposed deaf ASL signers read pairs of English words with a stimulus onset asynchrony of 1,000 ms. Half of the semantically unrelated pairs overlapped in two of three ASL phonological parameters (handshape, movement, and location; e.g., PAPER and CHEESE share handshape and location), whereas the other half did not overlap in ASL form (e.g., RELIGION and CHEESE). Targets preceded by primes that were phonologically related in ASL elicited less negativity within the window typically used to measure the N400 as compared to targets preceded by words with phonologically unrelated ASL translations. This effect was observed even when the deaf signers did not report an awareness of the form overlap in ASL. In contrast, the difference in negativities was not observed in a control group of hearing non-signers. These results suggest that cross-modal ASL representations were automatically activated during processing of English words in deaf signers.

C62 How are individual spoken words and signs represented in sign-speech bilinguals?

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Despite differences in language modality, sign and speech activate similar brain networks that include the inferior frontal and superior temporal cortex (MacSweeney et al., 2002). It has been assumed that common univariate activity for sign and speech reflects modality-independent representations of language. However, it is possible that some shared activity reflects attentional processes common to auditory and visual languages, rather than language representations per se. Further, previous studies have presented averaged group results making it difficult to establish the consistency of joint activity for sign and speech within individual participants. In the current study we establish whether shared univariate activity exists for individual words. These data will form the basis for future analyses in which we will examine the existence of common multivariate patterns of activation for individual words in sign and speech. We collected fMRI data from hearing, early sign-speech bilinguals with the initial aim of understanding whether overlapping activity for sign and speech was consistently observed across and within individual participants. We scanned six right handed participants (mean age: 29, range: 23-40) in a 3-Tesla scanner with continuous data acquisition. Participants were hearing, skilled BSL signers who learnt BSL from an early age and reported a high BSL proficiency (mean = 6/7, range: 3-7). Participants were presented with single BSL signs and spoken English words in an event related design. Nine lexical items, produced by a male and a female language model in sign and speech, were the focus of analysis. These items belonged to three semantic categories: fruit, animals and transport, and were matched across category for high familiarity and imageability, early age of acquisition, degree of iconicity, and syllable and phoneme length. Additional 'filler' lexical items were included, from within the three categories, as well as additional target items from outside the categories. Participants engaged in a semantic monitoring task during scanning in which they identified the targets (8% of trials) that did not belong to one of the categories (mean hits=35/36; mean d' = 4.77). Single subject univariate general linear modelling in five out of six participants showed significant shared activity (the conjunction null) for sign and speech at a corrected level (peak level uncorrected $p<0.001$, FDR cluster corrected $q<0.05$). The sixth participant demonstrated neural overlap but only at an uncorrected level. Shared activity, across the five participants who showed reliable within subject activity, was found in the left superior temporal sulcus and gyri extending into the inferior parietal lobule and in the right posterior superior temporal sulcus. These results demonstrate consistent overlap of activity for sign and speech within temporal and inferior parietal regions. Activity outside these regions was

less consistently observed. Our results form the basis for further Representational Similarity Analyses (RSA) and Independent Component Analyses (ICA) aimed at assessing the representational content and wider network connectivity for sign and speech.

Speech Motor Control and Sensorimotor Integration

C63 Using Acoustic Measures to Refine the Differential Diagnosis of Apraxia of Speech: A Behavioral and Multimodality Neuroimaging Study

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Differentiating speech production errors that can be attributed to higher-level phoneme selection (phonemic paraphasias) from lower-level motor planning/programming impairments (i.e., articulation errors that occur in apraxia of speech, AOS) remains a challenge. Relating speech production errors that characterize AOS to associated patterns of brain damage may elucidate regions, and their connections, that support articulate speech. To our knowledge, no study has compared different objective measures within the same sample, or related these measures to patterns of brain damage. Therefore, the purpose of this study was 1) to identify acoustic measures that account for the greatest amount of variance in diagnostic classification (i.e., individuals with AOS vs. those without), and 2) to determine regional damage and network connections predictive of these behaviors. Methods: Acoustic measures were obtained from three connected speech samples from 58 individuals in the chronic phase of stroke recovery (at least 6 months post-stroke, 21 female; mean age=60.82±10.37), including: a) normalized pairwise variability index derived from the duration of successive vowel segments (nPVI-V), b) voice onset time (VOT), and c) measures derived from amplitude modulation spectra over the 1-32 Hz octave band (peak frequency, peak amplitude, 1 Hz and 4 Hz band energy, and 16-32 Hz band energy; Liss et al., 2009; Ghitza, 2011). Speech samples were also characterized by speech fluency (syllables/second) and the proportion of phonemic errors and distortion errors. All measures were entered into a linear discriminant analysis (LDA), where participants were classified into two groups (with and without AOS, as defined by the ASRS; Strand et al., 2014) using a leave-one-out procedure. The measures with the highest discriminative weights were then entered into voxel-based lesion symptom mapping (VLSM) and behavioral scores were correlated with white matter fiber counts between regions implicated in the Hierarchical State Feedback Control model (HSFC; Hickok, 2012). Results: Performance of participants with AOS (n=20) was significantly different from that of speakers without AOS, across all measures (Mann Whitney U test; all $p<0.05$). LDA classification was 88.9% accurate ($p<0.001$) at predicting AOS. The three variables with the greatest discriminative weight were (in order of weight): 16-32 Hz energy, proportion of distortion errors, and nPVI-V. Of these three measures, nPVI-V was the only to survive VLSM analysis with permutation thresholding and lesion volume correction, with 70% of the statistical map localized in the left post-central gyrus (LPoCG), 22% in the superior longitudinal fasciculus, and 8% in the precentral gyrus (LPrCG). All three variables had significant correlations with total fiber counts between the LPrCG and left anterior corona radiata (LaCR), the LPoCG and LaCR, and LPrCG and left supramarginal gyrus. Each measure had additional unique correlations with fiber count connections that included the basal ganglia, corona radiata, angular gyrus, and supramarginal gyrus. Conclusions: These results underscore the importance of white matter connectivity disruption in the pathophysiology of AOS. They support recent work focused on identifying measures that predict AOS classification (e.g., Ballard et al., 2016). Finally, this study is unique in that it provides preliminary information regarding dorsal stream network connections supporting articulation.

C64 Cortical representation of vocal pitch production

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Introduction Speakers use vocal pitch to communicate various aspects of meaning, including mood, emphasis, and syntactic structure. Furthermore, precise control of pitch is thought to have been one of the first evolutionary changes in vocal control that ultimately led to human-specific speech abilities. Despite the importance of pitch control in speech production, its neural mechanisms remain poorly understood. To address this, we use electrocorticography (ECoG) to understand the cortical representation of vocal pitch in humans. Methods Ten subjects were implanted unilaterally with ECoG arrays as part of their treatment for epilepsy (5 left hemisphere). We recorded ECoG while subjects produced spoken utterances. In one task, subjects produced the sentence “I never said she stole my money,” and were cued to emphasize specific words on a trial-by-trial basis. In a second task, the subjects sang a pitch pattern alternating between “do mi so mi do” and “so mi do mi so” (singing task). To understand how electrodes in the ventral sensorimotor cortex control vocal pitch during speaking, we used multivariate regression to predict the high-gamma (HG; 70-150Hz) neural signal from the pitch pattern 200ms into the future. Results We found that the produced pitch contour significantly predicted activity in two focal cortical areas that straddled the primary motor homunculus. The first group of electrodes was on the dorsal precentral gyrus, a region that has been implicated in other types of laryngeal control, including voicing and glottal stops (Brown et al., 2008). Pitch control in this upper laryngeal region was particularly prominent in the right hemisphere. Contrary to reports from non-invasive human imaging studies, we also identified a second pitch-encoding region in the subcentral gyrus. Recent reports suggest that the dorsal laryngeal area encodes auditory features during passive listening (Cheung et al., 2016), in addition to its presumed functions during production. We used the millisecond temporal resolution of ECoG to dissociate perception and production in this region by recording neural activity as subjects listened passively to the audio recording of their own production. We found that the same electrodes that were correlated with pitch during production were also correlated with pitch in this purely listening task. However, these two functions had different time-courses. During production, the neural activity is correlated with pitch preceding the produced pitch by ~100ms, while

passive auditory response lagged pitch by ~200ms. The singing task reaffirmed distinct feedforward and feedback responses associated with vocal pitch, while controlling for prosodic correlates in natural speech such as intensity and duration. Pitch selective electrodes differentiated between high and low pitch in the 50ms prior to acoustic onset, which is without auditory feedback. After the acoustic onset, pitch tuned electrodes separated further, and were maximally differentiated during production. Thus, we conclude that the dorsal laryngeal area performs both feedforward control and auditory processing of vocal pitch.

C65 Investigating the role of auditory feedback in the production of speech and non-speech vocal behaviours

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Investigating the role of auditory feedback in the production of speech and non-speech vocal behaviours Agnew, Z., Kothare, H., Nagarajan, S., Houde, J Whilst the neural basis of speech production has been the target of numerous investigations over the last few decades, the neural control of emotional vocalisations has gone relatively under studied. A number of lines of evidence suggest that the neural control of speech production and the production of emotional vocalisations may be distinct, and further, that emotional vocalizations may be more akin to vocalizations made by non-human primates than to human speech. Many emotional vocalizations, for example, are universal, i.e. recognizable across distinct cultures. Conversely, speech sounds are highly over-learnt articulations that are not common across different cultures. Given these differences, it has been suggested that emotional vocalisations may rely on evolutionarily older, or different neural systems. Here we investigate the hypothesis that feedback control of emotional vocalisations is distinct from that employed during highly learnt vocal behaviours such as speech. Subjects were trained to either produce emotional vocalisations for the categories of laughter, disgust, or speech sounds, in response to a written cue. In separate blocks, subjects heard these same sounds and their task was simply to listen. This allowed us to specifically investigate motor induced suppression (MIS), which is a neural marker for feedback processing, defined by a reduced response to production compared to listening in auditory regions of temporal cortices. We have previously demonstrated that different cortical regions are active during overt production of the two articulations and that sensory cortices show significantly different responses during the production of speech and emotional vocalisations using functional magnetic resonance imaging. Here we use magentoencephalography imaging (MEGI) to investigate time resolved neural responses in auditory cortex to self produced speech and non-speech vocalisations, and compare time resolved MEGI findings to our previous findings in fMRI. We report activity in sensorimotor cortices associated with speech production during the production of both speech sounds and emotional vocalisations. In addition we report distinct responses in auditory regions during production compared to listening, for both speech and emotional vocalisations. These data suggest that motor control of speech may be distinct from that of other vocal behaviours and serve to elucidate distinct neural networks for the production of non-speech vocalisations. These data are discussed with respect to current feedback control models of speech production and primate functional neuroanatomy.

Control, Selection, and Executive Processes

C66 Age-related changes in differentiated neural responses to resolution of conflict in magnitude system

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In this study, we investigated the age-related differences in electrophysiological correlates of conflict resolution by using the modified version of size-congruity comparison, a Stroop-like task in which numerical value and physical size were varied independently under task-relevant and -irrelevant conditions. We further manipulated the levels of cognitive load in order to probe the degree of conflict between dimensions of magnitude system. Both young and older adults were included. In addition to the general slower response times for older adults, both young and older adults showed that the effects of congruity were modulated by the tasks and the cognitive load. Specifically, congruity effect is greater as cognitive load increased in the numerical comparison task, whereas congruity effect is reduced as cognitive load increased in the physical comparison task. The ERP results showed that incongruent conditions elicited larger anterior N200s than congruent conditions, indicating the detection of conflict information. However, the N200 effects were only observed in young adults. Interestingly, both age groups showed similar parietal-distributed P300 patterns, which is larger in congruent conditions than in incongruent conditions for both tasks. Importantly, cognitive load modulated P300 amplitude for the incongruent conditions differently in two tasks but not for the congruent conditions. In the physical task, the P300 amplitude is larger for high cognitive load. In contrast, the P300 amplitude is larger for low cognitive load in the numerical task. Our findings suggest that the cognitive load modulated the processing of conflict resolution between the irrelevant and relevant dimensions of magnitude systems differently during response organization. Moreover, older adults are less efficiently in monitoring the conflict information.

C67 An early locus of associative and categorical context effects in speech production: Evidence from an ERP study using the picture-word interference paradigm

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A key issue in the production literature concerns the mechanism of lexical selection in speech production. The Lexical Selection by Competition (LSC) view assumes that lexical selection involves competition among multiple co-activated lexical units. Supporting evidence comes from picture-word interference (PWI) studies. In a PWI task, participants are asked to name individually presented picture and ignore a word distractor. Participants' naming latencies were slower if the target (DOG) and distractor (cat) were from the same semantic category,

relative to an unrelated control (pen). Such semantic inhibition effect has been considered as supporting the LSC view as only the semantically related distractor, but not the unrelated distractor, would intensify the competition among target and its competitors during lexical selection. Dissimilarly, the Response Exclusion Hypothesis (REH) assumes a late locus of the semantic inhibition effect. According to REH, longer time is required to exclude a categorially related response from the response buffer and hence for the inhibition observed. Furthermore, semantic facilitation in PWI tasks has been reported if the distractor was associatively related to the target (bone and DOG). The REH assumes that the associative facilitation arises from an early conceptual priming stage and the categorical inhibition from a late post-lexical stage. Conversely, the LSC view assumes both associative and categorical effects are having a lexical locus. To verify the above two accounts, this study was conducted using the PWI paradigm with concurrent ERP recording. According to the REH, the ERP effects induced by associative and categorical contexts would have distinctive time courses with the former occurred much earlier than the latter. Conversely, the LSC view predicts both effects appear in a similarly early time window. Thirty-four native Mandarin speakers participated. Fifty line-drawings each depicts an object with a di-syllabic Mandarin name were used. Each picture was paired with three word distractors, namely categorically related, associatively related, or phonologically related (i.e., target and distractor shared the same word-initial syllable). Three corresponding unrelated conditions were constructed by re-pairing the targets and distractors in each condition. Participants' naming latencies were slower in the categorically related condition (877±106ms) than its unrelated control (830±101ms), $F=33$, $p<.001$. A similar, but weaker in size, inhibition was found in the associative condition (related: 829±101ms; unrelated: 818±93ms), $F=7$, $p=.012$. Significant facilitation, however, was found in the phonological condition (related: 809±103ms, unrelated: 831±91ms). Mean amplitude values in each successive bin of 50-ms window were obtained and submitted for ANOVAs. The ERPs of categorically related and unrelated conditions started to diverge from 300ms post-target onset and the effects were anterior-oriented ($F=7.1$, $p=.012$). The waves of associatively related and unrelated conditions diverged from each other in both 100-150ms and 350-450ms time windows ($Fs>3.4$, $ps<.05$), and the effects were widespread. A phonologically associated ERP effect was observed in the 250-300ms window ($F=4.1$, $p=.03$). The early (within 300ms post-target) and overlapping ERP effects observed in the categorical and associative conditions are not consistent with the REH. Instead, the present results are consistent with the LSC which assumes a lexical locus for both semantic effects.

C68 Control of Language Production: The Influence of Strategy Provision on Verbal Suppression and its Neural Substrates in Parkinson's Disease

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The ability to rapidly select a single lexical-semantic representation, in the face of multiple competing alternatives, can be considered a product of the complex interaction between cognitive control and language. Current models describing the interface between these domains remain contended and underspecified, particularly regarding underlying cortical and sub-cortical architecture. Parkinson's disease (PD) represents a unique platform for research in this area, as patterns of language disturbance in this condition have been observed to vary as a function of cognitive control. However, multiple processes are subsumed under this umbrella term, including response initiation, suppression, and internal strategy generation. The Hayling Sentence Completion Task (HSCT) was developed as a means of isolating response initiation from suppression. Participants with PD have demonstrated impaired performance on the suppression component of this task, however little consideration has been given to the influence of the ability to internally generate search and retrieval strategies. The present study aimed to determine whether poor performance on a verbal suppression task in a Parkinson's disease population is attributable to (i) the inability to suppress a pre-potent response or (ii) difficulty in the generation of an internal strategy to facilitate task execution. Functional Magnetic Resonance Imaging (fMRI) was used in order to observe underlying patterns of neural activation. 13 individuals with PD and 20 healthy controls were recruited. In the fMRI study, participants were presented with high cloze-probability sentence stems and required to overtly provide a word which (a) would complete the sentence as accurately as possible, or (b) was unrelated to the sentence. An additional novel condition was also introduced in order to allow for isolation of processes related to suppression of a pre-potent response from processes related to strategy generation. This condition provided participants with a category clue after each sentence stem to assist them in generating an unrelated word. Images were acquired using a blocked fMRI design. Regions-of-interest (ROI) were selected a priori based on current literature concerning fronto-subcortical circuitry and previous fMRI studies of language production (left DLPFC, left IFG), or were anatomical (left ACC, left striatum). The MARSBAR toolbox was used to extract mean % signal and a Mann Whitney U analysis was run to test for between-group differences. The only significant difference between groups was observed in the left DLPFC, where PD participants showed significantly less activity than controls for the Unrelated condition ($U=69$, $Z=-2.247$, $p=0.025$), while there was no significant difference between groups for the Complete ($U=81$, $Z=-1.805$, $P=0.071$) or Strategy ($U=118$, $Z=-0.442$, $P=0.658$) conditions. These results support the hypothesis that in the PD population, poor performance on a verbal suppression task can be explained by difficulties in internal strategy generation, rather than difficulty suppressing competing alternatives. In addition, the present fMRI findings indicate that the left dorsolateral prefrontal cortex may subserve this function.

Meaning: Prosody, Social and Emotional Processes

C69 Metaphor in Politics: Bringing affect to the decision space?

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Moral evaluations in language often construe (im)morality in terms of (im)purity and hence disgust (e.g., "A rotten thing to do."). According to Conceptual Metaphor Theory, the concept of immorality is intimately tied with our understanding of physical disgust as co-occurrences of these two concepts during development establish cross-domain mappings. In support of this view, recent behavioral studies show that experiencing disgust impacts moral judgment, as does the framing of moral issues as disgusting acts. However, it is currently unknown if comprehension of moral disgust metaphors involves the recruitment of brain regions implicated in disgust processing and whether or not this could impact moral judgment in the brain. In this fMRI study we specifically investigated how familiar disgust metaphors that expressed specific moral political attitudes (e.g., "Using taxpayer money to cover healthcare costs for the uninsured is rotten.") modulated both brain areas involved in physical disgust experience and moral cognition when compared to their literal counterparts (e.g., "Using taxpayer money to cover healthcare costs for the uninsured is wrong."). Participants read each statement during a reading period after which they were presented with a 7-point Likert scale during a response period and indicated how much they agreed with each statement. Stimuli were controlled for semantic similarity, familiarity, and arousal/valence. Although disgust metaphor did not impact judgment compared to literal paraphrases, our results revealed that moral disgust metaphors and literal paraphrases were processed distinctly at the neural level. Overall we found that the processing of moral disgust metaphors, both reading and during judgment, involved increased activation in a number of emotion-related brain regions, previously implicated in disgust processing (i.e., amygdala, thalamus, basal ganglia, anterior insula/frontal operculum, and OFC), when compared to their literal counterparts. Critically, activity in a number of these emotion-related brain regions significantly covaried with political orientation during moral disgust metaphor comprehension when compared to literal paraphrases. In contrast, literal moral reading and judgment showed stronger involvement of regions involved in higher-level emotion processing (i.e., VMPFC) and cognitive control (i.e., bilateral DLPFC). Lastly, although we did not find differences in disgust propensity in conservatives vs. liberals at the behavioral level, we did find that a number of emotion-related brain regions associated with disgust processing during the viewing of disgust pictures versus neutral pictures did covary with political orientation. This is line with previous findings showing increased physiological responses to disgust for conservatives. Taken together these findings suggest that moral disgust metaphors may influence the decision-space by engaging affective processes to a greater extent than their literal counterparts and that this effect may be more pronounced for conservative moral judgment. Nevertheless, this may not be enough to impact the final outcome of the moral decision-making process, which depends on the integration of information from multiple sources (e.g., prior held political beliefs).

Methods

C70 Estimating aphasia scores with SMAP: stacked multimodal aphasia predictions

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INTRODUCTION: The prediction of aphasia severity is highly relevant for clinical and research purposes. Recent predictive models rely on a large number of patients (Hope, 2013) or on standard linear models (Wang, 2011). In this study, we introduce SMAP (stacked multimodal aphasia predictions), a method that produces intermediate predictions from non-linear multimodal neuroimaging datasets, and stacks these predictions into a final predictive model. SMAP uses random forests (RF), which allow the detection of non-linear relationships between predictive variables and the behavioral score, as well as interactions between variables (i.e., aphasia may emerge when a frontal and a temporal area are both lesioned). METHODS: Fifty-three left hemispheric chronic stroke patients (age: 57.1±12.3yrs, post-stroke interval: 1.6±1.7yrs, 25 female) participated in this study. Lesion tracing was performed manually by an expert neurologist. All analyses were performed in ANTsR (Avants, 2015). The aphasia quotient (WAB-AQ; Kertesz, 1982) was used to train and test the predictive models. After preprocessing the resting state data, a 268x268 connectome matrix was obtained for each subject (268-node parcellation scheme; Finn; 2015). A first prediction was obtained by computing the similarity of the connectomes (Pearson correlation) and using these similarities as weights to compute a weighted AQ score for each patient (it is assumed that patients with similar connectomes should have similar brain functionality, hence, similar behavioral performances). Subsequently, graph theory measures were computed from thresholded connectomes (density=0.25). Three graph measures were used: degree, betweenness, and local transitivity. For each of these, a variable selection process with 30,000 RF permutations was used to rank the 268 variables and yield an optimal number of variables. The selected variables were then used in a leave-one-out prediction scheme to produce RF predictions. A fifth prediction was obtained by using the amount of damage in the parcellation nodes in a leave-one-out RF scheme (Pustina, 2016). Finally, the five predictions were stacked in a single multiple regression model (again, leave-one-out). RESULTS: All intermediate predictions correlated significantly with the true score ($p<.001$). Four predictions produced positive correlations, while the connectome similarity produced a negative correlation (Fig. 1). The optimal number of predictors for graph theory measures was 11 in all three cases. The combination of the five predictions into the final model produced a correlation of 0.85, a root mean square

error of predictions 11.5, and an average prediction error of 9.3. Importantly, the true-predicted correlation produced by the final stacked prediction was significantly higher than any of the individual predictions alone. This advantage remained significant even when all the variables that constituted the individual predictions were used to create a global model that crated predictions at once (Fig. 1). DISCUSSION: In this study, we introduce a tool that relies on an innovative combination of multimodal imaging, non-linear machine learning, and prediction stacking. Our results show that stacked predictions outperform individual intermediate predictions or global models that include all predictors. SMAP can provide accurate predictions of aphasia scores with a fraction of the patient numbers used in other prediction models (Hope 2013).

Writing and Spelling

C71 The functional relationship between language and motor processing in typing: An EEG study

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There is growing interest in understanding the functional relationship between language and motor processing during language production. We addressed this issue using event-related potentials recorded during a typing task. Linguistic processes were indexed by the N400 component. Motor processes were indexed by lateralized response-related potentials. In this way, we combined two time-honoured psychophysiological markers within a single innovative experiment. At stake was the relationship between the two markers. The experiment consisted in a semantic-priming paradigm, with written prime-words briefly presented before auditory target-words. We manipulated factorially the Semantic Relatedness between primes and targets (Related vs. Unrelated), and Response Side (first two letters of the targets typed with Right vs. Left hand). The standard N400 effect was replicated, with an attenuation of the negative going potential in the Related compared to the Unrelated condition. Response Side yielded lateralized potentials traditionally linked with motor-response preparation, consisting in negative-going components over electrodes contralateral to the responding hand, and more positive-going ones over ipsilateral electrodes. The two manipulations yielded independent effects, with no signs of statistical interaction. These results are in line with a staged account of the transition from language to motor processes during language production. The scope of this interpretation is discussed.

Poster Session D

Perception: Auditory

D1 Predictive coding is key for early sensory language processing in both auditory and visual modalities

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How does the brain deal with the richness of language in naturalistic environments? The predictive coding framework suggests that predictive forward models "explain away" redundant parts of the sensory input, thereby greatly reducing the complexity of the input. For example, several characteristics in a continuous speech signal, such as the speech envelope, are largely predictable based on prior time points. Therefore, neuronal processing for predictable events is omitted, whereas unpredictable events become increasingly important and should thus have a great impact on the neural processing of language. For printed texts, which are distributed in two-dimensional space, expectability-based visual templates might reduce redundant sensory information. For both the auditory and visual modality, we investigate this predictive coding-based hypothesis of language processing. We implement simple, but effective computational models, which quantify perceptual predictability, i.e., a Kalman filter for speech and a template mismatch algorithm for reading. Model simulations were evaluated on multiple MEG/EEG datasets (N > 80/60) for the auditory model and fMRI/EEG datasets (N = 39/17) for the visual model. SPOKEN LANGUAGE PROCESSING: MEG/EEG was recorded during the presentation of coherent speech (144 individual sentences as well as multiple short narratives). The auditory prediction error was quantified by modeling the entire speech envelope with a forward-looking adaptive Kalman filter, and subtracting its predictions from the actual signal. Time-resolved regression analysis indicated for each dataset (i) a significant dependence of early neural activity on the absolute prediction error - over, beyond, and at different time points than for non-predictive features such as the raw speech envelope or "acoustic landmarks"/auditory edges, and (ii) a significantly improved cross-validated prediction of temporal cortex brain activity by models containing in contrast to models without the envelope prediction error . VISUAL WORD RECOGNITION: fMRI/EEG was recorded during silent reading of five-letter words. The prediction error was modeled for each word by subtracting the mean pixel-wise redundant visual information, based on all five-letter words of the SUBTLEX database, from the visual information of the presented stimulus. The sum of the residual values for each pixel of the relevant area (i.e., how much black/white could not be predicted) served as prediction error, which reduces the amount of visual information to be processed drastically. This prediction error estimate was associated with early ERP components and BOLD activity in bi-lateral posterior occipital areas. In contrast, luminance differences between words activated only a more anterior left hemisphere cluster. CONCLUSIONS: Across modalities, predictive models explain brain activity early in the processing hierarchy better than non-predictive models. We propose that across modalities, at least in the initial stages of language processing, brains operate by constructing simple, yet effective forward models (based on, e.g., adaptive temporal filters or visual templates). The degree to which input is surprising given such models might be one of the primary determinants of language-related brain responses. Prediction-based computations described here are a valid model of real-world language processing.

D2 Neural entrainment reflects temporal predictions guiding speech comprehension

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Speech segmentation requires flexible mechanisms to remain robust to features such as speech rate and pronunciation. Recent hypotheses suggest that low-frequency neural oscillations entrain to ongoing syllabic and phrasal rates, and that neural entrainment provides a speech-rate invariant means to discretize linguistic tokens from the acoustic signal. How this mechanism functionally operates remains unclear. Here, we test the hypothesis that neural entrainment reflects temporal predictive mechanisms. It implies that neural entrainment is built on the dynamics of past speech information: the brain would internalize the rhythm of preceding speech to parse the ongoing acoustic signal at optimal time points. A direct prediction is that ongoing neural oscillatory activity should match the rate of preceding speech even if the stimulation changes, for instance when the speech rate suddenly increases or decreases. Crucially, the persistence of neural entrainment to past speech rate should modulate speech perception. We performed an MEG experiment in which native Dutch speakers listened to sentences with varying speech rates. The beginning of the sentence (carrier window) was either presented at a fast or a slow speech rate, while the last three words (target window) were displayed at an intermediate rate across trials. Participants had to report the perception of the last word of the sentence, which was ambiguous with regards to its vowel duration (short vowel /ɑ/ – long vowel /aː/ contrast). MEG data was analyzed in source space using beamformer methods. Consistent with previous behavioral reports, the perception of the ambiguous target word was influenced by the past speech rate; participants reported more /aː/ percepts after a fast speech rate, and more /ɑ/ after a slow speech rate. During the carrier window, neural oscillations efficiently tracked the dynamics of the speech envelope. During the target window, we observed oscillatory activity that corresponded in frequency to the preceding speech rate. Traces of neural entrainment to the past speech rate were significantly observed in medial prefrontal areas. Right superior temporal cortex also showed persisting oscillatory activity which correlated with the observed perceptual biases: participants whose perception was more influenced by the manipulation in speech rate also showed stronger remaining neural oscillatory patterns. The results show that neural entrainment lasts after rhythmic stimulation. The findings further provide empirical support for oscillatory models of speech processing, suggesting that neural oscillations actively encode temporal predictions for speech comprehension.

D3 The relationship between speech production and speech perception deficits in Parkinson's disease

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Introduction: Hypokinetic dysarthria in patients with idiopathic PD is a distinct speech disorder associated with basal ganglia (BG) control circuit pathology. The discovery of sensory-motor circuitry involved in speech processing might indicate that speech production and perception depend on a large network of interacting cortical and subcortical brain areas. With this in mind, it is striking that patients with PD are able to improve their speech production in 'lab-based' tasks or following external cues, whereas they are not able to self-correct. Lack of self-correction strongly suggests that the internal monitoring of speech production is related to a disturbed auditory speech perception in PD. This study investigated the possible relationship between hypokinetic speech production and auditory speech perception in patients with PD. Methods: Subjects included 14 patients with idiopathic PD and 14 age- and gender-matched healthy controls (HC). First, speech production was objectified through a standardized and norm-referenced speech intelligibility assessment, acoustic analysis, and speech intensity measurements. Second, overall speech perception was determined by an overall estimation task in which participants had to judge seven speech characteristics in two different conditions (immediate and playback perception) for two different tasks (their own spontaneous speech and reading). Correlation analysis was performed between participant's judgment of speech characteristics and the acoustic analysis of the corresponding fragments. Third, an intensity estimation task was used to evaluate speech intensity perception. The interaction between speech production and speech intensity perception was investigated by an intensity imitation task. Results: Acoustic analysis and speech intensity measurements demonstrated a significant decrease in speech production in patients with PD, compared with HC. In the overall estimation task, patients with PD evaluated their own speech differently according to condition ($P < 0.05$) and task ($P < 0.001$). They judged their own speech better in the immediate perception condition and at reading, unlike the evaluations of the HC, which did not depend on condition or task. Despite the low cognitive load of the intensity estimation and imitation task, a different pattern in auditory speech intensity perception could be demonstrated in the PD group. Patients with PD systematically showed a lower speech intensity estimation at the highest intensities (75 and 80 dB SPL), compared with HC ($P < 0.05$), and a higher speech intensity estimation at the lowest intensities (60 and 65 dB SPL). Conclusion: The present results suggest a disturbed auditory perception in PD which might be related to an automatic speech monitoring deficit. The results indicate the role of attention and feedback processes in the auditory regulation of speech in PD and are consistent with the involvement of the BG in the online monitoring of auditory feedback during speech (Chen et al., 2013). The BG are also considered to be important gateway hubs in the cortico-subcortical brain network (Gulberti et al., 2015). Further research should focus on the neurophysiological changes of spectro-temporal processing in PD and on the interaction between speech production and auditory speech perception, especially on the level of gating, attention, and feedback processes.

D4 Cortical-acoustic alignment in cochlear implant users: is it an artifact or a measure of speech processing?

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For normal hearing listeners, the entrainment of slow cortical oscillations to the temporal envelope of speech appears to reflect measures of comprehension, or successful speech processing (e.g. Ding & Simon, Front. Hum. Neurosci, 2014). For cochlear implant (CI) users, thus profoundly deaf listeners whose hearing sensation is based on the electric stimulation of the auditory nerve, an alignment between the cortical and the speech signal is also a device-induced artefact since the stimulation is based on the time-amplitude envelope of speech. EEG recordings with CI users thus offer the possibility to disentangle the role of the signal versus stimulation on cortical-acoustic entrainment and its linguistic function. We combine measures of cortical-acoustic coherence with behavioural measures of comprehension, and relate these to our findings from EEG recordings with an artificial brain, which capture the technical artefact of the CI. EEG recordings (64 channels) of ten experienced CI users and ten normal hearing (NH) controls were compared with recordings of ten NH listeners presented with an acoustic CI simulation (8-channel noise vocoded speech). Listeners were presented with 270 sentences of a length between 2.5-6 s. For the first 2 seconds of each sentence the coherence between the acoustic and the cortical signal within the range of 2-20Hz was computed by means of neurospec software (Halliday, 2008). The recordings of each trial were paired with the amplitude envelope of the sentence presented during this trial and transformed into frequency domain, and cross-spectral density between the acoustic signal and all EEG channels was extracted. The coherence was then pooled across participants and electrode groups. For statistic reference, recordings of each trial were also paired with 100 random sentences. In addition, EEG recordings with a dummy, which was created as to mimic the conductivity of the human brain were conducted and analysed accordingly. Overall, the randomly paired signals did not show significant coherence, while the EEG trials paired with respective acoustic signals did. For NH listeners, coherence was found in the theta range (4-8 Hz) for electrodes on the bilateral temporal lobes and on central electrodes. For NH listeners presented with vocoded speech coherence was smaller in magnitude and present only on central and left temporal electrodes. For CI user, coherence was overall greater in magnitude, found on central and bilateral temporal electrodes, and limited to the theta range. The recordings on the dummy head showed a coherence that is similar in magnitude to the one obtained for CI users but present over a wide range of frequency bands. These results speak to the idea that coherence is a measure of comprehension

or intelligibility, since processing of degraded speech leads to smaller coherence. For CI users relative to the dummy head we see that the stimulation, rather than the signal, leads to greater coherence, but the frequency range of coherence is limited by active processing of the brain. The CI users show great individual variability in their behavioural performance, and we will discuss the relation between these individual data and individual coherence values.

Perception: Speech Perception and Audiovisual Integration

D5 The role of ventral and dorsal pathway in sublexical speech perception: insights from fMRI

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Natural speech perception suffers from uncertainty and ambiguity due to environmental noise. One factor that can greatly improve the perception of degraded speech is contextual information. However, the underlying neuronal mechanisms and cortical brain regions involved in this perceptual enhancement are not well understood. According to the dual stream model of speech perception (Hickok and Poeppel, 2007), contextual information could be integrated in a ventral lexical-conceptual speech processing stream and/or a dorsal motor speech processing stream (Hickok, 2012). The current study aims to disentangle the different functional roles of ventral and dorsal stream contribution to sublexical speech processing under adverse listening conditions. We hypothesized that the ventral and dorsal stream make use of different contextual features to generate internal predictions about upcoming sensory events. The functional specificity of the ventral stream to map sensory representations onto lexical conceptual representations makes it particularly suitable to generate predictions based on the semantic and lexical context of speech stimuli. The dorsal stream instead might be crucial for the integration of prior knowledge about the phoneme sequence in a word independent of meaning. To investigate the modulatory role of prior knowledge on speech perception we collected fMRI data from 18 subjects in a speech priming experiment. On each experimental trial we presented a sequence of three pseudowords: first a degraded pseudoword, then a clear pseudoword and finally the first degraded pseudoword was repeated. The intermediate clear pseudoword either matched or did not match the degraded pseudoword (equal probability). Subjects were instructed to repeat the last presented degraded utterance. For the behavioral analysis we analyzed success or failure of repetition. In addition, we analyzed the BOLD activity elicited by the second degraded word. We expected that the intermediately presented matching pseudowords, can enhance speech perception and repetition of the degraded word. As we used pseudowords, enhanced speech intelligibility would represent a perceptual effect caused by the prior clear presentation of the phoneme sequence rather than semantic and lexical context. Matching clear pseudowords significantly improved the listener's perception of degraded speech stimuli from (6.01% to 70.26% correct responses). The enhancement of intelligibility by matching words was associated with bilateral neuronal activation modulation in posterior middle temporal gyrus, a ventral stream area, and supramarginal gyrus. In contrast, low intelligibility of degraded words in the unmatched condition, was associated with increased neuronal activation in areas of the dorsal processing stream, namely the left dorsal pars opercularis, left ventral premotor cortex and left anterior insula. Our results suggest that modulation of activity elicited by degraded speech in a ventral stream area indicates enhanced speech processing after successful integration of prior knowledge provided by the matched pseudoword. On the other hand, increase of the activation in dorsal stream areas elicited by the combination of degraded words preceded by non-matching clear words suggests a function as integrator of predicted and perceived phonetic speech structures and may indicate enhanced processing effort.

D6 Pure Linguistic Interference during Comprehension of Competing Speech Signals

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In certain situations, human listeners have more difficulty in understanding speech in a multi-talker environment than in the presence of non-intelligible noise. The costs of speech-in-speech masking have been attributed to informational masking, i.e. to the competing processing of the target and the distractor speech's information. It remains unclear what kind of information is competing, as intelligible speech and unintelligible speech-like signals (e.g. reversed, noise-vocoded, and foreign speech) differ both in linguistic content and in acoustic information. Thus, intelligible speech could be a stronger distractor than unintelligible speech because it presents closer acoustic information to the target speech, or because it carries competing linguistic information. In this study, we intended to isolate the linguistic component of speech-in-speech masking and we tested its influence on the comprehension of target speech. To do so, 24 participants performed a dichotic listening task in which the interfering stimuli consisted of 4-band noise-vocoded sentences that could become intelligible through training. The experiment included three steps: first, the participants were instructed to report the clear target speech from a mixture of one clear speech channel and one unintelligible noise-vocoded speech channel; second, they were trained on the interfering noise-vocoded sentences so that they became intelligible; third, they performed the dichotic listening task again. Crucially, before and after training, the distractor speech had the same acoustic features but not the same linguistic information. We thus predicted that the distracting noise-vocoded signal would interfere more with target speech comprehension after training than before training. To control for practice/fatigue effects, we used additional 2-band noise-vocoded sentences, which participants were not trained on, as interfering signals in the dichotic listening tasks. We expected that performance on these trials would not change after training, or would change less than that on trials with trained 4-band noise-vocoded sentences. Performance was measured under three SNR conditions: 0, -3, and -6 dB. The behavioral results are consistent with our predictions. The 4-band noise-vocoded signal interfered more with the comprehension of target speech after training (i.e. when it was intelligible) compared to before

training (i.e. when it was unintelligible), but only at SNR -3dB. Crucially, the comprehension of the target speech did not change after training when the interfering signals consisted of unintelligible 2-band noise-vocoded speech sounds, ruling out a fatigue effect. In line with previous studies, the present results show that intelligible distractors interfere more with the processing of target speech. These findings further suggest that speech-in-speech interference originates, to a certain extent, from the parallel processing of competing linguistic content. A magnetoencephalography study with the same design is currently being performed, to specifically investigate the neural origins of informational masking.

D7 A brain potential signalling linguistic pre-activation? An analysis of the pre-activation negativity (PrAN)

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Introduction: It has previously been found that strongly predicted words can be pre-activated in constraining contexts (e.g. DeLong, Urbach & Kutas, 2005). Furthermore, it has been suggested that an anticipated continuation from one syllable to another can be pre-activated before it is present in the input (Roll, Söderström, Mannfolk, Shtyrov, Johansson, van Westen & Horne, 2015). We describe a proposed event-related potential (ERP) effect – the 'pre-activation negativity' (PrAN) – which is hypothesised to index the degree of pre-activation of highly likely possible continuations of word-initial fragments (WIFs). ERP data from three previous studies was re-visited in order to investigate the effect of anticipation and lexical competition on the previously found brain potential. The effect, occurring between 136 and 280 ms following spoken word onset, was found to increase as lexical competitors associated with a word-initial fragment decreased. Methods: ERP item data from three previous studies was used (Roll, Horne & Lindgren, 2010; Roll et al., 2015; Roll, 2015) to investigate the relationship between the amplitude of the proposed PrAN and degree of lexical competition, defined as the "number of words which could complete a given word-initial fragment", where "word-initial fragment" is defined as the first 2-3 phonemes of a word, including word prosodic features. The hypothesis was that the PrAN amplitude would increase as the number of upcoming potential lexical competitors decreased. The language studied was Swedish, in which tones on word-initial fragments can function as cues to possible continuations of a word (i.e. whether a suffix will follow or whether the initial fragment is the first constituent of a compound word). The lexical competition data was taken from a Swedish lexicon database, which listed the number of words which began with a particular WIF. Results: As a first step, an analysis of variance with the factor Competitors ("few", "many", as determined by a median split) was conducted in order to determine which electrode sites to focus the subsequent regression analysis on. Following this, a linear regression analysis was carried out on z-scores of ERP amplitude and lexical competition on the dataset of each study separately. Significant regression equations were found for each dataset, showing that as the number of potential lexical competitors decreased, the PrAN amplitude on the word-initial fragment increased. Conclusion: The results indicate that brain potentials elicited by word-initial fragments become more negative as a function of the number of lexical competitors that are potential continuations of a given fragment. We suggest that this pre-activation negativity (PrAN) is an index of the certainty as to how a word will end.

D8 On the role of low-frequency neural entrainment to acoustic envelopes during phonological and semantic processing of speech

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[Introduction]: It is long known that slowly-fluctuated envelopes are critical for speech comprehension (Drullman et al., 1994, 1995; Shannon et al., 1995). Moreover, there has been accumulating neurophysiological evidence that entrainment of neural oscillations to acoustic envelopes at low-frequency range (< 10 Hz) is involved in speech perception and the degree of this entrainment is correlated with speech intelligibility (Peelle et al., 2013; Doelling et al., 2014). However, as contribution to speech intelligibility is made during processes at different linguistically hierarchical levels, how such entrainment interacts with these processes still remains unclear. The current EEG experiment attempted to investigate this question by using speech stimuli similar to previous studies (Binder et al., 2000; Saur et al., 2010) in order to dissociate phonological from higher-level semantic processing, both of which contribute to speech intelligibility. [Methods]: 20 native Mandarin speakers listened to three types of 4-Hz-syllable-rate Mandarin utterances (64 different utterances for each type): (1) real-word utterances, consisting of meaningful disyllabic words assembled with a valid syntactic structure; (2) pseudo-word utterances, consisting of morphologically valid syllables but no meaningful words; (3) time-reversed versions of (1) and (2). In each trial, a brief cue sound (all different across trials and not semantically meaningful) was played prior to the target utterance and participants were required to complete a forced-choice sound-matching task by judging whether the cue sound appeared in the target utterance or not. Correlation between delta-theta (2~8 Hz) EEG and acoustic envelopes at the same frequencies was quantified via picking the maximal Pearson's coefficient among EEG-acoustic correlations at multiple neural-lags from 20 to 220 ms. The coefficient was then Fisher-transformed and the resultant entrainment value was obtained via further subtracting a random-level correlation value for each utterance. [Results & Discussions]: As expected, the results showed that both delta (2~4 Hz) and theta (4~8 Hz) EEG-acoustic entrainment (EAE) were significantly higher for forward speech (real-word plus pseudo-word) than for time-reversed speech, implying a top-down control of EAE by high-order linguistic processing. More interestingly, the results further showed a significant lower delta EAE and a non-significant lower theta EAE effect comparing the real-word condition with the pseudo-word condition. Our explanation is that the richer semantic information in real-word utterances may assist in recognition of phonological contents during the current sound-matching tasks, reducing the phonological processing demands as indexed by delta EAE, thereby giving rise to lower delta EAE for real-word than pseudo-word utterances. We argue that this may thus reflect bottom-up effects of delta EAE on assisting in phonological recognition in the cases that lack semantic information. This is also consistent with findings that delta-rate acoustic envelopes

are important for recognition of semantically meaningless syllables (Arai et al., 1996, 1999) and that delta EAE can reflect increased listening efforts in attention-demanding speech recognition conditions (Ding et al., 2014). [Conclusion]: Overall, the current results thus underline the bottom-up and top-down facilitation between neural-acoustic entrainment and psycholinguistic processing preferably at the phonological level rather than at the semantic level during speech comprehension.

D9 Lexical and lip-reading information as sources of phonemic boundary recalibration

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Listeners can flexibly adjust boundaries between phonemes when exposed to biased information. Ambiguous sounds are particularly susceptible to being interpreted as certain phonemes depending on the surrounding context, so that if they are embedded into words, the sound can be perceived as the phoneme that would naturally occur in the word. Similarly, ambiguous sounds presented simultaneously with videos of a speaker's lip movements can also affect the listener's perception, where the ambiguous sound can be interpreted as the phoneme corresponding with the lip movements of the speaker. These two forms of phonetic boundary recalibration have been demonstrated to be utilized by listeners to adapt in contexts where speech is unclear, due to noise or exposure to a new accent. The current study was designed to directly compare phonemic recalibration effects based on lexical and lip-reading exposures. A specific goal was to investigate how easily listeners are able to follow alternating lexical and lip-reading exposures, in order to determine the most optimal way in which listeners can switch between the two. In the experiment, participants (N=28)were exposed to blocked presentations of words or videos embedded with an individually determined, ambiguous token halfway in between /oop/ or /oot/. In lexical blocks, the stimuli consisted of audio recordings of Dutch words that ended in either /oop/ or /oot/, with the naturally occurring ending replaced with the ambiguous token. In lip-reading exposure blocks, the stimuli were made up of video recordings of the same native Dutch speaker pronouncing pseudo-words that visually appeared to end in /oop/ or /oot/, but the audio of the ending was also replaced with the same ambiguous token. Two types of presentations were administered to two groups of 14, with one version switching the modality of exposure after every block, and the other every four blocks. Following each exposure block, a 6 item post-test was presented, where participants heard the ambiguous token and its two neighbors from a 10-step continuum in isolation, each presented twice, and were asked to report if each sound resembled /oop/ or /oot/. Results from a mixed-factor ANOVA determined that subjects could flexibly adjust phoneme boundaries, as there was a main effect of the phoneme being biased, such that there was a greater proportion of /oot/ responses (pooled across all post-test items) following /oot/ bias blocks than following /oop/ bias blocks, $F(1,28) = 15.828$, $p<0.01$. There was also a main effect of exposure type, comparing lexical and lip-reading exposures, $F(1,28) = 4.405$, $p<0.05$ which indicated that recalibration strength was stronger following lip-reading exposure than lexical exposure. Additionally, a significant interaction between exposure type and phoneme bias was revealed, $F(1,28) = 6.475$, $p<0.05$, showing that the magnitude of the difference between p and t-biased blocks was also greater with lip-reading exposure. No significant differences were found between the two presentation types, neither for exposure type nor for phoneme bias. These results indicate that phoneme boundaries can be influenced by alternating lexical and lip-reading sources of information, and that lip-reading information is especially effective accomplishing this.

D10 Laterality and unilateral deafness: Patients with congenital right ear deafness do not develop atypical language dominance

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Auditory speech perception, speech production and reading lateralize to the left hemisphere in the majority of healthy right-handers. The origins of hemispheric specialization have been attributed to several influences such as genetic, evolutionary, developmental and environmental factors. In this study, we investigated to what extent sensory input underlies the side of language dominance by measuring the lateralization of three core subprocesses of language in patients who have profound hearing loss in the right ear from birth. Projections from the hearing left ear to the contralateral right hemisphere may gain importance in these patients, leading to an atypical lateralization pattern. Seven patients and control subjects matched on age, sex and education level took part in an fMRI (1) semantic decision listening task involving speech and sound stimuli that were contrasted against noise (auditory perception) (2) a word generation task in which subjects had to mentally generate words beginning with a target letter or repeat a nonword (speech production) and (3) a passive reading task in which words were contrasted against chequerboards (reading). The results show that a lack of sensory auditory input on the right side, which is strongly connected to the contralateral left hemisphere, does not lead to atypical lateralization of speech perception. General results for patients and controls together showed activity in the bilateral superior temporal gyrus as expected. Three out of seven patients were clearly left lateralized with individual lateralization indices (LIs; calculated as a weighted mean of activity in the left and right hemispheric region of interest) above +0.50, another three were also left lateralized with indices between 0.35 and 0.44 and one patient had a more bilateral LI towards the right hemisphere with a score of -0.16. Even though this pattern was more mixed than expected, our paradigm most importantly elicited a similar pattern in the control subjects (Mann-Whitney U-test: $p = .26$). Speech production lead to strong activity in the inferior frontal gyrus in the pars opercularis and pars triangularis, with a clear lateralization towards the left hemisphere for all patients and control subjects (except one patient with LI = -0.27 but Mann-Whitney U-test showed no differences between patients and controls: $p = .37$). Finally, reading elicited activity in the ventral occipitotemporal region in all subjects. Everyone had a clear LH lateralization with values above +0.50. Only one patient had a slightly weaker LI of +0.38 but still activated his LH most during passive word reading. The same distribution

of lateralization indices in patients and controls was again confirmed by a Mann-Whitney U-test (p = .37). In conclusion, the individual indices (which are rarely reported in other studies) of the patients and controls made clear that both groups produced a similar lateralization pattern for speech perception, speech production and reading. Other factors such as genetic constraints presumably overrule the role of sensory input in the development of (a)typical language lateralization.

D11 How early does linguistic processing start and where in the brain?

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It is commonly assumed that phonological and semantic processing of linguistic stimuli (whether aurally or visually presented) is mediated by speech-specific left hemisphere networks and follows the analysis of the sensory features of such stimuli which is mediated by bilateral activation of the primary sensory cortices and lasts more than 100 ms from stimulus onset, that is, after the resolution of the N100 component of the Event Related Potentials (ERPs) or the N100m component of Evoked magnetic fields (EMFs). There are some indications however, principally in the magnetoencephalography literature that lateralized linguistic processing starts earlier, during the N100m component. To define the precise onset of phonological and semantic processing we collected and localized the intracranial sources of successive EMF components to linguistic and non-linguistic (control) stimuli in the context of four tasks. Two basic findings emerged from the analysis of the results: first that lateralized linguistic processing takes place well before the resolution of the N100m component therefore it appears proceed almost synchronously with pre-linguistic (sensory) processing. Second, left-lateralized linguistic processing involves only the already known language-related regions to the exclusion of other regions with the exception of the primary auditory (for aural speech stimuli) and the primary visual cortex (for visual linguistic stimuli). These findings challenge our long-standing assumptions regarding linguistic processing in the brain and call their revision, an outline of which will also be presented.

Multilingualism

D12 Neural Network Modelling of Lexical Development in Bilingual Toddlers

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How does the learning of first words differ in monolingual and bilingual infants? And how does bilingual word learning differ when the two acquired languages present similar phonological and prosodic characteristics compared to when such cross-linguistic differences are more pronounced? We explore these questions with an articial neural network model for early bilingual lexical development, which is novel for being applied to five different language pairs. The model is based on an autoencoder architecture (Plunkett et al., 1992) trained on phonological and semantic representations of words from the early bilingual lexicon. The training set comprises 286 translation equivalents, compiled from cross-linguistic adaptations of the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 1993) in six languages: British English, Dutch, French, Polish, Greek, and Mandarin. In a first set of simulations (baseline), the autoencoder architecture is exposed to English words only, to simulate monolingual word learning. In five additional series of simulations, the architecture is trained on English plus one Additional Language. We evaluate the model against questionnaire data for 509 monolingual English-speaking infants, aged 12-30 months (64 aged 24 months), and 326 24-month-old bilingual infants (56 acquiring English and one of the target Additional Languages of the model). The model captures several characteristics of bilingual word acquisition present in our questionnaire data: (1) English words are learned faster in monolingual compared to bilingual language acquisition, and this difference is conditioned by measurements of phonological distance between English and the Additional Language for a given language pair (the more distant the two languages phonologically, the slower the learning of English words); (2) In both monolingual and bilingual language acquisition, the age of acquisition of individual English words depends on phonological complexity (shorter words tend to be acquired earlier) and word frequency in child-directed speech corpora (Theakston et al., 2001); (3) The age of acquisition of individual English words is very similar in monolingual and bilingual language development. This applies to all language pairs of our study, however, similarity is also conditioned by the phonological distance between English and the Additional Language. In other words, learning an Additional Language phonologically or prosodically close to English has an even weaker effect on the age of acquisition of English words; (4) In bilingual language acquisition, the age of acquisition of words with the same meaning (translation equivalents) is highly similar across the two languages. Again, this similarity is conditioned by phonological distance (the closer English and the Additional Language are, phonologically, the more similar the acquisition of translation equivalents). Although our model could not offer a full account of the acquisition of individual words (e.g., it does not capture differences in the age of acquisition of words from different grammatical classes), it provides a useful framework for the study of phenomena in bilingual lexical acquisition considering effects of linguistic distance. This framework allows for the study of complex interactions between two languages in bilingual lexical development and is currently extended to address new data, for example within- and cross-language priming data.

D13 Contextualizing Treatment Outcomes in a Bilingual-Speaker with Anomia by Examining Gray Matter Volume and Functional Connectivity

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Introduction: Individuals with semantic variant primary progressive aphasia (svPPA) show a gradual decline in naming and object knowledge in conjunction with atrophy in the anterior temporal lobes. Speech and language interventions for anomia have proven effective in monolinguals with svPPA. However, studies have yet to examine the effects of treatment in bilingual speakers with this diagnosis and, additionally, to examine treatment-induced changes relative to structural

and functional changes at the neural level. In this study we investigated the utility of a naming intervention in which treatment was provided to a bilingual participant with svPPA in two languages. We predicted that our bilingual (Spanish-English) participant would demonstrate improved naming for trained items as a result of therapy, with the potential for cross-language generalization. We also predicted that VBM would reveal subtle decreases in regional gray matter volume, reflecting disease progression, and that seed-based resting state connectivity analyses would show changes in connectivity within the left-hemisphere semantic network as a result of treatment. Method: A single-subject multiple baseline design was used with a Spanish-English bilingual speaker. The participant received naming treatment in Spanish, followed by treatment in English. Six sets of words were treated for three treatment sessions each, for a total of nine weeks of treatment. Voxel-based morphometry (VBM; SPM 5) was used to examine regional atrophy relative to healthy controls pre- and post- treatment. Connectivity (z-correlations) between an anterior temporal lobe (ATL) seed and left frontal and temporoparietal seeds in the language network as well as right hemisphere homologues was examined in the patient relative to healthy controls before and after treatment. Results: Our participant showed comparable and significant improvements in naming for treated items in English and in Spanish. However, these effects were better maintained for English-trained words throughout the course of treatment. VBM revealed significant atrophy bilaterally (left greater than right) in the temporal lobes, consistent with the atrophy profile observed in monolinguals with svPPA. Cross-sectional comparison of gray matter volumes at pre- and post-treatment revealed a greater extent of temporal atrophy at post-treatment and also increased atrophy in the bilateral frontal lobes. Resting-state connectivity analysis revealed non-significant differences between the patient and controls at pre- and post-treatment. Conclusion: This is the first study to examine treatment for anomia in a bilingual speaker with svPPA and to use single-subject neuroimaging to characterize structural and functional changes in the brain from pre- to post-treatment. Behavioral outcomes revealed significant improvements in naming in both languages, with greater maintenance for English-trained words throughout treatment. VBM revealed greater atrophy post-treatment in the temporal lobes, which are understood to support semantic processing. Despite prominent structural abnormalities, there were no significant differences in connectivity between the ATL and nodes within the left perisylvian language network or right hemisphere homologues at pre- or post-treatment. Taken together, these findings suggest that treatment-induced change is possible in PPA, despite ongoing structural decline in the language network. Further work is needed to assess the utility of seed-based functional connectivity analyses in detecting functional change at the single-subject level.

D14 Proactive and reactive control during bilingual lexical access is driven by different portions within the prefrontal cortex

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Both "proactive" and "reactive" control processes are at play during bilingual language switching (Wang et al., 2009). However, whether and how they interact with lexical access is still unknown. To explore this question, we conducted an fMRI study wherein Spanish-English bilingual participants named pictures by alternating between the two languages. We manipulated (1) the cue-picture time interval (long and short) to engage or prevent proactive control (e.g., Czernochowski, 2015); and (2) the cognate status of the picture name (non-cognate and cognate), to capture the presence of selective pre-activation of the target language. First, we hypothesized that BOLD responses in the left anterior vlPFC (BA47) might be more sensitive to the proactive control demands (long versus short intervals) compared to the left mid-vlPFC (BA45) (see Badre & Wagner, 2007). Second, we hypothesized that cross-language interference might be eliminated (null cognate effect) only when proactive control is engaged (long intervals), and we expected this modulation in the anterior vlPFC, but not in the mid-vlPFC (see Badre & Wagner, 2007). In support of our first hypothesis, our results demonstrated that the left mid-vlPFC and the left anterior vlPFC were differently sensitive to proactive control demands. Only the anterior vlPFC demonstrated a stronger activation when task conditions relied mostly upon proactive control (long versus short intervals). Furthermore, the effect of cross-language interference (cognate effect) was notably reduced only when proactive control was engaged (long intervals). Importantly, this effect was present in the left anterior vlPFC, but absent in the left mid-vlPFC (see: Badre & Wagner, 2007; Bar et al., 2006), supporting our second hypothesis. This dissociation suggests that the left anterior vlPFC, along with other areas such as the left middle temporal gyrus, the anterior cingulate cortex and the parietal cortex, is recruited to selectively pre-activate the target language during language switching. In contrast, the left mid-vlPFC might be related to the implementation of reactive control processes that are applied to resolve cross-language competition between simultaneously active lexical representations.

Meaning: Lexical Semantics

D15 Mapping the multiple graded contributions of the anterior temporal lobe representational hub to abstract and social concepts: Evidence from distortion-corrected fMRI

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A growing body of recent convergent evidence indicates that the anterior temporal lobe (ATL) has connectivity-derived graded differences in semantic function: the ventrolateral region appears to be the transmodal, omni-category center-point of the hub whilst secondary contributions come from the neighboring regions in a manner that reflects their differential connectivity to different input/output modalities [Rice, Hoffman & Lambon Ralph (2015) Graded specialization within and between the anterior temporal lobes. Annals of the New York Academy of Sciences, 1359, 84-97]. One of the key challenges for this theory is how different types of concept, especially those with less reliance upon external sensory experience (such as abstract and social concepts), are coded across the graded ATL hub. Recent fMRI studies probing ATL contributions

to social concept processing report differential activation of superior regions [e.g., Zahn et al. (2007). Social concepts are represented in the superior anterior temporal cortex. Proceedings of the National Academy of Sciences, 104 (15), 6430-6435]. Whether the ventrolateral ATL (vATL) is also involved in processing such abstract concept categories is less clear, perhaps owing to reduced sensitivity of conventional fMRI techniques for detecting BOLD responses in this region. We used a distortion-corrected fMRI technique, optimized to detect activations across the entire ATL region, to map commonalities and differences in the neural basis of social and psycholinguistically matched abstract concepts. Nineteen healthy, native English-speaking individuals were scanned while completing a two-alternative forced-choice (2AFC) semantic decision task. Our experimental design included a replication of the landmark study by Zahn et al. (2007) which contrasted judgments on social concepts (e.g., matching 'tactless' with 'impolite') with those on non-social concepts that referred to animal functions (e.g., matching 'nutritious' with 'useful'). We further included a third condition comprising judgments on non-social abstract concepts that were closely matched a priori to the social concepts on psycholinguistic variables (e.g., matching 'edition' with 'version'). Activation during semantic judgments was also contrasted to that during an equally demanding 2AFC baseline task requiring number magnitude judgments. As contrasted against the baseline condition, all three types of concept engaged a core left-hemisphere semantic network, including inferior frontal regions, the posterior middle temporal gyrus and, notably, the vATL. Additionally, we replicated the previous findings of differential activation of the superior ATL for the processing of social stimuli in addition to the stronger, omni-category activation observed in the vATL. These results are compatible with the view of the ATL as a graded transmodal substrate for the representation of coherent concepts. Given the strong connectivity to medial temporal limbic and frontal limbic regions (via the uncinate fasciculus), the dorsal-polar ATL regions may become important for the assimilation of emotion and valence-related information into coherent semantic representations. In contrast, the maximal convergence of multiple sources of input into the vATL generates an omni-category characteristic and therefore an equivalent and considerable contribution to social and non-social concepts.

D16 Processing abstract concepts: The role of imageability and emotional valence

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It is generally assumed that abstract, less imageable, concepts are linguistically coded (e.g., Paivio, 2007; Schwanefligel & Shoben, 2003; Hoffman et al., 2015), thus engaging the left perisylvian language network. Moreover, according to some accounts (Shallice and Cooper, 2013) abstract concepts would further strongly rely on the computational characteristics of left inferior frontal areas as their meaning would require computing possible states, binding entities within a structure and the use of embedding (recursion). Other behavioural and imaging work, which used tighter matching of items than previous studies, suggests, however, that abstract concepts also entail affective processing to a greater extent than concrete concepts (Kousta et al., 2011) and engage rostral anterior cingulate cortex, an area associated with emotion processing (Vigliocco et al., 2014). Here, we set to specifically test the role of left inferior frontal areas as well as the affective system in the processing of abstract concepts. We use a relatively low-level task (lexical decision), which does not pose high demands on semantic processing (and therefore may not engage semantic control functions, see Hoffman et al., 2015) to tap more into representational differences among these concepts. We included a large number of words (480) varying in their degree of imageability and emotional valence, to better assess whether the affective system is differentially engaged in processing more and less imageable words. We took a parametric multiple regression approach: words varied in imageability and emotional valence but also in length, frequency, familiarity and age of acquisition. These latter factors were taken into account first (treating them all as modulations of lexical decision > rest), then we tested the partial effects of the imageability and valence parameters. We first considered only main effects (for valence including (a) linear term: negative vs. positive emotion; and (b) quadratic term: emotional vs. neutral). Variation in imageability predicted change in BOLD signal only for positive slopes (increase in BOLD signal for more imageable words) in left frontal gyrus, bilateral angular gyrus and right middle temporal gyrus. Crucially, however, imageability did not modulate effects in left inferior frontal gyrus (highly activated for words > rest). For emotional valence we found: (a) positive > negative led to increased activation broadly, including bilateral angular gyrus, bilateral middle and inferior temporal gyrus, and bilateral precuneus. (b) Emotional > neutral led to increased activity in left rostral anterior cingulate gyrus (as in Vigliocco et al. 2014), in addition to same areas as in (a). A subsequent analysis tested for interactions between valence and imageability. Only right angular gyrus showed an interaction (particularly increased activation for words that were highly imageable and emotional). These results do not provide evidence for a specific role of left IFG in abstract processing. Moreover, they suggest that the emotional system is equally engaged by concrete and abstract words.

D17 The Good, the bad, and the neutral: The brain organizes abstract semantics primarily by valence

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Abstract words such as "logic", "passion", "creativity", constitute nearly half of human lexicon and are the foundation of human thoughts. Classical prevailing cognitive theories assume that abstract semantics are organized differently from concrete meanings (e.g., apple), with the former relying solely or predominantly on verbal contextual properties and the latter involving various modalities of sensory/motor properties. Past neuroimaging studies have revealed that abstract words as a group tend to more strongly activate left inferior frontal gyrus and anterior temporal cortex, regions that are important for verbal representations, and such results have been assumed to support the verbal account. Recent conceptual theories have also proposed underlying nonverbal semantic dimensions for abstract semantics, yet whether verbal or specific nonverbal

dimensions are the principles in which the brain organizes different abstract words is unknown. In this study, we took a whole-brain data-driven approach to examine the primary dimensions in which the brain organizes the abstract semantic space. We collected blood-oxygen-level-dependent (BOLD) fMRI responses to 360 abstract words of six healthy adults in four scanning sessions, so that the whole-brain response patterns for each word can be constructed by averaging 12 repetitions. We applied principal component analysis over the whole-brain fMRI activation patterns of each of the 360 words, focusing on the voxels that were stable across repetitions (a total of 49,965 voxels). We found that two principal components of the neural activity patterns explained over 20% of the total variance among words. Across the 360 words, the neural representational similarity space constructed using these two neural components significantly correlated with a semantic similarity space constructed from the subjective ratings of 12 semantic dimensions for each word ($r = 0.033$, $P < 10\text{-}16$), but not with semantic spaces constructed from verbal contextual statistical measures with two common algorithms (the word2vec algorithm, $r = 0.007$, $P > 0.05$; latent semantic analysis, $r = 0.005$, $P > 0.05$). Furthermore, words' loadings on the first neural component negatively correlated with their valence ratings (positive-negative scale) ($r = -0.177$, Bonferroni corrected $P < 0.05$), but not with ratings of 11 other potential semantic dimensions ($rs < -0.094$, Bonferroni corrected $Ps > 0.912$), such as social interaction, emotion, quantities, or sensation. These results indicate that the whole-brain neural pattern of abstract word processing is more consistent with a semantic-dimensional theory than a verbal-contextual statistical theory of abstract representation, and that the most prominent semantic dimension that influences abstract semantic processing in the human brain is whether and how much the meaning is deemed positive or negative.

D18 Predicting neural activity patterns associated with sentences using a neurobiologically motivated model of semantic representation

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This study investigates the problem of how conceptual representations are encoded in brain activity. We introduce an approach that predicts neural representations of meaning as words are read in sentences. We then superpose these to predict new sentences. A neurobiologically inspired semantic model based on 65 sensory, motor, social, emotional, and cognitive attributes was used as a foundation to define semantic content. Previous studies have predominantly predicted isolated words, using models that lack neurobiological interpretation. Fourteen participants read 240 sentences describing everyday situations while undergoing fMRI over multiple scanning visits. The sentences contained a diverse selection of nouns, verbs and adjectives, of varying concreteness. Example sentences include: "The clever scientist worked at the lab", "The corn grew in spring", "The minister lost the spiritual magazine". A model representation for each content word in the stimuli was built using behavioural ratings collected from a separate group. This second group rated each word according to the relevance of the 65 attributes. To connect sentence-level fMRI activation patterns to the word-level semantic model, we devised methods to decompose the fMRI data into individual constituent words. Activation patterns associated with each attribute in the model were then estimated using multiple-regression. This enabled synthesis of activation patterns for trained and new words, which were subsequently averaged to predict new sentences. Cross-validation analyses were used to evaluate the approach. The set of fMRI sentence activation patterns were partitioned into a training set of 238 sentences and a test set of 2 sentences. This partitioning meant that each word in the test sentences appeared in a different sentential context to those of the training set. The training sentences were decomposed into words, and these words were regressed on the attribute model. This regression mapping was then used to predict neural activation associated with content words in the test sentences. The predicted content word activations were averaged accordingly to predict activation for the test sentences. The two predicted sentences were correlated with each of the actual sentences. If correlations between the corresponding pair of predicted and actual test sentences was greater than with the incorrect pairing, decoding was evaluated as a success, otherwise a failure. This process was repeated holding out different sentence pairs, to give a quantitative metric of decoding accuracy. Statistical significance was evaluated using permutation testing. Successful decoding indicates that the predicted word representations generalized to the new sentence context. Repeating this analysis on select regions-of-interest revealed that prediction accuracy was highest using voxels in the left superior temporal sulcus, where 11/14 participants were decoded at an accuracy significantly better than chance. However a broad range of other regions returned statistically significant results, showing that semantic information is widely distributed across the brain. The results show how a neurobiologically inspired semantic model can decompose sentence-level fMRI activation into activation features for component words, and how these can be recombined to successfully predict activation patterns for new sentences. In so doing this validates the attribute model of semantic representation.

D19 GABA concentrations in the anterior temporal lobe predict human semantic processing

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There is now considerable convergent evidence from multiple methodologies and clinical studies that the human anterior temporal lobe (ATL) is a semantic representational hub. However, the neurochemical nature of the ATL in the semantic processing remains unclear. The current study investigated the neurochemical mechanism underlying semantic processing in the ATL. We combined functional magnetic resonance imaging (fMRI) with resting-state magnetic resonance spectroscopy (MRS) to measure task-related BOLD signal changes and GABA in the left ATL and the occipital cortex (OCC) as a control region in 20 healthy participants. Participants performed a semantic association task and a pattern matching

task (control task) during fMRI. BOLD signal changes were measured according to task conditions and the BOLD related fluctuation for semantic processing was determined using an ICA approach. The semantic association task evoked increased BOLD signals in the ATL, frontal and posterior temporal cortex. We found that the stronger ATL BOLD response induced by the semantic task, the lower GABA concentration in the same region. In contrast, there were no correlations between GABA and BOLD signal changes during the control task and fixation. Moreover, individuals with higher GABA concentration in the ATL showed better performance (higher accuracy) in the semantic task. The sum of low frequency fluctuation power (LFP) was used to indicate the strength of the signal in the network of interest. The GABA concentration in the ATL was positively correlated with LFP of the semantic network. Higher ATL GABA concentrations predicted stronger BOLD-related fluctuations in the semantic network. Also, we observed that individuals with better semantic performance had higher LFP in the semantic network. To examine the potential links between task performance and these various neural measures, we carried out a multiple regression analysis. Task performance was predicted by GABA concentration ($\beta = 0.18$, $p < 0.05$), regional signal change in the ATL ($\beta = -0.15$, $p = 0.058$), LFP ($\beta = 0.25$, $p < 0.05$) and age ($\beta = 0.62$, $p < 0.001$). This full model explained 63% of the variance (adjusted R2) and was highly significant ($F4, 15 = 9.00$, $p < 0.001$). Our combined fMRI and MRS investigation demonstrated that the resting-state GABA concentration predicts neural changes in the human ATL and task performance during semantic processing. Our data indicate that individuals with higher GABA may have a more efficient semantic processing leading to better task performance and imply that GABAergic neurochemical processes are crucial to the neurobiological contribution of the ATL to semantic cognition.

D20 tDCS to Premotor Cortex Changes Action Verb Understanding: Complementary Effects of Inhibitory and Excitatory Stimulation

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Introduction: Do neural systems for planning motor actions play a functional role in understanding action language? Across multiple neuroimaging studies, processing action verbs correlates with somatotopic activity in premotor cortex (PMC). Yet, only one neurostimulation study supports a functional role for PMC in action verb understanding: paradoxically, inhibiting dominant-hand areas in left PMC made people respond faster to verbs naming dominant-hand actions. Why did PMC inhibition lead to a behavioral increment? On one possibility, motor simulations may rely on a complex interaction of inhibitory and excitatory circuits. Stimulation may have facilitated performance by modulating activity of inhibitory PMC circuits: inhibition may be necessary to prevent people from overtly performing the actions named by verbs, rather than covertly simulating them. Here we use transcranial Direct Current Stimulation (tDCS) to test this proposal and show that excitatory and inhibitory stimulation to PMC cause complementary behavioral effects on action verb processing. Methods: Right-handers received excitatory or inhibitory tDCS to left PMC hand areas, then made lexical decisions on unimanual and abstract verbs, using their left and right hands. Response labels varied unpredictably from one trial to the next. Accuracy and RTs were collected. Results: As predicted, tDCS polarity selectively affected how accurately participants responded to unimanual action verbs (3-way interaction of tDCS polarity x Verb type x Response hand, $p = .02$). This 3-way interaction was driven selectively by responses to unimanual verbs (2-way interaction of tDCS polarity x Response hand, $p = .02$). After inhibitory stimulation to left PMC, participants tended to respond more accurately to unimanual verbs with their right hand than with their left hand, and after excitatory stimulation to left PMC participants showed the opposite tendency, responding less accurately with their right hand than with their left hand. As expected, tDCS polarity did not differentially affect responses to abstract verbs (no statistically significant 2-way interaction of tDCS polarity and Response hand, $p = .58$). We found no evidence that tDCS polarity differentially affected the RTs to unimanual or abstract verbs (no statistically significant 3-way or 2-way interactions, all ps > .15). Discussion: These results suggest a functional relationship between the neural systems for preparing hand actions and understanding language about those actions. tDCS to left PMC affected how accurately people processed action language, in a predictable way: inhibitory stimulation caused a relative increment in performance (consistent with our previous rTMS results), and excitatory stimulation caused a relative decrement. These complementary effects of excitatory and inhibitory tDCS were specific to unimanual action verbs, and depended critically on the hand that participants used to respond. Previous neurostimulation results have shown that modulating PMC activity can influence how fast people can respond to action verbs. The present results show that modulating PMC activity in the hemisphere that controls the dominant hand can also affect how well people process verbs that name dominant-hand actions, strengthening the evidence that motor simulations contribute to the meanings of action words.

D21 Neural decoding reveals differences between concrete and abstract words

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Abstract and concrete words differ with respect to a number of factors such as age of acquisition and frequency within a language. A common view is that statistical regularities in our environment will influence the way conceptual knowledge becomes organized in the brain. If concrete and abstract words are linked to different types of life experiences, the features that underlie their neural representations may also be partly different. In order to test this we applied a multivariate machine learning approach to decode a semantic feature set from magnetoencephalography (MEG) data on abstract and concrete words. We measured MEG from 20 healthy volunteers while they read 123 single words; 64 of words where categorized as concrete and 59 as abstract based on their imagebility score. Each word was presented randomly 20 times (across two sessions).The mean event-related response to each word was source localized using minimum norm estimation. The time series at each source location were then used to train a regression-based decoder which learns the relationships

between the cortical responses and a behaviorally derived feature set. The feature set was collected from a different group of participants who were asked to judge each stimulus word on a scale from 0-5 with respect to 85 questions (e.g. Can it fly?). The reliability of the decoder was estimated by a mean over leave-two-out cross-validation scheme. The MEG-based decoder distinguished significantly beyond chance level between neural responses to two written stimulus words that it had never seen before in 15 of 20 participants (n = 15, mean accuracy 63 %). The prediction was significantly better when one of the words was abstract and the other concrete (mean accuracy 69 %) as compared to within-category performance (within-abstract: 56%, within-concrete: 61%). Accordingly, MEG activity contains decodable semantic information related to the conceptual abstractness of a word. To check which features were best accounted for by the machine learning model we calculated a qualitative score. The top-predicted features were related to visibility, countability and the concept of concreteness, which supports the notion that the model captures the difference between concrete and abstract words. The prediction was lower when the model was trained on only abstract or concrete words. The model trained exclusively on concrete words performed significantly above chance in only 7 of 20 participants (n = 7, mean accuracy 67 %), whereas the model trained exclusively on abstract words preformed at chance level. This shows that features important for the abstractness/concreteness of a word (i.e. between-category classification) do not carry relevant information for distinguishing items within the abstract or concrete category. In conclusion, our results highlight that decoding categorical differences between concrete and abstract written words is feasible and can reveal aspects of single-word processing that complement the traditional univariate approach. We show that processing of concrete and abstract words is differently expressed in the brain and that successful within-concrete and within-abstract decoding seems to depend on at least partly distinct feature spaces.

D22 Individual differences in sentence processing based on handedness and family sinistrality in left- and right-handers

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It is well-attested that left-handers show a higher incidence of right-hemisphere dominance or bilateral processing in language production and comprehension (e.g. Knecht et al. 2000; Szaflarski et al. 2002). Behavioral designs (e.g. Keane 2002) have further shown an influence of family sinistrality on language processing in left- and right-handers. Recent investigations using event-related potentials (ERPs) or functional MRI confirm the influence of family sinistrality, yet have only included right-handers (Lee & Federmeier 2015; Tzourio-Mazoyer et al. 2010). In these studies, right-handers with left-handed relatives showed reduced left-lateralization in language suggesting that family handedness seems to have its own effect on language lateralization in the brain. This is particularly intriguing given that previous ERP studies on handedness effects in language comprehension have provided mixed results on whether or not left-handers exhibit ERP patterns different from right-handers (Coulson & Lovett 2004; Barrett & Rugg 1989). We investigated the effects of handedness and family sinistrality on ERPs in healthy native speakers of German who were classified as strong left-handers (LHs; N=20, 12 females; mean laterality quotient -84.65) or right-handers (RHs; N=20, 12 females; mean laterality quotient 97). Laterality quotient was calculated based on the Edinburgh Handedness Inventory. Ten LHs and nine RHs reported having at least one left-handed parent or sibling (FS+ group), while the FS- group (ten LHs, eleven RHs) had only right-handed first-degree relatives. Participants read antonym sentences ("black is the opposite of ...") for comprehension; the sentence-final target word was either the expected antonym ('white'), unexpected, but semantically related ('blue') or unexpected and unrelated ('nice'). These sentences have previously been shown to elicit a P300 in response to the antonym and graded N400 and late positivity effects in response to the unexpected endings (related < unrelated; cf. Roehm et al. 2007). We analyzed mean ERP amplitudes in two time windows (300-500, 500-800) with a 1x3 within-subjects design (antonym vs. related-unexpected vs. unrelated-unexpected). Using mixed-effects models, we estimated the contribution of handedness and family sinistrality on antonym processing. We found significant 2-way interactions between experimental condition and handedness or family sinistrality, respectively, in both time windows. Importantly, handedness modulated P300/N400 amplitude to a larger extent than family sinistrality (the t-ratio of estimate-to-error is larger), whereas both had a comparable influence on the amplitude of the late positivity. In both time windows, these interactions were qualified by a significant 3-way interaction between condition, handedness and family sinistrality, showing that familial handedness affected LHs and RHs differently. Interactions with topographic factors (sagittal, lateral) showed reverse patterns depending on individual and family handedness and condition. Our findings suggest that handedness alone does not fully capture individual differences in sentence processing as measured in ERP amplitudes and confirm previous results that family sinistrality has a measurable impact on ERP amplitudes. However, both factors also interact with one another and with the time window in which their influence is investigated. Overall, our data support recent claims that neuroscientific experiments should systematically include LHs to explain the full variance in neurocognitive processing (Willems et al. 2014).

D23 An Experiential Attribute Model of Semantic Representation Predicts Semantic Priming

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In the model of concept representation proposed by Binder et al. (Cognitive Neuropsychology, 2016), concepts are represented as points in a 65-dimensional space, where each dimension corresponds to the relevance of a conceptual attribute. The attributes correspond to neurobiologically realistic components of phenomenal experience, reflecting brain systems related to sensory, motor, spatial, temporal, affective, social, and cognitive processes. This type of model, which we call "concept representation as experiential attributes" (CREA), allows quantitative predictions about the overall similarity between lexical concepts in semantic memory. We

tested these predictions using automatic semantic priming in a lexical decision task. Methods: Participants (N = 15) performed lexical decision on a set of 210 nouns and 210 pseudowords matched for letter length, bigram and trigram frequency, and orthographic neighborhood size. Each target noun/pseudoword was preceded by a prime noun (150 ms) and a mask consisting of hash signs (50 ms). The prime was presented in lowercase and the target in uppercase letters. Word targets and primes were pseudorandomly selected from a list of 434 nouns that had been previously rated on all 65 attributes. To avoid association-based priming effects, prime-target pairs were restricted to those having no forward association according to the USF Free Association Norms (http://w3.usf.edu/FreeAssociation). The experiment was conducted in two sessions: Each target was preceded by a highly semantically similar prime in one session and by a less similar prime in the other. Semantic similarity was estimated based on the CREA model, by calculating the cosine between the attribute vectors for the two words. While the semantic similarity between the target and the "more similar" prime was always high (cosine > .94), similarity between the target and the "less similar" prime spanned a wide range (.14 to .94) to provide a continuous variable representing the predicted priming effect, computed as the difference between the cosine values of the two primes. Half of the word targets in each session were preceded by the more similar prime and half were preceded by the less similar prime. Session order was counterbalanced across participants to avoid order effects. The priming effect was calculated for each word as the response time (RT) to that word in the "less similar" trial minus the RT to that same word in the "more similar" trial. We hypothesized that the priming effect for a given target word would correlate with the predicted priming effect (differences in cosine similarity), i.e., that priming effects would be smaller for target words whose "less similar" primes had high cosine similarities (e.g., .90) than for target words whose "less similar" primes had low cosine similarities (e.g., .20). Results and Discussion: As predicted by the model, semantic priming showed a small but significant correlation with the difference between cosine similarities ($r = .15$, $p = .015$). The correlation was significant across words and across participants. These results show, for the first time, that a CREA model of concept representation, based on neurobiologically plausible features of phenomenal experience, successfully predicts automatic behavioral patterns driven by conceptual similarity.

Language Development

D24 Influence of early language experience on brain activation to language: A study of hearing infants with Deaf mothers

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Hearing infants with Deaf parents (HoD) have a very different early experience of speech and language to that of hearing infants with hearing parents (HoH). When the parents' dominant language is a signed language, such as British Sign Language (BSL), their speech and language input differs from that of HoH infants. First, HoD infants have reduced exposure to spoken language in the prenatal and early postnatal period. Many deaf signing individuals use speech to communicate with hearing people, but the extent to which they actually 'voice' this speech and produce sound, as opposed to silently mouth, is extremely variable. Second, the postnatal experience of HoD infants includes both a language in the visual modality, e.g. BSL, and one in the auditory modality, e.g. English, which can be used by the parents, as well as by hearing relatives and the rest of the hearing community. This study investigates the impact of early language experience on brain representation of language. Since HoD individuals grow up learning two languages, they are compared to HoH individuals growing up learning two spoken languages. Three groups of hearing infants (4-7 months) were recruited: 30 infants from a monolingual English speaking family, 30 infants from a bilingual family in which two spoken languages are frequently used by the parents, 30 infants with a Deaf mother for whom BSL is the dominant language. Functional near infrared spectroscopy (fNIRS) was used to study brain activation during spoken and sign language perception. Sentences were presented in infant-directed English and French (familiar and unfamiliar spoken languages), as well as in BSL and French Sign Language (familiar and unfamiliar sign languages). Results suggest strong activation to spoken language in the temporal cortex in all groups, which appears more left lateralised in HoH infants than HoD infants. Activation to sign language was found in a more restricted area of the temporal cortex. These results suggest an influence of early language experience on brain representation for language and will be discussed in relation to the particular experience of each group.

D25 Connectivity of the hippocampus and Broca's area during novel grammar acquisition: a PPI investigation

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Contributions of the hippocampal system and the prefrontal cortex to the initial stages of learning a second language (L2) have been established both for acquisition of novel grammar rules (Opitz & Friederici, 2003) and new vocabulary items (Breitenstein et al., 2005). Drawing on the previous findings, we conducted an artificial grammar learning experiment to investigate the connectivity of two crucial hubs in language processing and learning, the hippocampus and Broca's area. The study used fMRI to explore the initial stages of L2 acquisition in real time. Forty young adults learned an artificial grammar based on Opitz & Friederici (2003) during an fMRI scan. In the experiment, participants were exposed to a novel grammar over the course of three blocks of learning and test phases. In the learning phases, items were presented one by one with the instruction to discover the grammatical rules. Test phases consisted of grammatical and ungrammatical sentences and participants' judgements on the items were followed by feedback on their performance. A transfer test on new items was administered six days after the initial learning task. Data collected during the learning phases of the experiment were subject to a psychophysiological interaction analysis (PPI; Friston et al., 1997). Four seed regions were identified (left and right hippocampus, Broca's area and its right-hemisphere homologue) and four independent PPI analyses were conducted. We tested for increases and decreases in connectivity of each seed region over the course of the task,

and whether they were modulated by the rule knowledge estimated by means of the delayed transfer test. The results showed that acquisition of novel grammar rules was coupled with an increase of connectivity of Broca's area and its right-hemisphere homologue in time. Both Broca's area and its right-hemisphere homologue increased their connectivity with the right angular gyrus, and the left premotor cortex. An increase in connectivity between Broca's area and the cingulate gyrus was also observed. Connectivity of these areas was not coupled with participants' performance. When it comes to the hippocampal regions, decrease in connectivity of the left hippocampus (with contralateral occipital and temporal structures) over the course of the task was predictive of the ultimate rule knowledge. The study indicates that learning-related hippocampal connectivity can be seen as a marker of successful acquisition of novel grammar rules. Furthermore, we provide evidence for bilateral contributions of Broca's area to the process of acquisition of novel grammar, and underscore the role of the right angular gyrus and the left premotor cortex in rule learning. || Breitenstein, C. et al. (2005). Hippocampus activity differentiates good from poor learners of a novel lexicon. NeuroImage, 25, 958–68. Friston, K. J. et al. (1997). Psychophysiological and modulatory interactions in neuroimaging. NeuroImage, 6, 218–229. Opitz, B., & Friederici, A. D. (2003). Interactions of the hippocampal system and the prefrontal cortex in learning language-like rules. NeuroImage, 19, 1730–1737.

D26 Sex differences in second language word learning: fMRI evidence

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Whether sex differences exist in second language learning and its underlying neural mechanism is still unclear. Shaywitz and colleagues (1995) for the first time using fMRI showed males are more lateralized to the left inferior frontal gyrus, while females show more bilateral activation in language tasks (e.g. Kansaku, Yamaura, & Kitazawa, 2000). However others did not find such differences (Frost et al., 1999; Sommer, Aleman, Bouma, & Kahn, 2004). Chen and colleagues (2007) explored possible sex differences in the neural mechanisms of learning visual words. After 2-week training program on pseudo Korean characters, Chinese male and female participants had equal learning performance and neural activation in passive-viewing fmri task. Interestingly, they found left-lateralized fusiform activation predicted visual word learning in males, and bilateral fusiform activation predicted visual word learning for females. Considering previous reports on sex differences in auditory processing (e.g. McFadden, 2009; Brown, 2010), it is possible that their discrepancy might be more evident when learning auditory words. This study explored sex differences in their cognitive and auditory abilities and their distinct neural mechanism underlying auditory word learning. Twenty right-handed undergraduates (11 females and 9 males) from Penn State University participated in this fmri study. First, all participants took a battery of behavioral tests to measure their English vocabulary (Peabody picture vocabulary test, PPVT4), Nonverbal intelligence (Raven's standard progressive matrices), Processing Speed (Digital symbol substitution test, DSST), Working Memory (Letter-number sequencing, LNS), and Executive Functions including inhibition (Flanker task), shifting (color-shape task) and updating (n-back). In addition, they completed tests on auditory perceptual skills, including pitch pattern discrimination, intonation and rhythm discrimination abilities. These monolingual English speakers, who had no prior knowledge of tonal languages, then learned 48 Chinese pseudoword sounds associated with pictures in a six-week training session. They were asked to perform a sound-picture pair judgment task inside the scanner after the training and their accuracy in this task indicates their final learning attainment. Nonparametric Mann-Whitney U tests of our pre-training behavioral data showed the males performed better than the females in working memory task (LNS), but they had much more local switching cost than the women. There are no significant differences between the two groups in terms of their auditory perception skills. And both groups achieved equal learning outcome. FMRI results of the post-training sound-picture judgment task showed brain activations at bilateral putamen, right caudate, left middle occipital gyrus and right cerebellum, and deactivations at bilateral medial frontal gyri and superior temporal gyri for all learners. Group comparisons revealed males have more brain activity at bilateral precunues/posterior cingulate gyrus (BA 31) than females when explicitly retrieving learned vocabulary knowledge. As posterior cingulate cortex is a key component of default mode network, it is possible that the default mode networks of male and female learners were differently engaged when they recall second language words. In conclusion, males and females rely on different cognitive abilities and brain functions to achieve the same second language learning attainment.

D27 Do 6 months of bilingual exposure impact neuronal processing of native and non-native regularities?

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So far, it is not clear whether bilingualism beneficially or rather adversely affects language development. Especially when bilingual infants have to deal with an associative learning context, such as learning that one object has two different names in the two languages of the infants' surrounding, difficulties might occur. However, might more efficient neuronal processing strategies overcome these difficulties? To address this question a language learning study was performed in 6-month-old bilingual and monolingual infants confronted with an associative learning context. We were particularly interested in the learning process of native but also non-native linguistic regularities in order to challenge the plasticity of the brain while having to acquire unknown linguistic rules in a difficult learning setting. Brain plasticity effects were monitored simultaneously by the electroencephalography (EEG) and the functional near-infrared spectroscopy (fNIRS) while infants underwent a semantic word learning training. 6-month-old German monolinguals as well as German-Italian balanced bilinguals were acoustically presented with pseudowords

either corresponding to phonotactic rules of the native language German (e.g., brop)or complying to phonotactic rules of the non-native Slovak language (e.g., bzop). Infants underwent a pretest, a semantic training, and a posttest. During pre- and posttest, native and non-native pseudowords were acoustically presented. During training pseudowords were repeatedly combined with colored pseudoobjects visible on the screen. The EEG results of monolingual infants showed an increased negativity for the posttest compared to the pretest for both native and non-native phonotactic rules. A similar modulation was also supported by the fNIRS results. Bilingual infants, however, showed differential processing between native and non-native phonotactic rules. Furthermore, a stronger impact of the training was observable in bilinguals compared to monolinguals, especially for non-native rules. These regularities showed increased positivities for trained pseudowords whereas untrained ones elicited increased negativities. The most striking difference between monolinguals and bilinguals concerned hemispheric lateralization being more left-dominant for bilinguals already at this young age. The study demonstrates differential neuronal processing mechanisms between monolingual and bilingual infants. Already at 6 months of age we could find an impact of the bilingual exposure. Results showed indices for increased processing flexibility as well as increased difficulties encountered during the semantic associative learning context. We will discuss these results highlighting the importance of combining EEG and fNIRS in assessing language development.

D28 Neocortical dynamics underpinning rapid and automatic learning mechanism in children: A neuromagnetic investigation

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Although children learn new words with ease, often acquiring a new word after very few repetitions, the neurobiological foundations of this rapid learning ability are poorly understood. Studies probing neurophysiology of rapid word learning in adults indicate that the process of memory-trace build-up for novel words can be tracked as an amplitude increase in the brain's event-related responses elicited by novel word forms over just a few minutes of repetitive exposure to them. In adults, this enhancement (generated in left perisylvian neocortex) takes place regardless of the individual's focused attention on the speech input and appears to be specific to the acquisition of novel items with native phonology only. Given behaviourally established ultra-rapid word acquisition in children, it seems plausible that the neural correlates of this phenomenon may manifest as adult-like – or even more efficient – plastic changes in the brain activity. Here, we tested this suggestion of neural dynamics underlying fast word acquisition in children experimentally. We used magnetoencephalography and presented four types of words and word-like sounds to 5-12 year-old native Danish-speaking children: real Danish words, novel Danish pseudo-words, pseudo-words incorporating non-native (French) phonology and musical rain sounds, which mimic complex acoustic properties of a speech signal but cannot be interpreted as speech. We scrutinised the brain dynamics elicited by these sounds throughout a 20-minute passive exposure session, during which the participants did not pay attention to the stimulation and were engaged in watching a silent film. Cortical generators of neural activity underlying surface MEG dynamics were analysed using distributed source reconstruction techniques (wMNE). We found neural dynamics that closely matched that known for adults: rapid enhancement in ERF amplitudes as early as ~100 ms, likely associated with formation of memory traces for novel sounds. However, such dynamics were elicited by all novel sounds (and not just phonologically native word forms, as seen in adults), although with diverging topographies. For novel Danish word forms, the enhancement was seen in the left-temporal regions only, suggesting reliance on pre-existing phonetic/phonological circuits for acquiring words with native phonology. In contrast, exposure to pseudo-words with non-native phonology intensified the activity in the right hemisphere, suggesting neuroanatomically distinct online acquisition processes subserving learning of such items. Finally, bilateral increase of neural activity was observed for non-speech sounds. Our results illustrate, for the first time, the spatiotemporal dynamics of rapid and automatic build-up of neural memory traces for words and word-like items in children, manifest as complex online changes in bilateral perisylvian regions. Specifically, our results suggest that the developing brain recruits different neural circuits to manage the formation of memory traces for novel items depending on the stimulus characteristics, as evidenced by the differences observed between speech and non-speech items, as well as between items with native and non-native phonology. These findings indicate that partially similar neural processes underlie word acquisition in children and adults, but unlike adults, the children's brain is still sufficiently plastic to automatically process and rapidly learn words with non-native phonology as well as non-speech items.

Grammar: Syntax

D29 The role of procedural memory in the skill for language: Evidence from syntactic priming in patients with amnesia.

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Syntactic priming, the phenomenon in which participants adopt the linguistic behaviour of their partner, is widely used in psycholinguistics to investigate syntactic operations. Although the phenomenon of syntactic priming is well documented, the

memory system that supports the retention of this syntactic information long enough to influence future utterances, is not as widely investigated. We aim to shed light on this issue by assessing 17 patients with Korsakoff's amnesia on an active-passive syntactic priming task and compare their performance to controls matched in age, education and premorbid intelligence. Patients with Korsakoff's amnesia display deficits in all subdomains of declarative memory, yet their implicit learning remains intact, making them an ideal patient group to use in this study. We used the traffic-light design for the syntactic priming task: the actors in the prime trial photos were colour-coded and the participants were instructed to name the 'green' actor before the 'red' actor in the picture. This way we can control which syntactic structure the participant uses to describe the photo. For target trials, the photos were grey-scale so there was no bias towards one structure over another. This set-up allows us to ensure the primes are properly encoded. In addition to the priming task, we also measured declarative memory, implicit learning ability, and verbal IQ from all participants. Memory tests supported the claim that our 17 patients did have a severely impaired declarative memory system, yet a functional implicit/procedural one. The control group showed no deficit in any of the control measurements. In line with the hypothesis that syntactic priming relies on procedural memory, the patient group showed strong priming tendencies (12.6% passive structure repetition). Unexpectedly, our healthy control group did not show a priming tendency. In order to verify the absence of a syntactic priming effect in the healthy controls, we ran an independent group of 54 participants with the exact same paradigm. The results replicated the earlier findings such that there was no priming effect compared to baseline. This lack of priming ability in the healthy older population could be due to cognitive interference between declarative and non-declarative memory systems, which increases as we get older (mean age of the control group is 62 years).

D30 How expectation modulations based on verb bias and grammatical structure probabilities shape the sentence processing network

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During language processing we use available information to facilitate the processing of incoming information. This allows for efficient processing of predicted information but also causes prediction error when expectations are unfulfilled. In the present experiment we manipulated two types of information in the linguistic input, the statistics of the input (the proportion of two sentence structures across different blocks) as well as verb cues biasing towards one structure or the other. We investigated the brain networks involved in using these two types of contextual information during language processing. We acquired fMR images while 20 participants read ditransitive sentences in their native language (German). The sentences were created with verbs that either biased towards a prepositional object (PO) structure (e.g. "sell" biases towards PO sentences like "The girl sold the book to the boy") or a double object (DO) dative structure (e.g. "show" biases towards a DO structure like "The girl showed the boy the flower"). The grammatical structure probabilities were manipulated across blocks (Block 1: 75% DO structure, 25% PO; Block 2: 25% DO, 75% PO; block order was counterbalanced across participants). In each block these constructions occurred with equal amounts of DO and PO-biased verbs. After 12% of the sentences a comprehension question was asked to ensure attention. SPM12 was used for fMRI activation and the gPPI toolbox for functional connectivity analyses (flexible-factorial models, voxel-level threshold $p<.005$, cluster-level $pFWE<.05$). The anterior cingulate cortex (ACC), a region thought to monitor changes in statistical contingencies, in consort with regions of the language network in temporal and inferior frontal cortex, appears to prepare the network for what is most likely to appear next. The ACC was more tightly coupled to the left posterior temporal cortex as well as the left temporal pole and left inferior frontal gyrus for sentences containing a verb cue towards the overall more likely structure in German (DO). Connectivity to left middle and anterior temporal cortex on the other hand was strongest when the verb cue biased towards the structure that was currently more frequent according to the statistics of the current block. Within the language network, regions of interest related to syntactic processing in left inferior frontal gyrus and left posterior middle temporal gyrus showed greater activation if a prediction based on the verb cue was not fulfilled. This prediction error effect was larger if the verb biased towards the less frequent structure in every day statistics (PO). For the DO verb cue on the other hand, an effect of unfulfilled prediction was seen when the DO was the more infrequent structure in a block and localised to left posterior temporal/occipital cortex and the ACC. In sum, the language network dynamically shifts its connectivity profile in accordance with different information that can be used for building up predictions. Within those regions unfulfilled predictions cause a prediction error, which is modulated by the reliability of the previous prediction. This research was supported by the SFB-TRR31 fund and a fellowship at the Hanse Institute for Advanced Studies to KW.

D31 Event-related potentials (ERP) in healthy young and older participants: semantic integration, verb argument structure, and morphosyntactic processing

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Introduction. Unlike memory and executive functions, language comprehension is usually unaffected by healthy aging. However, electrophysiological (ERP) studies investigating age-related changes on semantic integration processes found that the N400 is delayed, reduced in amplitude, and more bilaterally distributed in older (vs. younger) participants (Kutas & Iragui, 1998; Huang et al., 2012; Meyer & Federmeier, 2007). Evidence for effects of aging on ERP components associated with syntactic processing (LAN, P600) is limited to a few studies that consistently report no effect of aging

on the amplitude/latency of the P600 (Kemmer et al., 2004). No studies have addressed aging effects on verb argument structure (VAS) processing. The present study investigates age-related changes to ERP components associated with semantic, VAS, and morphosyntactic processing. Materials and Methods. Two groups of healthy participants (younger: 18-28 years, n=17; older: 45-78 years, n=10) performed an auditory sentence acceptability judgment task while EEG was recorded from 32 scalp electrodes. The study included three conditions: (a) a semantic condition, with verb-object incongruencies (e.g. *Albert was poking [vs. wearing] sandals in the restaurant), (b) a verb argument structure (VAS) condition, with violations created by deleting obligatory direct objects of the verb (e.g. *Mary was devouring [vs. eating] in the kitchen), and a morpho-syntactic condition, with violations of subject-verb agreement (e.g. *The babysitters was [vs. were] sneezing in the room). Results. Semantic violations elicited an N400 of similar amplitude in both groups, but the effect was later for the older (500-800 ms) than the younger (400-700 ms) participants, and the scalp distribution was shifted rightwards in younger but leftwards in older participants. In the VAS condition, both groups showed a bilateral P600 with centro-posterior distribution that was similar in amplitude and scalp distribution. In the morpho-syntactic condition, although both groups showed a LAN-P600 pattern, the LAN was distributed broadly over anterior electrodes in young participants, but was left-lateralized and reduced in amplitude in older participants. In addition, the P600 was restricted to left posterior electrodes for younger participants, but had a broader and more bilateral distribution for older participants. Conclusion. In line with previous studies, the N400 to semantic violations was delayed and had a different distribution in older (vs. younger) participants, suggesting age-related changes in semantic integration processes. Similarly, the LAN to morpho-syntactic violations displayed reduced amplitude and more focal distribution in older (vs. younger) participants, suggesting aging effects on syntactic integration processes. While the P600 to VAS violations did not change with age, the older group exhibited a more broadly distributed P600 to morpho-syntactic violations than younger participants, suggesting recruitment of additional neural resources for morphosyntactic processes, e.g., re-analysis/repair processes. Differences in the sensitivity of the P600 to aging across violation types may point to different underlying revision processes. Results indicate that healthy aging may affect language comprehension at multiple levels. References. Kutas & Iragui (1998). Electroencephalography and Clinical Neurophysiology, 108: 456–471 Huang et al. (2012). Neuropsychologia, 50: 26-35. Meyer & Federmeier (2007). Brain Research, 1183: 91–108. Kemmer et al. (2004). Psychophysiology, 41. 372–84.

D32 Spread the word: MMN brain response reveals whole-form access of discontinuous verbs

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Words are widely agreed to be indivisible: they resist being split up and having their parts separated from each other by intervening words in a sentence. This consensus, however, has fueled a long and lively debate in linguistics about the precise status of a class of verbs which are ubiquitous in Germanic languages: particle verbs. These are verbs which consist of a root and a prefix which can occur contiguously, but in many other cases separated by linguistic elements. English examples include “call [him] up,” or “take [it] out.” The debate about these cross-linguistically common language items centres on a perennial question: Are they understood as whole-form stored words or phrases resulting from the combination of smaller units? Here we utilise the mismatch negativity (MMN) event-related potential to shed light on this long-disputed linguistic issue. Previous neurophysiological research had indicated that the MMN response to real words is larger than the MMN to pseudowords, whereas well-formed syntactic combinations produce a smaller MMN than asyntactic combinations. Therefore, the MMN can be used as a diagnostic to assess whole form storage vs. combinatorial assembly of linguistic structures whose status is ambiguous. A previous experiment measured MMN responses to felicitous English root-prefix combinations (e.g. “cool down”, “heat up”) and compared them with those of infelicitous combinations (e.g. *”cool up”, *“heat down”), finding stronger MMNs to felicitous strings than to infelicitous ones thus arguing in favour of whole form storage and access (Cappelle et al., 2010). The crucial linguistic question now is whether the same whole form storage pattern of the MMN would emerge even if the two parts of the particle verb occur in a discontinuously, thus appearing as two separate units across a sentence. We investigated here short German sentences with discontinuous particle verbs, half of which were felicitous, and the other half non-felicitous (e.g., ‘they cool it down’, ‘they cool it up’). Trials were further sub-divided by semantic transparency - i.e. whether the meaning of the word could be predicted straightforwardly as the combination of its parts. Finally, the relevant prefixes were distributed orthogonally across these manipulations, to control for acoustic-based variation in the ERP signal. Results revealed that felicitous particle verbs once again consistently produced stronger MMNs than infelicitous ones, regardless of semantic transparency or prefix. This finding, along with those of Cappelle et al. 2010, support the interpretation that particle verbs are accessed as whole forms. The present study extends this finding to German, and most importantly, to ‘discontiguous words’, showing the potential for whole form activation of linguistic units to be realised non-consecutively. Cappelle, B., Shtyrov, Y., Pulvermüller, F., 2010. Heating up or cooling up the brain? MEG evidence that phrasal verbs are lexical units. Brain Lang. 115 (3), 189–201.

D33 Retrieval cues in language comprehension: Interference effects in monologue but not dialogue

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Language production and comprehension require us to integrate incoming linguistic representations with past input, often across intervening words and phrases (Miller & Chomsky, 1963). In recent years, the cue-based retrieval framework has amassed evidence that interference is the main determinant of processing difficulty during long-distance dependency resolution (Lewis et al., 2006; Lewis & Vasishth, 2005; McElree et al., 2003; McElree, 2006; Van Dyke & McElree, 2006, 2011). Yet, little is known about the representations that function of cues in

language processing. Furthermore, most of the aforementioned data comes from experiments on silent reading, a form of monologue. But, the computational challenge of dependency resolution is actually most potent in dialogue, where representations are often omitted, compressed, reduced, or elided, and where production and comprehension must occur dynamically between two brains. Previous event-related brain potential (ERP) studies of ellipsis in silent reading have shown interference effects from different types of relevant linguistic representations (Martin et al., 2012, 2014). The current study presents ERP data from a dialogue-overhearing paradigm where the distance between antecedent and ellipsis site was manipulated. Thirty-six native speakers of British English listened to 120 spoken discourses that were spoken either by one speaker (Monologue) or split over two speakers (Dialogue). The second factor, the recency of the antecedent compared to the ellipsis site (Antecedent: Recent, Distant), yielded a 2x2 Dialogue x Recency design: Dialogue, Recent antecedent A: After reading the exposé on the MP, Jane filed a complaint. B: I don't remember about what_. Perhaps about job shortages. Dialogue, Distant antecedent A: Jane filed a complaint after reading the exposé on the MP. B: I don't remember about what_. Perhaps about job shortages. Monologue, Recent antecedent A: After reading the exposé on the MP, Jane filed a complaint. A: I don't remember about what_. Perhaps about job shortages. Monologue, Distant Antecedent A: Jane filed a complaint after reading the exposé on the MP. A: I don't remember about what_. Perhaps about job shortages. All stimuli were grammatical, and listeners answered a comprehension question on 25% of trials. A Dialogue x Recency interaction was observed on a frontal late, positive-going component that was maximal between 800-1000msec, starting ~400msec post-CW onset. The interaction was driven by the reliable difference between the Monologue Distant condition and the Monologue Recent condition, whereby the former was more positive compared to the latter. This interaction pattern suggests that interference effects can be ameliorated by speaker-related cues in dialogue listening. That suggests, minimally, that interference patterns in ellipsis resolution differ as a function of speaker information. If speaker-related cues are relevant during linguistic dependency resolution, then retrieval cues must be composite in nature, containing both speaker information and grammatical information. Such an architecture would mean that a wider range of information types might interact incrementally during in online language comprehension 'in the wild.'

D34 A fine differentiation of Korean NPIs: Evidence from ERP responses

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Previous studies have examined licensing of negative polarity items (NPIs) such as ever and any in the context without negation and with inaccessible negation, eliciting an N400 followed by a P600 compared to their grammatical counterparts (Drenhaus et al., 2004, 2005, 2006). They suggested that the failure in licensing NPIs is not exclusively related to semantic integration costs (N400), but the elicited P600 components reflect differences in syntactic processing as well. Xiang, Grove and Giannakidou (2016) also noted that explicit and implicit negative meaning were integrated into the grammatical representation in different ways, leading to a difference in the P600, and calling for a separation of semantic and pragmatic integration during NPI licensing. Likewise, in Korean it is still controversial whether Korean NPIs are licensed by nonveridical contexts like interrogatives and before-clause in Korean, although it is well established that two NPIs, amwu N-to 'any N' and teisang 'any more', are licensed by an overtly negated predicate (Lee, 1999, Hwang, 2013). Thus, in order to examine whether licensing of NPIs can be observed in Korean speakers' processing, this study conducted two ERP experiments in addition to offline and online acceptability tasks with amwu-N-to (Expt 1) and te isang (Expt 2) within four different contexts (see below). a) overtly negative predicate Kyengmi-ka [amwu yoli-to/teisang yoli-lul] leysutholang-eyse cwumwunha-ci anhassta-ko chinkwu-ka sayngkakhayssta Kyengmi-NOM [any dish/ any more dish-ACC] restaurant-LOC order-COMP didn't-COMP friend-NOM thought b) positive predicate Kyengmi-ka [amwu yoli-to/teisang yoli-lul] leysutholang-eyse cwumwunha-ko issess-ta-ko chinkwu-ka sayngkakhayssta Kyengmi-NOM [any dish/ any more dish-ACC] restaurant-LOC order-COMP PROGRESSIVE-COMP friend-NOM thought c) interrogative Kyengmi-ka [amwu yoli-to/teisang yoli-lul] leysutholang-eyse cwumwunha-ko issess-nunci chinkwu-ka cilmwunhayssta Kyengmi-NOM [any dish/ any more dish-ACC] restaurant-LOC order-COMP INTERROGATIVE friend-NOM asked d) before-clause Kyengmi-ka [amwu yoli-to/teisang yoli-lul] leysutholang-eyse cwumwunha-ki ceney chinkwu-ka tochakhayss-ta. Kyengmi-NOM [any dish/ any more dish-ACC] restaurant-LOC order-COMP before friend-NOM thought arrived Seventeen right-handed normal functioning Korean native speakers, who had normal or corrected-to-normal vision (12 males, mean age 22.8), participated in the experiments. In Experiment 1 (i.e., amwu N-to), the ERPs component N400 was elicited in conditions (b) ($F(1,16)=10.04$, $p<0.01$), (c) ($F(1,16)=10.32$, $p<0.01$), and (d) ($F(1,16)=12.28$, $p<0.01$), compared to (a), but no P600 was elicited. It is consistent with the results of offline ($F(3,57)=115.43$, $p<0.001$) and online ($F(3,48)=4.51$, $p<0.05$) acceptability tasks. However, in Experiment 2 (i.e., teisang), the anterior P600 ($F(1,16)=7.20$, $p<0.05$) was elicited in condition (d) compared to (a), while N400 was elicited in other conditions. Interestingly, the condition (d) elicited high acceptability scores in both offline (3.2 out of 4) and online (67.3 out of 100) ratings. Therefore, the observed P600 was not due to the syntactic violation or anomaly. Given that the late anterior P600 may indicate an increased memory demand in sentence comprehension (Nakano et al., 2014), the anterior P600 observed in this study might show complex pragmatic/discourse processing involving time-referencing, rather than syntactic processing. This study showed experimental evidence for licensing of Korean NPI teisang in the before-clause context, also supporting for the Xiang et al.'s (2009) argument.

D35 Selectional restriction and chord sequence incongruities: Further evidence from event-related potentials in processing language and music

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In order to test the domain-specificity/generality of language and music processing, this study used the event-related potential (ERP) paradigm to compare neural responses elicited

from violations in language and music. Employing selectional restriction (SR) for language and chord sequence (CS) for music, we constructed sentences and musical pieces where the sentence/musical piece-final verb or chord was manipulated to be either congruous or incongruous with the preceding structural context, and then went on to zoom in on the following questions. Q1: What ERP component(s) result from semantic-syntactically incongruous verbs in language? Q2: What ERP component(s) stem from harmonically incongruous chords in music? Q3: What commonalty or difference arises in ERP responses to semantic-syntactically incongruous verbs in language and harmonically incongruous chords in music? Twenty right-handed, native Korean-speaking subjects (male: 10; age: 19–26 years) participated in the present experiment. The two sessions of ERP experiments revealed that SR-violating sentence-final verbs and harmonically incongruous sequence-final chords evoked two different sets of ERP components: N400 followed by N600 in language, and anterior P600 in music. In accounting for these results, we set out to attribute the divergence between the ERP results of our study and those of Patel et al. (1998) to the different experimental designs. SR violations in our experiment elicited more meaning-centered ERP components such as N400 and N600, while phrase structure violations in Patel et al.'s (1998) elicited more structure-dependent ERP components such as LAN and P600. For music, on the other hand, the elicitation of anterior P600 from harmonically incongruent chords in our study was attributed to non-musician participants perceiving harmonically incongruent chords as being simply complex, thus giving rise to an anterior scalp distribution of P600. In fact, musically trained subjects in Patel et al.'s study (1998) perceived harmonically incongruent chords as being anomalous, calling for revision processes that give rise to a posterior scalp distribution of P600. Factoring out the presumably meaning-proper correlate of SR and the presumably structure-proper correlate of CS. we narrowed down to the ERP component elicited approximately 600 ms from SR, and suggested that this component is a right candidate for a comparison with the ERP component elicited at approximately 600 ms from CS, noting the parallelism between SR and CS in terms of temporality of ERP responses. Thus, ERP components elicited approximately 600 ms in both SR and CS are understood analyzed as indexes of syntactic integration: N600 is an index of meaning-centered syntactic integration, whereas P600 is an index of structure-centered syntactic integration. To the extent that this analysis is on the right track, the results in our study especially in terms of ERP component render further compelling evidence showing that SR-related semantic-syntactic and CS-related harmonic incongruities elicit the ERP component that is indistinguishable at about 600 ms.

Language Disorders

D36 Semantic word category impairments in semantic dementia and posterior cortical atrophy

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There is general agreement that perisylvian language cortex plays a major role in lexical and semantic processing; but the contribution of additional, more widespread, brain areas in the processing of different semantic word categories remains controversial. We investigated word processing in two groups of patients whose neurodegenerative diseases preferentially affect specific parts of the brain, to determine whether their performance would vary as a function of semantic categories proposed to recruit those brain regions. Cohorts with (i) Semantic Dementia (SD), who have anterior temporal-lobe atrophy, and (ii) Posterior Cortical Atrophy (PCA), who have predominantly occipito-parietal atrophy, performed a lexical decision test on words from five different lexico-semantic categories: colour (e.g., crimson), form (rectangle), number (thirteen), spatial prepositions (between) and function words (moreover). Sets of pseudo-word foils matched the target words in length and bi-/tri-gram frequency. Word-frequency was matched between the two visual word categories (colour and form) and across the three other categories (number, prepositions, function words). Age-matched healthy individuals served as controls. Although broad word processing deficits were apparent in both patient groups, the deficit was strongest for colour words in SD and for spatial prepositions in PCA. The patterns of performance on the lexical decision task demonstrate (a) general lexicosemantic processing deficits in both groups, though more prominent in SD than in PCA, and (b) differential involvement of anterior-temporal and posterior-parietal cortex in the processing of specific semantic categories of words.

D37 Aberrant neural activity and linguistic dimensions during natural conversation in autism.

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People with an Autism Spectrum Disorder (ASD) typically struggle with conversation. However, we know little about the neural substrate for conversation in typically developed (TD) people let alone those with an ASD. Here, we used fMRI to measure brain activity of ASD and TD subjects while they engaged in natural conversations with the experimenter, who was visible throughout the experiment via a video screen. In our first analyses we found that the amount of time subjects spoke during the conversations was correlated with increased whole-brain correlation of perisylvian cortical activity (ASD and TD subjects combined). These perisylvan regions, in turn, showed differential correlation patterns with 17 additional regions. Coupling between these regions was stronger in the ASD than the TD. Analysis of the linguistic content of the conversations using the Linguistic Inquiry Word Count (LIWC; a measure of linguistic aspects of a text along ~80 dimensions) and multi-dimensional scaling (MDS) identified two global linguistic dimensions in these conversations. Dimension 1, characterized by shortness of speaking turns ("Tersensess")

did not differ in strength between groups nor did it correlate with autism symptom severity (ADOS). However, Dimension 2, characterized by decreased use of verbs and personal pronouns ("Social Language"), differed between groups with the TDs using more Social Language than ASD subjects. This dimension also correlated with autism symptom severity (ADOS) and brain activity. Thus during natural conversation, the ASD subjects produced a paucity of 'Social Language' which, in turn, was related to autistic symptoms and abnormally increased neural coupling throughout multiple brain regions.

D38 Dysprosody As A Clinical Biomarker In Neurodegeneration

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Introduction: Personality and behavioral changes leading to social disability is a hallmark of the clinical presentation of patients with the behavioral variant of Frontotemporal Degeneration (bvFTD). Empathic deficits (1, 2) and difficulty with self-perception (3) contribute to the behavioral changes observed in bvFTD and can also interfere with effective interpersonal communication or discourse. This corresponds to a bvFTD patient's apparent disengaged and non-empathic speech in conversation. Previous work has shown a deficit in understanding (4) and expressing (5) narrative discourse. We hypothesize that narrative speech deficits in bvFTD also may be manifested in speech as changes in prosodic features that are essential to pragmatic aspects of language. This dysprosody can be measured acoustically as abnormal pitch range and contours and changes in amplitude that inappropriately match the social situation. We expect these acoustical features to correlate with atrophy in specific anatomical brain regions. Methods: Our center collects spontaneous speech samples from patients enlisted in clinical trials using a picture description task – the "Cookie Theft" picture from the Boston Diagnostic Aphasia Exam (6). We analyzed multiple clean subject speech segments from 40 subjects with bvFTD and 35 matched controls, using an automated Speech Activity Detector (SAD) – a computational method that directly identifies speech within an audio signal (7). We then performed pitch tracking – another computational tool that estimates the fundamental frequency (f0) within an interval of speech sounds (8). F0 is a measure that correlates well with the perceived speaker tone (pitch). We compared the tonal features of patients to their controls and correlated the differences with Grey Matter (GM) density in high resolution structural images of patients' brains using ANTs software. Results: We found a significantly reduced f0 range and standard deviation within the bvFTD patient group compared to the control group (control mean range 114.57 Hz, SD 66.74; bvFTD mean range 64.68 Hz, SD 46.85 Hz; $p = 0.000$). Mainly, the subjects with bvFTD make less use of the higher f0 frequencies (90th percentile at 248.37 Hz on average in controls compared with 201.78 Hz in bvFTDs, $p = 0.002$) and this is mostly apparent within the male subpopulation. GM density analysis revealed significant atrophy in frontal and anterior temporal cortical regions ($p<0.05$ FWE-corrected). We used regression analysis to relate GM density to the limited f0 range in bvFTD. Conclusions: We developed a novel automated approach to acoustically analyze and characterize speech patterns in bvFTD, and found reduced f0 range in bvFTD compared to controls. This corresponds to shallower tonal variability and the nonempathic speech style often described in people with bvFTD. It is a clinical marker of dysprosody in bvFTD and correlates with known neuroanatomical markers of disease. REFERENCES 1. Eslinger PJ, Moore P, Anderson C, Grossman M. Social cognition, executive functioning, and neuroimaging correlates of empathic deficits in frontotemporal dementia. J Neuropsychiatry Clin Neurosci. 2011;23(1):74-82. 2. Eslinger PJ, Moore P, Antani S, Anderson C, Grossman M. Apathy in frontotemporal dementia: behavioral and neuroimaging correlates. Behav Neurol. 2012;25(2):127-36. 3. Massimo L, Libon DJ, Chandrasekaran K, Dreyfuss M, McMillan CT, Rascovsky K, et al. Self-appraisal in behavioural variant frontotemporal degeneration. J Neurol Neurosurg Psychiatry. 2013;84(2):148-53. 4. Farag C, Troiani V, Bonner M, Powers C, Avants B, Gee J, et al. Hierarchical organization of scripts: converging evidence from FMRI and frontotemporal degeneration. Cereb Cortex. 2010;20(10):2453-63. 5. Ash S, Moore P, Antani S, McCawley G, Work M, Grossman M. Trying to tell a tale: Discourse impairments in progressive aphasia and frontotemporal dementia. Neurology. 2006;66(9):1405-13. 6. Goodglass H, Kaplan E, Weintraub S. Boston Diagnostic Aphasia Examination. Philadelphia: Lea & Febiger; 1983. 7. Reynolds D, editor An overview of automatic speaker recognition. Proceedings of the International Conference on Acoustics, Speech and Signal Processing (ICASSP); 2002. 8. Talkin D. A robust algorithm for pitch tracking (RAPT). 1995.

D39 Longitudinal resting state functional connectivity patterns in the early phase of recovery from aphasia

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Substantial language improvements can be observed within the first days after stroke. However, underlying changes in the functional status of the language network during the acute phase remain to be demonstrated. In a resting-state functional connectivity (RSFC) fMRI study we assessed changes in functional connectivity repeatedly (acute(t1)=2.2±0.8 subacute(t2)=9.2±1.5 days post-onset) in aphasic patients (N=29, 62±16 years, 16 male) with left hemisphere stroke. Language recovery scores for comprehension and production were calculated based on the Aachener Aphasie-Test. For RSFC analysis 9mm spherical ROIs reflecting core language regions in the left anterior inferior frontal (aIFG: x=-54 y=32 z=1, MNI-space), posterior middle temporal gyrus (pMTG: x=-54 y=-43 z=4) and their right hemisphere homologous were selected. Seed-to-whole-brain analysis from left aIFG or pMTG revealed RSFC to right hemisphere homologous frontal or temporal areas at t1 and t2, but no significant changes between the two time points ($p<.05$, FWE corrected). In a subsequent ROI-to-ROI-analysis, at t1 or t2 RSFC between the four seeds did not correlate with LRScomp or LRSprod and there was again no significant changes of RSFC for any of the six ROI-to-ROI-connectivities. However, change of RSFC from t1 to t2 did correlate with the language improvement, such that an increase in connectivity between right and left pMTG was observed in patients who improved in LRScomp ($r=.574$, $p=.005$) while an increase in the RSFC between right pMTG and right aIFG ($r=.459$, $p=.032$) or right pMTG and left aIFG ($r=.580$, $p=.005$)

was observed in patients that improved in LRSprod. These results held true when controlling for multiple comparisons with Bonferroni-Holm, known prognostic factors such as age, lesion volume or initial severity of Aphasia and when looking at subgroups only including patients with intact aIFG or intact pMTG. To conclude, we observed early ipsi- and contralesional changes in the language networks functional connectivity and associated language improvements indicative of acute diaschisis and subsequent reorganization within the distributed language network where interhemispheric connectivity increase of middle temporal gyri was associated with gains in speech comprehension while intra- and interhemispheric connectivity increases from right temporal lobe to inferior frontal gyri was associated with improvement in speech production.

D40 A biomarker for recovery and decline of language function years after stroke

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INTRODUCTION Language deficits (aphasia) are some of the most feared consequences of stroke. Recovery from aphasia has long been thought to plateau within the first year post-stroke, after which little residual change is expected. Here, we report evidence that chronic aphasia can change, for better or worse, and that this is associated with increases and decreases in brain structure. METHODS We extracted patient data from the PLORAS database: including native-English speaking, right-handed patients with left-hemisphere stroke, who had been scanned twice with structural MRI >1 year post-stroke, around the same dates as their object naming skills (a classic test of speech production) were assessed with the Comprehensive Aphasia Test. We used Voxel-Based Morphometry (VBM) to correlate rates of change in language skill with rates of change in brain structure, controlling for time post-stroke and task score at first assessment and age at stroke onset. We also used leave-one-out cross-validation to estimate how predictable behaviour change was in new patients, given brain change. Finally, we used fMRI in a separate sample of 35 neurologically normal controls to probe the function of the region where structural adaptation was most strongly correlated with behaviour change. The task of interest was object naming, and this was compared to semantic association tasks on (a) the same object pictures and (b) heard object names. RESULTS 28 patients (10 women) met our inclusion criteria; mean / standard deviation of: (i) age at stroke onset = 51.7 / 10.4 years; (ii) time post-stroke when first assessed (T1) = 50.7 / 43.7 months; (ii) time post-stroke when next assessed (T2) = 80.4 / 53.5 months; T2-T1 = 30.7 / 25.8 months. We observed improvement in 13/28 patients and decline in 11/28, with no main effect of change (t=0.28, p=0.78). However, the changes were significantly associated with structural adaptation in the right middle temporal gyrus, with the strongest correlation in an anterior cluster (the 'peak cluster'). Every fold of the cross-validation analysis also selected a voxel inside that peak cluster, and the resultant predictions were strongly correlated with the patients' empirical rates of behaviour change (R2=0.76, p<0.001). Voxels in the peak cluster were significantly more active when the neurologically normal participants named visually presented objects than in either of the semantic decision tasks (peak voxel at [48,-6,-30], Z=5.67, p<0.05, corrected for multiple comparisons), and they were not significantly activated for either baseline task independently (p>0.05, uncorrected). We suggest that these voxels serve a word-retrieval / articulation function in the undamaged brain. CONCLUSION In summary, we found that changes in language skill in chronic aphasia were both systematically associated with, and predictable given, structural adaptation in a right anterior temporal region of the brain. This region appears to serve a word-retrieval / articulation function in the undamaged brain, so can plausibly be interpreted as a biomarker of neural compensation. These results are not consistent with the prevailing view that chronic aphasics' language skills are stable; on the contrary, they imply that change continues over years after stroke onset.

D41 Dynamics of perilesional activation in aphasia recovery

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Introduction: Recovery from post-stroke aphasia evolves in time and space spanning anatomically distributed brain networks (Saur et al., 2006). Increased perilesional activity associated with treatment-related language improvements has been confirmed in the chronic phase (Meinzer et al., 2008; Fridriksson et al., 2012), but has not yet been systematically demonstrated during the early phases of stroke recovery. Studies on the pathophysiology of stroke suggest increased neuronal excitability and dendritic turn over that are present days to months after stroke underpin perilesional neuroplasticity (Schiene et al., 1999; Brown and Murphy, 2008) and might foster the reorganization of representations for language in the vicinity of the lesion site. Methods: We compared fMRI BOLD response to intelligible speech (SP) and reversed speech (REV) using an auditory comprehension paradigm (Saur et al., 2006) administered repeatedly (acute (t1)≤1 week, subacute (t2)=1-2 weeks, chronic (t3)>6 months post-onset) to aphasic patients with left frontal (N=17) or temporoparietal (N=17) stroke. Language activation (SP>REV) obtained from three perilesional ROIs expanding stepwise to 39mm beyond the lesion (DISTANCE) was compared between TIME points and different lesion locations (GROUP). Results: A 3x3x2 repeated-measure analysis of covariance adjusted for lesion volume revealed language activation significantly changed over TIME ($p < .05$) and was lager in patients with frontal as compared to temporal lesions (main effect of GROUP, $p < .05$). In patients with temporal lesions perilesional activation decreased with distance (DISTANCE x GROUP, $p < .05$), yet activation significantly increased from t1 to t3 across all perilesional temporoparietal ROIs ($p < .05$, Bonferroni-adjusted). In contrast, perilesional activation only increased in ROIs closest to the lesion ($p < .05$, uncorr.) in patients with frontal lesions. While in both patient groups early (t1) perilesional activation predicted initial aphasia severity, improved language comprehension was associated with the subacute (t2-t3) increase in perilesional activation only in ROIs distant from temporoparietal lesions ($p < .05$). Conclusions: The reorganization of cortical language representations in undamaged left perilesional cortices is likely to commence during the subacute phase of recovery. Aphasia severity and

improvements of language functions can partially be attributed to the functional re-establishment of frontal or temporal perilesional areas. These findings open new perspectives for targeting perilesional areas with neuromodulation techniques that increase perilesional excitability as adjunct to speech and language therapy. References: Brown CE, Murphy TH. Livin' on the edge: imaging dendritic spine turnover in the peri-infarct zone during ischemic stroke and recovery. Neuroscientist 2008; 14(2): 139-46. Fridriksson J, Richardson JD, Fillmore P, Cai B. Left hemisphere plasticity and aphasia recovery. Neuroimage 2012; 60(2): 854-63. Meinzer M, Flaisch T, Breitenstein C, Wienbruch C, Elbert T, Rockstroh B. Functional re-recruitment of dysfunctional brain areas predicts language recovery in chronic aphasia. Neuroimage 2008; 39(4): 2038-46. Saur D, Lange R, Baumgaertner A, Schraknepper V, Willmes K, Rijntjes M, et al. Dynamics of language reorganization after stroke. Brain 2006; 129(Pt 6): 1371-84. Schiene K, Staiger JF, Bruehl C, Witte OW. Enlargement of cortical vibrissa representation in the surround of an ischemic cortical lesion. J Neurol Sci 1999; 162(1): 6-13.

D42 Brain regions supporting phonological and semantic reading processes in Central Alexia

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Introduction: Central Alexia (CA) is a broad term that describes reading impairments in patients with aphasia (Leff & Starrfelt, 2014). We aimed to investigate whether there are statistically significant associations between the amount of damage to a given brain area and reading impairments in patients with CA. Specifically, we hypothesised that separable lesion locations underpin phonological and semantic impairments in reading. Methods: 23 patients with chronic CA following left MCA stroke (15 males, age range 25 – 78 years, mean 54.4 years) were assessed with 9 measures of reading ability that tapped into phoneme-to-grapheme conversion, reading aloud and reading for meaning. MRI data (3T Magnetom TIM Trio, Siemens) was also acquired on the patients according to the multi-parameter mapping protocol (Weiskopf et al, 2013). Behavioural scores were entered into a Principal Components Analysis (PCA) with varimax rotation to produce orthogonal factors. In our study we had a Kaiser-Meyer-Olkin Measure for sample adequacy of 0.636 and a subject to variable ratio of 2.6. High-resolution structural MRI brain scans were pre-processed and analysed in SPM12 (http://www.fil.ion.ucl.ac.uk/spm). Magnetization transfer images were segmented and normalised into MNI space using the Automatic Lesion Identification toolbox (Seghier et al. 2008). Segmented grey matter images were entered into the design matrix as the dependent variable. The design matrix included a multiple regression within-group model with subjects' scores on each major PCA factor as the behavioural covariates. We also entered lesion volume, time since stroke and picture naming scores as covariates of no interest. Results: The PCA model produced two factors with an eigenvalue (e) > 1 accounting for 65% of the variance in the data. The first factor accounted for 44% of the variance. We labelled it "phonology" as it loaded onto non-word reading and reading aloud tasks (e=3.9). The second factor accounted for 21% of the variance. We labelled this "semantics" as it loaded onto the reading-for-meaning tasks (e=1.8). The SPM results were thresholded at an uncorrected peak of $p<0.01$, with a cluster-level significance of $p<0.05$ with family-wise error correction. Performance on the phonology factor correlated with a cluster of 950 contiguous voxels in the left supra-marginal gyrus. Performance on the semantics factor correlated with a ventral temporal lobe cluster of 758 voxels overlapping the left lateral middle/inferior temporal gyri. Higher grey matter probabilities were associated with better reading performance. Conclusion: We identified two anatomically separable dominant regions that support different aspects of reading in patients with CA. The phonology factor explained the largest variance and identified the STG as a part of the dorsal language pathway involved in sub-lexical grapheme-to-phoneme conversion (Hickok & Poeppel, 2007). The semantic factor identified more ventral temporal regions known to be involved in supporting semantic knowledge (Brambati, et al, 2009). References: Brambati, et al. (2009) Neuropsychologia. 47:1893-900. Hickok, G & Poeppel, D. (2007). Nature Reviews, Neuroscience, 8, 393 – 402. Leff, A & Starrfelt, R. (2014) Alexia: Diagnosis, treatment and theory. London: Springer. Seghier, et al. (2008) Neuroimage, 41, 1253. Weiskopf, et al. (2013) Front Neurosci. 7, 1-11.

D43 Fragmentation of structural brain networks is associated with more severe post-stroke aphasia.

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Introduction The neurobiological bases for functional impairment after a stroke in remote and spared areas is not completely understood. However, the loss of white matter projections to other grey matter regions can lead to disconnection of these regions. Importantly, the degree of white matter disconnection of key spared grey matter regions is an independent predictor of language impairment, beyond the size and location of the necrotic ischemic damage. Likewise, residual structural connectivity of spared regions plays a significant role in therapy-related improvement in subjects with aphasia. Recent results from structural connectivity studies in aphasia suggest key language regions need not only be preserved, but also connected and integrated into a network to enable language processing. This hypothesis has not been directly. Therefore, in this study, we employed graph theory methods to assess the community structure or grouping of global and peri-Sylvian networks. We hypothesized that fragmentation of the brain community structure and disintegration of peri-Sylvian networks, even when these regions are relatively spared, will be associated with more severe aphasia. Methods We included 90 right handed participants with single left hemisphere ischemic or hemorrhagic stroke. All participants underwent language assessment using the Western Aphasia Battery (WAB; Kertesz, 2007) that yields a global measure of aphasia severity on a scale of 0-100 (WAB-AQ). MRI scanning was performed where T1, T2-weighted and diffusion scans were collected. Data analysis was performed on each subject's individual connectome, a weighted adjacency matrix M of size 189 x 189,

where Mi,j represents the weighted link between ROI i and ROI j constructed from the diffusion scans using probablilistic tractography. Each connectome was partitioned into communities by optimizing Newman's modularity algorithm. For each subject, we extracted the modularity score, and the optimal community structure. We then calculated the mean of upper triangular affiliation matrix, to obtain the left and right hemisphere community affiliation index (C). To obtain the fragmentation index, a ratio of the right to left community affiliation index was calculated, which indicated how intact the community structure of the left hemisphere was, compared to the right hemisphere. Finally, we determined which pairs of nodes had to be in the same module for a high WAB-AQ score by running a one tailed unpaired t-test for every entry that was at least 50% preserved in the left hemisphere community affiliation matrix Aij. Results We found that modularity (Q) significantly increased with aphasia severity ($r = -0.46$, $p < 0.00001$) - partial correlation controlling for proportion of damage in the left hemisphere. We also observed a positive correlation between the left hemisphere community affiliation index and WAB-AQ ($r = 0.43$, $p < 0.00001$). There was a significant negative correlation between the fragmentation index and WAB-AQ ($r = -0.4247$, $p < 0.0001$), indicating that patients with more fragmented left hemispheres had more severe aphasia. Conclusion We demonstrate that the preservation of the community structure of global and peri-Sylvian networks is essential for preservation of language after stroke, and the fragmentation of this structure leads to severe language deficits.

D44 The unique neural correlates of speech fluency, phonology and semantics in chronic post-stroke aphasia.

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Individual differences in the performance profiles of neuropsychologically-impaired patients are pervasive yet there is still no resolution on the best way to model and account for the variation in their behavioural impairments and the associated neural correlates. To date, researchers have generally taken one of three different approaches (for discussion see Shallice, 1988): a single case-study methodology in which each case is considered separately; a case-series design in which all individual patients from a small coherent group are examined and directly compared; or, group studies, in which a sample of cases are investigated as one group with the assumption that they are drawn from a homogenous category and that performance differences are of no interest. In recent research, we have developed a complementary alternative through the use of principal component analysis of individual data from large patient cohorts (Butler, Lambon Ralph, & Woollams, 2014). This data-driven approach not only generates a single unified model for the group as a whole (expressed in terms of the emergent principal components) but is also able to capture the individual differences between patients (in terms of their relative positions along the principal behavioural axes). We demonstrate the use of this approach by considering speech fluency, phonology and semantics in 31 patients with a chronic post-stroke aphasia diagnosis and classification, as well as their unique neural correlates. All patients underwent a large-scale neuropsychological test battery (21 tests) that covered receptive/expressive language assessments and executively demanding tests. Principal component analysis of the large-scale behavioural data resulted in four statistically independent behavioural components reflecting phonological, semantic, executive-demand and speech fluency abilities. Even after accounting for overall lesion volume, as a measure of overall severity and non-random sampling of the brain damage, entering the four behavioural components simultaneously into a voxel-based correlational methodology (VBCM) analysis (using continuous T1-weighted images) revealed that speech fluency (or more specifically speech quanta) was uniquely correlated with left motor cortex and underlying white matter (including the anterior section of the arcuate fasciculus and the frontal aslant tract), phonological skills with regions in the superior temporal gryus and semantics with the anterior temporal stem. The results mirrored the principle features of natural language and dimensions on which patients are classified (fluency, comprehension and repetition). By using the novel PCA-VBCM approach, we overcome the challenge of intercorrelation and severity among behavioural measures, which subsequently allow for the unique localisation of neural correlates Rather than adopting either a classical group-study or single-case investigation, the PCA data-driven approach not only generates a single unified model for the group as a whole (expressed in terms of the four emergent principal components) but is also able to capture the individual differences between patients (in terms of their relative positions along the principal behavioural axes). Whilst we have applied this PCA-VBCM approach to post-stroke chronic aphasia in the current investigation, this methodological approach should be applicable and beneficial across a range of acute and progressive neurological conditions.

D45 Reorganization of language networks in people with aphasia: resting state fMRI data

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While resting state networks, which reflect the large-scale functional architecture of the human brain (Biswal et al., 2010), have been extensively investigated in healthy population, similar studies remain less common in brain-damaged people and especially in people with aphasia (van Hees et al., 2014). Specifically, the patterns and the role of language networks reorganization in aphasia have not been clarified yet. The aim of this study was to investigate differences in resting state language networks in people with aphasia and non-brain-damaged individuals. Thirty two people with aphasia due to a stroke in the left hemisphere and 32 healthy age-matched individuals participated in the study; all were right-handed native speakers of Russian. T2*-weighted BOLD images (TR/TE/FA = 3s/50ms/90°; 3.9x3.9x3.75 mm voxel; 64x64 matrix; 35 slices; 180 time points) and high-resolution T1-weighted images (TR/TE/FA=1.9s/2.93ms/15°; 1x1x1 mm voxel; 256x256 matrix; 176 slices) were acquired for each participant on a 1.5 T Siemens Magnetom Avanto scanner. Participants

were instructed to stay relaxed in the scanner, with their eyes closed; no active task was given. Data preprocessing was performed in SPM8. Following the procedure recommended by Allen et al. (2011), we identified resting state networks using group independent component analysis in GIFT. As a result, in a joint cohort of 64 participants, 29 networks were revealed, including language, default mode, frontal executive, attentional, higher visual and visual functional networks. We used univariate tests corrected for multiple comparisons over all networks to test the difference between people with and without aphasia in the intensity of resting-state spatial maps, related to the connectivity and degree of co-activation within a network (Allen et al., 2011). The effect of group was only found significant in two language networks: the left frontal network (LFN), which mostly involved the lateral portion of the left frontal lobe from the inferior gyrus to primary motor cortex, and the bilateral temporal network (BTN), encompassing superior and middle temporal gyri bilaterally. To establish the direction of the group effect, using SPM8 we compared the intensity of activation between people with aphasia and healthy individuals in binary masks of the LFN and the two (left and right) components of the BTN. The LFN and the left part of the BTN displayed stronger intensity of spontaneous activity in healthy individuals than in people with aphasia, while the right part of the BTN was more strongly activated in people with aphasia. To conclude, a clear asymmetry has been found between healthy individuals and brain-damaged people with aphasia, regarding language networks. The left-lateralized frontal and temporal components of these networks were more strongly activated in healthy people, in contrast to the right temporal component, which was more strongly recruited in people with aphasia. More intense engagement of the right hemisphere language-related homologues under the condition of a left-hemisphere damage might underlie this asymmetry (Saur, 2006).

Meaning: Combinatorial Semantics

D46 A common, fine-grained code for object meaning in a subregion of the anterior temporal cortex

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Many studies have examined object knowledge by studying the neural representation of object categories (e.g., tools versus animals), which often broadly differ on coarse features, such as shape, size, and texture. However, little is known about the neural mechanisms for encoding the fine-grained semantic attributes of specific objects within a semantic category. For example, how do we know that a red apple is conceptually more similar to a green apple than to a blue apple? Here, we address this question by using a novel stimulus set that allowed us to leverage the natural statistics of object color information to investigate a neural code for object meaning. In an fMRI experiment, 16 subjects viewed images of objects that were systematically manipulated in color while performing an unrelated object detection task. The stimuli included three categories of specific objects (apples, leaves, and roses). The objects were each presented in five different colors (red, pink, blue, green, and yellow). For each object set, we created a semantic-similarity model based on the co-occurrence frequencies of color-object combinations (e.g., "yellow apple" from a large lexical corpus). This model predicts that "red apple" and "green apple" would have more similar neural representations than "red apple" and "pink apple" in brain regions that code high-level combinatorial information about object concepts. The semantic-similarity models were unique for each object category used in the experiment, and were orthogonal to perceptual models for shape or color similarity alone. Using representational similarity analysis of the multi-voxel patterns, we found that perirhinal cortex was the only region that significantly correlated with the semantic-similarity model ($p<0.01$, corrected), while earlier ventral visual regions correlated with the color similarity model and shape similarity model (V4 and LOC, respectively, $p<0.01$). Next, we proposed that a key function of these semantic codes is to provide a common understanding of object meaning across individuals. For example, my stored knowledge of the familiar object "red apple" should be similar to yours if we are to communicate and coordinate our behaviors. This predicts a specific functional architecture: neural codes in this high-level semantic region should be structured to provide a common ground between observers of the visual world. To test for this proposed organization, we hyper-aligned each subject's data to a common, high-dimensional space (Haxby et al., 2011). We hypothesized that within perirhinal cortex, inter-subject similarity would track the semantic typicality of the objects. Indeed, we found that perirhinal cortex was unique in containing population codes for which inter-subject similarity correlated with object typicality ($p<0.01$, corrected). For example, a typical object like "red apple" has a more similar neural instantiation across individuals than a less typical object like "blue apple." Our results suggest that perirhinal cortex encodes combinatorial information that underlies real-world knowledge of objects and may instantiate a neural "common ground" for object meaning across individuals.

D47 That was not what I expected: specifying the role of the left inferior frontal gyrus in processing unexpected words

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Several ERP studies have reported a greater N400 amplitude to unexpected words relative to expected ones during sentence processing (e.g., Kutas & Hillyard, 1980). Recent research combining ERP and fMRI methodology has associated this N400 effect to increased activation in the anterior left inferior frontal gyrus (aLIFG). Some authors have interpreted these findings as reflecting higher integration demands for the unexpected word, as they have less intrasentential contextual support (e.g., Zhu et al., 2012). Conversely, some ERP studies have found, in addition to the N400, a late positive component to unexpected words, when in highly constraining contexts (Federmeier et al., 2007). This component may be related to a mismatch between a pre-activated expected word and the actual target. Therefore it may be that suppression of the pre-activated word is necessary in order to select the unexpected one, which may engage the aLIFG. So far, it is still unclear if the activation of this region reflects integration or suppression and selection processes. Our fMRI study aims to specify the role of the aLIFG in processing unexpected words, by disentangling these two alternative accounts. Nineteen healthy

participants read sentences in Portuguese with expected or unexpected words in either a high or low constraint context. If aLIFG activation reflects integration demands, then the expectancy effect in this region should be similar for high and low constraint contexts, as all sentences with unexpected words require increased integration demands. Alternatively, if the aLIFG is related to suppression and selection processes, then expectancy effects in this region should be greater for high than low constraint conditions, as the former will create a stronger prediction and therefore require greater suppression and selection demands. Results showed an effect of expectancy, with greater LIFG activation for sentences with unexpected words (contrast unexpected > expected; all results thresholded at $p< .001$ uncorrected at voxel and $p<0.5$ FWE correction at cluster level). Moreover, this effect was observed for high constraint sentences, with significant clusters in left and right IFG (contrast high constraint unexpected > high constraint expected), whereas no effect was found for low constraint sentences (contrast low constraint unexpected > low constraint expected). Furthermore, an ROI analysis of the aLIFG showed a significant interaction between expectancy and context constraint. Greater activation for sentences with unexpected words relative to expected words was significant only in high constraint contexts with no differences found for low constraint ones. These findings support the view that the aLIFG is associated with suppression and selection, which occur when there is a mismatch between the predicted and the presented word.

D48 The Priming of Basic Combinatory Responses in MEG

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Introduction. While behavioral research has demonstrated that lexical access can be primed, the types of computations that can be primed above the word level are still not well understood. Our work addressed whether the most basic forms of phrasal composition, as exemplified by the combination of adjectives and nouns (red boat), can be primed. Methods. In two experiments, magnetoencephalography (MEG) was recorded during a picture-naming task where prime trials were designed to replicate previously reported combinatory effects (Bemis & Pylkkänen, 2011) and target trials to test whether those effects could be primed. On prime trials subjects named either colored objects as adjective-noun combinations, or outlines of objects with single nouns. On target trials participants always named colored objects using adjective-noun combinations. The prime-target overlap varied such that they shared i) the structure but no words (Structural: red boat – blue bell), ii) the structure and all words (FullOverlap: blue bell – blue bell) or iii) the noun but no structure (Lexical: bell – blue bell). Two control tasks not involving prime naming tested whether any obtained priming effects could be attributable to shared visual or conceptual analysis of the pictures. Results. In the primes, adjective-noun productions elicited increased activity as compared to single nouns in the left anterior temporal lobe (LATL) and ventromedial prefrontal cortex (vmPFC), replicating prior MEG studies. Priming of similarly timed activity was observed during target trials in the LATL, but only when the prime and target were lexically identical (FullOverlap) and only when participants named the prime. The second experiment tested whether this priming effect may reflect full overlap between prime and target, independent of composition. Under this hypothesis, the same priming effect should obtain for single concept repetition (bell - bell). Alternatively, if the effect reflected repetition of the same composed concept, it should obtain for blue bell – blue bell but not for bell – bell. To address this question, we created a design where lexical overlap (Same vs. Different) was crossed with Composition (Combinatory vs. Non-combinatory), yielding four prime target pairs of repeated vs. non-repeated phrases or single words (bell - bell, lamp - bell, blue bell - blue bell, green lamp - blue bell). Should the early priming effect be limited to combinatory productions, we additionally assessed how much lexical overlap was required for its elicitation. To address this, we included combinatorial pairs with only a shared noun (red bell - blue bell) and only a shared adjective (blue lamp - blue bell). Results showed no LATL priming for single word repetition and within the combinatory conditions, priming was observed whenever the initial adjective of the phrase was shared. Conclusion. This work revealed that basic combinatory responses in MEG can indeed be primed, though some lexical overlap between prime and target is necessary, suggesting combinatory conceptual, as opposed to syntactic processing. Both our combinatory and priming effects were early, onsetting between 100 and 150ms after picture onset and thus are likely to reflect the very earliest planning stages of a combinatory message.

D49 An ERP study of the relationship between verb semantics and events

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Languages differ in how events are described, but little is known about how semantics interacts with online event processing. This study targets this question examining placement events in Swedish. Swedish has three obligatory placement verbs for events where objects have support from below: sätta 'set', ställa 'stand', and lägga 'lay'. Swedish lacks a superordinate general term like English put (Gullberg & Burenhult, 2011). For every placement event the verb choice depends on object properties, and the direction of the object's extension from the ground. We use event-related potentials (ERPs) and appropriateness ratings of verb usage to investigate the interaction between verb semantics and event properties. Typically violations of semantic congruency positively affect the amplitude of the N400 (Kutas & Hillyard, 1980). Studies also report a centro-parietal positivity (P600) when real-world knowledge is violated and verbs are incongruous to preceding contexts (Kuperberg, 2007, for a review). Previous ERP studies of visually presented images or movies of actions and events have reported an N400 followed by a P600 when the function of an object is violated (e.g., using a screwdriver as a key, Bach, et al., 2009; Balconi & Caldiroli, 2011). Method: Native speakers (N = 24, 18-35 years) watched still images of placement events followed by sentences visually presented word by word. Sentences described the depicted events while ERPs were recorded and time-locked to the placement verbs. Participants also did an appropriateness rating offline. Object properties (Base/Without base), symmetry (Sym/Asym), and orientation from the ground (Vertical/Horizontal) were varied

and sentences with the three different placement verbs were combined with each image in a cross-subject design. Results: Base was important for appropriateness ratings of verb usage with symmetric objects while orientation was important for asymmetric objects. In contrast, there were no ERP effects to base (Base/Without) for symmetric objects. Asymmetric-base objects showed increased N400s and P600s with verbs incongruent with the depicted events (orientation, e.g., 'lay' with vertical glass). Asymmetric-Without base elicited an increased P600 when verbs were incongruent to depicted events when horizontally oriented (e.g., 'set' with horizontal avocado), but an increased N400 when verbs were incongruent to the atypical vertical placement of the objects (e.g., 'lay' with a vertical avocado). Discussion: Results showed an increased amplitude of both ERP effects (N400/P600) when placement verbs were incongruent with typical placement scenarios of objects that in the real-world are placed vertically or horizontally (Asymmetric-Base, e.g., a candle; cf. Bach et al., 2009). However, for objects without a base the anterior negativity was increased with a mismatch between the verb and the presented images (the depicted events), while the P600 increased for mismatches between the verb and typical real-world events. These results suggest the anterior N400 and the P600 indeed index different relationships with event processing as previously suggested for images (Sitnikova, et al., 2008). Our results agree with previous studies suggesting that the processing of verb meaning in language cannot be separated from knowledge of object handling in the real world (cf., Van Berkum, et al., 2008).

Meaning: Discourse and Pragmatics

D50 Online modelling of social perspectives in joint interaction: Event-related potential evidence

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Recent developments in Theory of Mind research have suggested that mentalizing in social situations relies on a dual-system approach. In this, a fast, automatic implicit system is supported later by a slower, effortful explicit mentalizing system. To date, demonstrations of this distinction have been confined to action and visual perspective-taking domains, with little corroboration in language research, and little understanding of the underlying brain mechanisms through which an implicit mentalizing might be achieved. The current study uses an extension of the Joint Comprehension paradigm (Rueschemeyer et al., 2015) to demonstrate early perspective-taking effects using a within-subjects language task, utilizing the event-related potential N400 response to study the effect of violation of expectancy at millisecond accuracy. Participants read the beginning of a story alone, and then read the final sentence of this story with a confederate who had no access to the prior context. This final sentence was either plausible in isolation (therefore plausible to both participant and confederate), or relied on the prior context for plausibility (therefore only plausible to the participant but not to the confederate). The results show that participants with full context show attenuation of the N400, indicating that context affects the interpretation of implausible sentences. However, when co-reading with their context-naive partner, the same participants then parse mutually-read sentences as if they were their context-naïve conversation partner, demonstrating a 'Social N400'. This paradigm is unique in demonstrating both that participants can comprehend a sentence for themselves, and that they model the comprehension of others online. The paradigm offers insights for how implicit mentalizing may be achieved, and provides a method by which implicit mentalizing may be studied in participants with specific impairments (such as those with Autism Spectrum Disorder).

D51 Neural correlates of social appropriateness in dynamic conversation

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For decades, researchers have studied the neurobiological foundations of language using event-related potentials (ERPs). However, most of the experiments were conducted using written material and isolated sentences, neglecting the multimodal, interactive, and social nature of language comprehension. Nonliteral language, such as sarcasm or jocularity, represent a unique challenge for the language comprehension system and involves the integration of a number of cognitive, pragmatic, affective and social processes. Additionally, people do not always act appropriately and might react bluntly or rudely when asked a question. In the current ERP study, we investigated the brain correlates as well as the timing of processing social appropriateness in response to auditory and audio-visual versions of dynamic stimuli. Twenty-four healthy adults listened to and watched interactions of two actors that ended either in a literal positive, jocular, bluntly negative or sarcastic comment. In the first half of the experiment, subjects listened to audio excerpts of the stimuli, whereas in the second half they watched the videos. While participants were rating both types of vignettes on social appropriateness, we recorded their brain responses using a 64-channel EEG system. The behavioural results show that, while the perceived appropriateness of literal utterances (sincere positive and bluntly negative) was not dependent on processing the audio or audio-visual versions of the stimuli, nonliteral utterances (jocularity and sarcasm) showed a different pattern. In particular, sarcastic comments were perceived as less appropriate processing audio-visual compared to auditory exchanges, whereas jocular comments were rated as more appropriate in the audio-visual version. The ERP results reveal an early positivity, overlapping N3/P3 components as well as an N400 effect in response to inappropriate versus appropriate utterances in the video version. In the auditory version, however, we only find effects of appropriateness in later time windows (P3/N400). Taken together, our results show that the visibility and emotional reaction of the person receiving a sarcastic or jocular comment in the videos influences the participants' appropriateness judgment. Additionally, they reveal that the brain responds to social appropriateness at early and late stages of online speech comprehension, possibly reflecting integration difficulties of impolite, blunt remarks. These ERP effects are strongly modulated by the availability of audio or audio-visual information, as well as the observation of social interaction. Further data analyses will explore how differences in empathy, social anxiety, and pragmatic skills will influence the current results.

D52 Finding your way in the zoo: how situation model alignment affects interpersonal neural coupling

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INTRODUCTION: We investigated how speaker-listener alignment at the level of the situation model is reflected in inter-subject correlations in temporal and spatial patterns of brain activity, also known as between-brain neural coupling (Stephens et al., 2010). We manipulated the complexity of the situation models that needed to be communicated (simple vs complex situation model) to investigate whether this affects neural coupling between speaker and listener. Furthermore, we investigated whether the degree to which alignment was successful was positively related to the degree of between-brain coupling. METHOD: We measured neural coupling (using fMRI) between speakers describing abstract zoo maps, and listeners interpreting those descriptions. Each speaker described both a 'simple' map, a 6x6 grid including five animal locations, and a 'complex' map, an 8x8 grid including 7 animal locations, from memory, and with the order of map description randomized across speakers. Audio-recordings of the speakers' utterances were then replayed to the listeners, who had to reconstruct the zoo maps on the basis of their speakers' descriptions. On the group level, we used a GLM approach to model between-brain neural coupling as a function of condition (simple vs complex map). Communicative success, i.e. map reproduction accuracy, was added as a covariate. RESULTS: Whole brain analyses revealed a positive relationship between communicative success and the strength of speaker-listener neural coupling in the left inferior parietal cortex. That is, the more successful listeners were in reconstructing the map based on what their partner described, the stronger the correlation between that speaker and listener's BOLD signals in that area. Furthermore, within the left inferior parietal cortex, pairs in the complex situation model condition showed stronger between-brain neural coupling than pairs in the simple situation model condition. DISCUSSION: This is the first two-brain study to explore the effects of complexity of the communicated situation model and the degree of communicative success on (language driven) between-brain neural coupling. Interestingly, our effects were located in the inferior parietal cortex, previously associated with visuospatial imagery. This process likely plays a role in our task in which the communicated situation models had a strong visuospatial component. Given that there was more coupling the more situation models were successfully aligned (i.e. map reproduction accuracy), it was surprising that we found stronger coupling in the complex than the simple situation model condition. We plan in ROI analyses in primary auditory, core language, and discourse processing regions. The present findings open the way for exploring the interaction between situation models and linguistic computations during communication.

Perception: Orthographic and Other Visual Processes

D53 The time course of lexical access for handwritten words: An ERP investigation

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Behavioural studies have shown that the legibility of the script affects the reaction times and accuracy of recognition of handwritten words. When compared with typewritten (henceforth printed) words, lexical effects such as the word-frequency effect are magnified for less intelligible (difficult) handwriting (Barnhart & Goldinger, 2010, JEP:HPP; Perea, Gil-López, Beléndez, & Carreiras, 2016, QJEP). This effect has been proposed to reflect the influence of top-down mechanisms during visual-word recognition. In the present experiment, we aimed to track the stages at which top-down processing meets early perceptual encoding. Therefore, we examined the event related potentials (ERPs) elicited by printed words and two types of handwritten words differing in legibility (easy vs. difficult to read). We conducted a lexical decision experiment in which the participants' behavioural and EEG responses were recorded to high- and low-frequency words that varied in legibility of the script (printed, easy-to-read handwritten, difficult-to-read handwritten). Behavioural results replicated previous findings, showing main effects of Word-frequency (RT: High < Low) and Script (RT: Difficult > Easy > Printed) as well as an interaction between the two factors: word-frequency effects were larger in the difficult than in both the easy handwritten and printed conditions. The ERP data showed a main effect of Script in the early (perceptual) stages of processing: larger negative amplitudes were found for the difficult handwritten than for the printed condition before 350 ms. In later time windows both handwritten conditions elicited larger negativities than the printed condition. Interestingly, the onset of the word-frequency effect varied across the different script conditions: word-frequency effects arose earlier for the printed condition (350-450 ms) than for the handwritten conditions (450 to 650 ms time window). Additionally, the maximum word-frequency effect in the difficult handwritten condition (peaking at around 540 ms) lagged the maximum frequency effect in both printed and easy handwritten conditions (both peaking at around 500 ms). These results suggest that lexical processing meets perceptual encoding earlier for printed words compared to handwritten words, a process that this is further delayed for the difficult handwritten words. Therefore, the legibility of the input code modulates the timing of top-down effects during visual word recognition.

D54 Early ERP effects of orthographic and phonological lexicality in native, Spanish-English, and Chinese-English readers of English

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Such compelling yet controversial claims of pre-100ms phonology (Wheat et al., 2010) and questions of the lexical nature of the N170 (Hauk et al., 2006) show that specific timing information and the serial/parallel nature of orthographic and phonological processing are still unclear. Details of such

early, pre-200ms activity are also vital to understanding language processing differences between native and non-native readers, as well as between non-native readers with different language types (e.g., alphabetic vs. logographic). Ultimately, investigating these early processes can provide important insight into how second languages are read (Brysbaert & Dijkstra, 2006). In the current study, behavioural and EEG/ERP (electroencephalogram, event related potential) responses were recorded from native monolingual English and late bilingual Spanish-English (non-native, alphabetic L1) and Chinese-English (non-native, non-alphabetic L1) readers while completing orthographic and phonological lexical decision tasks (oLDT and pLDT, respectively). Adapted from Twomey et al. (2011), the oLDT required judgement between real English words (RW) and pseudohomophones (PH1) to focus on orthography, while the pLDT used pseudohomophones (PH2) and pseudowords (PW) to provide information about phonological processing (van der Mark et al., 2009). Together, these tasks represent forms of orthographic and phonological processing through different perspectives of the pseudohomophone effect and lexicality, allowing observation of relative timing and top-down processing. The same pattern for behavioural response times (RW < PH1 < PH2 < PW) was found in all three groups. However, only the native English group exhibited a speed-accuracy trade-off between PH2 and PW. The Chinese-English group made most errors for non-RW conditions with the Spanish-English group making slightly fewer, but still more than the native English, showing clear stimulus, task, and group differences. ERP analysis, meanwhile, indicated differences at ~100ms (P1/N1) and ~170ms (N170) within and between groups in both tasks, suggesting initial orthographic processing to be stimulus-driven and dependent on native language. In particular, differences in ERP latency and between tasks were only found within non-native groups at these early timeframes with only amplitude effects in the native group at left hemisphere sites for the oLDT and right hemisphere sites for the pLDT. Lateralisation of frontal-central pLDT activity at ~100ms was found to differ between Spanish-English and native groups, while lateralisation of both orthographic and phonological activity at occipitoparietal and occipitotemporal sites differed between Chinese-English and native groups at both ~100ms and ~170ms timeframes. Furthermore, occipitoparietal and occipitotemporal activity was lesser in Spanish-English and later in Chinese-English compared with native readers. This combination of results proposes that different cognitive approaches to processing orthography and phonology are used between native, non-native alphabetic, and non-native non-alphabetic readers of English. These findings will be discussed in terms of current visual word recognition theories with an aim to integrate evidence of native and non-native processing.

D55 There is no „pure" orthographic brain area in the visual system of the blind

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Introduction: Following blindness, several high-level visual regions preserve their task specificity despite being recruited for different sensory input. For example, the blind's ventral visual stream responds to tactile and auditory object recognition, auditory perception of body shapes, and tactile reading (Reich, Szwed, Cohen, & Amedi, 2011). Indeed, tactile Braille reading in the congenitally blind activates the same brain area as in sighted readers: the Visual Word Form Area (VWFA) in the left ventral Occipito-Temporal cortex (vOT). Here we sought to determine whether responses in the vOT are deeply similar to the responses of the VWFA in the sighted, or alternatively whether the similarity of the vOT responses to the VWFA in the sighted is superficial, and the vOT in the blind is not a reading area but a multimodal language area. Method: A key feature of the reading area in the sighted is the sensitivity to orthography: VWFA responses are stronger to frequent letter strings ("shynb") and weaker to infrequent letter strings ("gcyzm"; Binder et al., 2006; Vinckier et al., 2007). Here we tested 15 right-handed congenitally blind adults (age: 19-34) using functional magnetic resonance imaging (fMRI) while they read 5-letter strings of varying approximation to Polish orthography (5 conditions of increasing similarity) displayed on a custom-made fMRI-compatible Braille display. Since another hallmark of the VWFA in the sighted is weak activation for spoken auditory stimuli, additional control conditions included the same letter stings (frequent vs. infrequent) presented in the auditory modality. In case of Braille stimuli, the subjects' task was to detect stimuli containing two-dot Braille letters. In case of spoken stimuli, the subjects' task was to detect stimuli spoken by a female voice. Results: The ventral visual system robustly differentiated Braille letter strings from nonsense Braille, which replicates our previous findings (Reich, Szwed, Cohen, & Amedi, 2011). However, we failed to find a ventral visual region which would show the same profile as the one found earlier in the sighted. Instead, responses in the ventral Occipito-Temporal cortex were v-shaped, with high for low frequencies ("lxlvę"), lowest for the medium frequencies ("arsmm"), and highest for high frequencies ("wstam"). The largest differences between infrequent and frequent strings were found in the anterior ventro-temporal region adjacent to the vOT [peak: x=-45.8, y=-43, z=-15] and the superior temporal gyrus/sulcus [x=-52.7, y=-43, z=2.5]. Crucially, and contrary to the Visual Word Form Area in the sighted, all three above-mentioned regions showed robust responses to auditory stimuli (infrequent letter strings ("lxlvę") vs. frequent letter strings ("wstam"), spoken). Conclusion: Preliminary analysis of our data indicates that there is no straightforward analog of the Visual Word Form Area in the blind, and that orthographic processing in the blind significantly differs from orthographic processing in the sighted. Instead, the blinds' orthographic processing region seems to overlap significantly with general language processing.

D56 The anatomy of the posterior segment of the arcuate fasciculus correlates with reading and vocabulary comprehension performance

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The inferior parietal lobule (Geschwind's territory) is a multimodal integration hub directly linked to Wernicke's and Broca's territories via the arcuate fasciculus (AF) (Catani et al., 2005). Recent studies suggest that connections between Geschwind's and Wernicke's territory, mediated by the posterior segment of the AF, are specifically important for reading (Thiebaut deSchotten et al., 2012). However, it is not clear whether the role of the posterior segment is linked only to orthographic-to-phonological coding or whether it also involves semantic aspects of reading. In this study, we performed tractography in-vivo dissections of the posterior segment of the AF in healthy subjects and explored the correlation between its anatomical variability and performances in reading and vocabulary comprehension tasks. Thirty-eight right-handed healthy participants, 20 females, aged 23-35 from the Human Connectome Project* (Van Essen, 2013) were scanned on a 3T Siemens MRI scanner (voxel size 1.25mm3, 210x210 matrix, 111 slices, b-value 2000s/mm2, 90 diffusion-weighted volumes, 18 non-diffusion-weighted volumes. Diffusion data was collected using a HARDI sequence and pre-processed for spherical deconvolution tractography (Dell'Acqua et al., 2013, www.natbrainlab.com). Virtual dissections were manually performed on TrackVis using anatomically-defined regions of interest. The long segment (from Broca's to Wernicke's territories) of AF, considered to be a multifunctional language pathway involved in production of meaningful language and speech, was chosen as a control tract. Behavioural tasks were obtained from NIH-Toolbox 1.0 (www.nihtoolbox.com). Oral Reading task: participants were asked to read and pronounce words as accurately as possible. Higher scores indicated more accurate and faster pronunciation of increasingly difficult words. Picture vocabulary comprehension: Participants were presented with audio-recording of a word and four photographic images on a computer screen and asked to select the picture that most closely matched the meaning of the word. Higher scores reflected wider vocabulary knowledge and faster comprehension. Correlation analyses were used to investigate the relationship between tract properties of the posterior segment and language skills. Results showed that scores of reading performance correlated significantly with volume in the left hemisphere posterior segment ($r=0.6$; $p=0.02$). Similarly, scores of vocabulary comprehension correlated with volume in left hemisphere posterior segment ($r=0.5$, $p=0.04$). There was no association between oral reading and the long segment of AF ($r=0.2$, $p=0.2$), nor between vocabulary comprehension and the long segment ($r=0.2$, $p=0.2$). No correlation with the posterior segment of the AF in the right hemisphere. Performances in oral reading and vocabulary comprehension tasks were associated with increased volume of the left posterior segment of AF. By mediating connections between the visual word form area (temporal-occipital region) and inferior parietal areas, the posterior segment is likely involved in encoding an orthographic-to-phonological route as well as visual representations of words (Braet et al , 2012; Ben-Schachar et al., 2007). Moreover, the posterior segment might also be involved in enforcing a semantic route that is dependent on auditory and temporal connections related to word comprehension (Carreiras et al., 2009). As the inferior parietal region is amongst the latest areas to mature, this might explain why general semantic knowledge progressively increases throughout life.

Phonology and Phonological Working Memory

D57 MMN investigation of voicing features in Russian

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Phonologists have used the mismatch negativity (MMN) component of the event-related potential to investigate the organization of speech sounds in phonological space. It has been observed (Eulitz & Lahiri, 2004, among others) that the MMN may reflect whether the long-term mental representation of a speech sound is underspecified (i.e. highly abstract) or fully specified (i.e. more detailed). In particular, a larger MMN is elicited in an oddball paradigm when the standard (the more frequently presented sound) has a fully specified—rather than an underspecified—representation. Using this observation, we tested the laryngeal realist hypothesis (Iverson and Salmons 1995, Honeybone 2005, Beckman et al 2011, et sqq.) that the laryngeal features are language-specific (perhaps drawn from a universal set) and aligned with the language's phonetic properties. Russian is argued to be a language in which the contrast between /t/ and /d/ is based on a [Voice] feature (Petrova, et al. 2006) rather than [Spread Glottis] as in English. Thus, in the two-category contrast of Russian /t/ and /d/, /d/ is marked for [Voice] and /t/ is unmarked whereas for English /t/ is marked for [Spread Glottis]. Assuming this, we expect to find opposite MMN patterns in Russian and English: whereas English shows greater MMNs for unmarked [d] deviants in the context of marked /t/ standards than for marked [t] deviants in the context of unmarked /d/ standards (e.g., Hestvik & Durvasula 2016), Russian should show the opposite MMN pattern as the marking is flipped. In three concurrent experiments, we tested the MMN response to voiced and voiceless sounds in Russian using an oddball paradigm using 1) stops ([te] vs [de]), 2) coronal fricatives ([s] vs [z]) and 3) fricatives from three places of articulation ([f], [s], and [ʂ] vs [v], [z], and [ʐ]). The stops are comparable to Hestvik & Durvasula (2016), and the fricatives to Hestvik & Durvasula (2015) and Schluter, Politzer-Ahles, and Almeida (2015). We tested different manners of articulation in order to investigate whether stops and fricatives may have different featural specifications within Russian, since the voiced/voiceless contrast is realized via different acoustic cues in stops and fricatives. Preliminary results from 7 native Russian-speaking participants suggest a trend towards the same asymmetric effect in each of the three experiments both in terms of amplitude and latency: the voiced deviant embedded in voiceless standards appears to elicit a stronger response than the voiceless deviant

in voiced standards. Overall, Russian seems to show the same MMN pattern as English for voiced and voiceless contrasts. Assuming the MMN taps into phonological representations, the results may be incompatible with the laryngeal realist hypothesis that Russian uses [Voice] as the marked and fully specified feature whereas English uses [Spread Glottis]. Alternatively, the results could suggest that this paradigm tapped not into phonological representations but to cross-linguistic acoustic/phonetic perceptual biases (see, however, Hestvik & Durvasula, 2016, and Politzer-Ahles et al., 2016, for evidence that this paradigm does indeed tap into phonological representations).

D58 The involvement of the pedunculopontine nucleus (PPN) in phonological auditory processing: A case report

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Introduction: The pedunculopontine nucleus (PPN) has been implicated in the modulation of arousal, sleep-wake states, posture and locomotion, and in the modulation of sensory input (Garcia-Rill, 1991; Reese et al., 1995). Nevertheless, there is a substantial body of neurophysiological research demonstrating that different subcortical nuclei, including the thalamus and subthalamic nucleus, are also involved in language processing. To date, the PPN involvement within a cortico-subcortical language network is not yet known. In this case report, direct neurophysiological language registration was performed within the PPN. Methods: A 51-year-old man with a clinical diagnosis of idiopathic Parkinson's disease was included in this case report. Local field potentials were recorded one week after deep brain stimulation of the PPN by means of both a pre-attentive and attentive auditory phonological oddball task. Results: Auditory evoked potentials related to early auditory processing could be demonstrated in the PPN for both tasks. Results related to phonological processing could not be found in this study. Conclusion: These preliminary results support the involvement of the PPN in early auditory language processing.

Signed Language and Gesture

D59 Neural integration of speech and naturally produced, meaningful gestures

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To enable the many functions of co-speech gesture (e.g., directing attention, prosodic cueing, conveying semantic information), manual gestures must be integrated with auditory speech at both the sensory and semantic levels. Previous studies have employed scripted gestures (often with artificial blurring/obscuring of the face), which may impact brain responses involved in multimodal integration. In this fMRI study, participants (N = 28) viewed audiovisual recordings of spontaneous speech produced with natural (ecologically valid), meaningful co-speech gesture. Half of the participants were native users of American Sign Language (bimodal bilinguals) and half were monolingual native English speakers. We hypothesized that bimodal bilinguals might show differential sensitivity to representational co-speech gestures in regions associated with biological motion perception (e.g. posterior STG) and action understanding (prefrontal and parietal cortices), key nodes in the network for comprehension of visual-manual languages. The stimuli were derived from the original recording of extemporaneous speech used by Hubbard, Wilson, Callan, and Dapretto (2009). We selected only segments that contained representational (meaningful) co-speech gestures (as rated by a separate group of subjects) and presented them under four conditions: speech (audio only) with a motionless speaker; co-speech gestures without audio; co-speech gestures with concurrent speech; and still frames of the speaker at rest, without audio (still baseline). Participants passively viewed the segments, answering one true/false question at the completion of each run and completing a 20-question true/false quiz immediately following the scanning session. Accuracy was high, indicating participants attended to the stimuli. Perception of speech with gesture (relative to perception of speech alone and gesture alone) elicited heightened activation in bilateral posterior superior temporal and premotor cortices, and in the inferior frontal gyri. In addition, within these superior temporal and premotor regions, but not within the inferior frontal regions, we identified circumscribed clusters of superadditive activation. We hypothesize that these differing response profiles suggest that posterior temporal and premotor cortices support integration across both sensory and semantic domains, whereas the inferior frontal gyri support integration in only one of these domains (i.e., semantic or sensory). Relative to gesture alone, speech with gesture elicited decreased activity in middle temporal and parietal regions. Decreased activity here may reflect reduced reliance on regions associated with action understanding when speech aids comprehension of gestures that are difficult to interpret in isolation. Several language-related regions also showed reduced activation for comprehension of speech with gesture relative to speech alone, indicating allocation of fewer neural resources when meaningful gestures accompany speech. Contrary to our predictions, sign language experience did not affect co-speech gesture activation, suggesting development of relatively segregated systems for gesture and sign. In general, we have shown that results with ecologically valid stimuli are consistent with those from studies that used scripted co-speech gesture to investigate gesture-speech integration, although none have reported the superadditive integration effects observed here. Overall, the findings indicate that integration of meaningful co-speech gestures relies on a distributed neural network, with discrete regions involved in sensory and semantic multimodal integration.

D60 The neural basis of the integration of speech and gesture: A brain stimulation approach

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Previous neuro imaging studies have reported activity of the left superior temporal gyrus (pMTG) and the left Inferior frontal gyrus (LIFG) during co-speech gesture comprehension. It is currently unclear, however, which of these brain areas plays a causal role in gesture-speech integration. The current study builds on the paradigm of Kelly et al., (2010) which provides a reaction time index of gesture-speech integration. Briefly, participants were presented with co-speech gestures (e.g., pantomiming typing while saying 'write'), with gender and semantic congruency of audio-visual stimuli being manipulated. Based on a naming study, gestures were split

into pantomimes (that can be easily understand without the involvement of speech) and iconics (that need speech to be disambiguated). At the beginning of each experimental session, theta-burst TMS was either applied to the left IFG, the left pMTG or a control area. The participants' task was to respond to the gender of the speaker as quickly and accurately as possible. Results show that LIFG is more involved in the integration of speech and pantomime, while pMTG/STS is crucial for the integration of speech and iconics. This suggests that LIFG has a role of unifying meaning from different modalities when both gesture and speech have clearly defined meanings in isolation, where pMTG is crucial for integrating meaning from different modalities when the input of at least modality is ambiguous.

Speech Motor Control and Sensorimotor Integration

D61 Exploring the interaction between the rhythms of motor and auditory cortices

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The classical approach to study the sensorimotor integration of speech is through exploring the inhibitory/excitatory effect that motor and auditory cortices exert on each other. Herein a shift in this paradigm is proposed: to characterize the interaction of these brain regions by examining the relationship between their rhythms. More specifically, an MEG protocol was developed to investigate the coupling between the phases of the slow oscillations (2-7 Hz) in motor and auditory cortices. The experiment consisted in two main blocks. In the first one, a functional source localization protocol was employed to uncover each subject's speech-motor and auditory cortical regions. In the second, subjects were instructed to passively listening to a set of audio trials composed by strings of syllables synthesized at fixed rates. The MEG signals originating in the previously localized areas were extracted and evaluated for synchronization. The results showed that synchronization between motor and auditory brain activity increases as the heard syllable rate approaches to 4.5 Hz. The specific features of this coupling invite the hypothesis that the motor and auditory cortices behave as two weakly coupled phase oscillators; a coupling that could be crucial at the early stages of speech development. Moreover, the natural rhythm of motor cortex arises around 4.5 Hz. Curiously, the natural open-close jaw cycle occurs at about the same frequency and has been pointed out as comprising the opening and closing pattern of syllables. These results suggest that the rhythmic structure of speech could emerge as an interaction between the oscillatory brain activity and the anatomical features of the vocal tract.

D62 Acoustic and articulatory outcomes of speech training examined with real-time vocal tract MRI

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Introduction It is a well documented phenomenon that achieving native-like pronunciation in a second language becomes increasingly challenging in adulthood, with highly variable outcomes across listeners. Producing speech in a non-native language requires novel articulations to be accurately learned and deployed flexibly in a variety of word-level contexts. We have been using a speech training paradigm combined with real-time imaging of the vocal tract (rtMRI) to explore vocal imitation skill, and chart the articulatory outcomes of learning L2 speech, in single-phoneme and word-level contexts. Methods In two studies, native speakers of British English were trained to imitate a native unrounded front vowel (/i/ or /a/) and a non-native rounded front vowel (/y/ or /oe/) prior to scanning. Their performance on imitation of these vowels in isolation (Experiments 1 and 2) and within novel mono- and trisyllabic non-word contexts (Experiment 2) was then measured during a series of real-time MRI scans of the vocal tract. Vocal tract dynamics were measured using a real-time T1-weighted gradient echo sequence (100ms temporal resolution, or 10 fps). Here, participants imitated vowels presented in mini-blocks, where three real-time runs were collected within a larger scanning session that included fMRI (total acquisition time ~ 1 hour). In-scanner acoustic recordings of speech output were made using a MR-compatible microphone. Results and Discussion Behavioural results showed that acoustic imitations of non-native vowels were less accurate than for the corresponding native vowels, with considerable individual differences in imitation success. Vocal tract rtMRI data revealed measurable changes in lip aperture, and evidence of increased lip protrusion, following training in lip rounding. Moreover, we found that syllabic context effects modulated the extent of lip protrusion achieved by participants. Using lip protrusion indices from rtMRI tracking of lip position across vowels, we explored the extent to which success of lip rounding was related to the acoustic success of imitation, for vowels in isolation, and within word level contexts. These results will help to inform an account of L2 speech imitation as an articulatory skill, with respect to vocal tract and acoustic outcome measures.

D63 Functional brain outcomes of speech training: generalization from phones to words

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Introduction: Producing speech in a non-native language requires phonemes to be deployed flexibly in a variety of word-level contexts. However, the complexity of vocal behaviour, particularly in multisyllabic contexts, may hinder L2 learners' attempts to faithfully reproduce L2 phonemes within words. While much is known concerning the neural networks involved in producing multisyllabic speech, relatively few studies have investigated the neural outcomes of training with L2 speech when phones must be generalized to word level. Here, we used a speech training paradigm combined with fMRI to explore vocal imitation skill, and chart the neural outcomes of generalizing L2 speech from phoneme to word level. Methods: Native speakers of British English were trained to imitate a native unrounded front vowel (/i/) and a non-native rounded front vowel (/y/) prior to scanning. Their performance on imitation of these vowels in isolation and within novel mono- and trisyllabic non-word contexts was then measured during approximately 1 hour of in-scanner imitation. We measured

the BOLD response using a rapid-sparse, event-related fMRI protocol (TR: 3.2 s; TA: 1.7 s) in which participants were cued either to 1) listen to or 2) listen to and then imitate native and non-native vowels, and the corresponding mono- and trisyllabic words that contained these vowels (i.e., T[/i/]b; T[/i/]t[/i/]b[/i/]; T[/y/]b; T[/y/]t[/y/]b[/y/]). In-scanner acoustic recordings of speech output were made using a MR-compatible microphone. Results and Discussion: Behavioural results showed that acoustic imitations of the non-native vowel were less accurate than for the corresponding native vowel, with considerable individual differences in imitation success arising depending on word-level context. fMRI results showed significantly greater activation in somato-motor cortex, IFG and superior temporal cortex when participants listened in preparation to produce speech, versus either listening without preparation to repeat, or during production itself. Effects of generalising vowels to word level varied across individuals, and were associated with differential activation of lateral somato-motor, inferior frontal and cerebellar regions. By comparing data reflecting the acoustic fidelity of vowel imitations (in isolation and at word level) to neural activation during pre-imitation listening as well as later imitation, we could assess how imitation performance predicts neural activation within speech fronto-temporal networks across utterances of varying complexity. These results will help to inform an account of the neural regions that support L2 vocal learning and generalization of phonemes to novel syllabic units.

Control, Selection, and Executive Processes

D64 Development of the Frontal Aslant Tract (FAT) and its relation to executive function in typical children.

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The Frontal Aslant Tract (FAT) is a fiber pathway proposed to connect posterior inferior frontal gyrus (IFGOp and IFGTr) to the pre-supplementary motor area (pre-SMA) and supplementary motor area (SMA) (Catani et al., 2013). Because of its putative connectivity the tract may be important for developing executive function. The proposed study will explore the relation between age-related changes in the FAT across a broad age range, infancy through middle childhood, and relate the microanatomical properties of this tract to behavioral measures of executive function. Eighty-seven participants (51 females, 36 males; age range = 3 to 126 months, M age = 66.72 months, SD= 34.99) were scanned in an MRI scanner using diffusion-weighted imaging/high angular resolution imaging (DWI/HARDI). Executive function was assessed using the Emotional Control, Initiation, and Metacognition subtests of the Behavior Rating Inventory of Executive Function (BRIEF). Our preliminary results suggest significant age-related differences in both left FAT (r=0.35) and right FAT (r=0.37), specifically increasing generalized fractional anisotropy with age. Additionally, microstructural properties of the FAT in both hemispheres predicted executive function measures of the BRIEF (both initiation and inhibition sub-scores), even after controlling for a number of confounding factors (age, sex, and whole brain white matter microstructure). This provides initial support for the involvement of the FAT in supporting developing executive function from infancy through elementary school.

D65 Language-Related Functional Networks in the Ventromedial Prefrontal Cortex

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INTRODUCTION The ventromedial prefrontal cortex (vmPFC) is often implicated in language and semantic tasks. However, it is not known whether this vmPFC activation reflects language-specific or domain-general processing or whether there are multiple functional regions within this area. Additionally, activity may be identified inconsistently, perhaps due to signal loss and distortion near air-filled cavities using fMRI. In order to assess its role in language and semantic processing, we parcellated the vmPFC based on its intrinsic functional connectivity as evaluated by resting-state fMRI. METHODS Resting-state scans (where participants viewed a fixation cross for 6.25 minutes) were collected for 71 participants. Dual-echo fMRI was used to maintain signal in inferior frontal and temporal cortices without loss of signal elsewhere. These scans were pre-processed (including extensive motion correction) before the timeseries was extracted for each voxel in MNI space. Each participant's timeseries could then be concatenated for each voxel. Varimax rotated principal component analysis was performed on the resulting timepoint-by-voxel matrix. Components explaining more than five percent of the overall variance were retained. These components were projected on to the brain in order to identify functionally-distinct subregions of the vmPFC. In order to visualise the differential functional connectivity patterns driving this parcellation, these areas were used as seed ROIs in a functional connectivity analysis. The functional connectivity of each ROI was entered in to a repeated measures ANOVA to identify the unique connectivity corresponding with each vmPFC region. RESULTS The vmPFC was parcellated into four regions on the basis of identifying four components with distinct functional connectivity. These corresponded to the medial orbitofrontal cortex, the frontal pole, the medial surface and the ventral anterior cingulate cortex. Each region had unique connectivity corresponding to a known resting-state network; the medial orbitofrontal cortex to a visual semantic network, the frontal pole to the frontoparietal network responsible for executive control, the medial surface to the default mode network and the ventral anterior cingulate cortex to the salience network. CONCLUSIONS The functional connectivity of the vmPFC suggests there are four functional subregions within this area. These results are in accordance with prior assessments of the structural and functional connectivity of this complex region, yet provide further detail as to the involvement of multiple resting-state networks. The medial orbitofrontal cortex connects to semantic and visual regions, suggesting it may be particularly important in semantic processing when a visual element is required, as in reading. This may relate to top-down semantic processing of visual stimuli, including recognition of words and objects. Identification of vmPFC activity in other language tasks may be due to domain general processing. For instance, the DMN-related medial surface may show difficulty-related deactivation. The frontal pole was identified as part of

the frontoparietal control network, suggesting an involvement in domain-general executive processing which could be particularly important for complex language tasks. The use of fMRI techniques that maintain inferior frontal signal is critical for further investigations of the role of these vmPFC subregions in language and top-down semantic cognition.

D66 The role of task complexity in mediating relations of whole brain modularity to task performance

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Recent work in functional neuroimaging has been directed towards understanding the interactions between brain regions involved in networks supporting task performance. Graph-theoretic approaches have been applied to obtain measures of network organization. The measure focused on here is modularity (M; Newman, 2006) - which is the strength of connections of brain regions within a module relative to those between modules. Using this algorithm, brain regions are sorted into modules such that the difference between within-module and between-module connections are maximized. Prior work has shown significant correlations between individuals' degree of modularity and behavioral task performance (e.g., working memory), though the direction of these relations has varied across studies. The present study addressed a proposal derived from work in theoretical biology (Chen & Deem, 2015) which predicts that highly modular networks are preferred for the performance of simple tasks at short time scales whereas networks with lower modularity (and higher between-network connections) are preferred for the performance of complex tasks at longer time scales. The present work addressed this proposal, deriving modularity from functional correlations among regions during resting state fMRI and relating these modularity values to behavioral performance on tasks varying in complexity. We used an attention network test (ANT; Fan, 2002) to tap the simple cognitive processes involved in alerting and orienting, and to tap more complex processes involved in attentional inhibition (i.e., conflict resolution in a variant of the flanker task). We also used the operation span task (Unsworth, 2005) as a complex task which measures participants' working memory capacities. In this task, participants alternate between processing a math problem and encoding a letter and, at the end of 6 or 7 such math problem – letter pairs, they recall the letters in order. For the brain network analysis, we constructed the whole brain network of modules based on the correlation in resting-state activation across 84 Brodmann areas. The modularity value was calculated separately for each individual based on their correlation matrix, and then these values were related to the behavioral measures. In line with predictions, a positive correlation was observed between modularity and performance on the simple orienting task and a negative correlation was obtained between modularity and performance on the complex working memory span task. These results support the proposed model, suggesting that the strong connections within a module benefit low-level processes needed for simple tasks, whereas stronger connections between modules benefit high-level processing and interactions among modules needed for more complex tasks. However, performance on the alerting and inhibition components of the ANT did not correlate with modularity. Alerting may depend on subcortical regions not tapped by the functional connectivity analyses. The lack of relation for the inhibition component of the ANT task is less clear, perhaps due to its being intermediate in complexity between orienting and working memory capacity. In general, the current study provides novel evidence regarding the relation between measures of whole brain organization and cognition which could be applied to understanding language and its neural substrate in the future.

Meaning: Prosody, Social and Emotional Processes

D67 Temporal network dynamics of prosody perception: An MEG study

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In language research, the notion of left dorsal and ventral streams – as the neural core of the language faculty – has become largely undisputed. Recently, we demonstrated a similar multi-pathway architecture in the right hemisphere for the processing of linguistic prosody – i.e., the melodic aspects of speech – by means of functional and diffusion-weighted neuroimaging (Sammler et al., 2015). Categorization of speech stimuli that gradually varied in their prosodic pitch contour involved (1) an auditory ventral pathway connecting posterior (pSTS) and anterior superior temporal sulcus (aSTS), and (2) auditory-motor dorsal pathways connecting pSTS and inferior frontal (IFG) and precentral gyrus (PMC). What is currently not known, however, are the temporal dynamics within this functional neural network. To chart the time points at which the nodes within the network contribute to prosody perception, we recorded magnetoencephalography (MEG) data from 16 native German listeners while they were presented with single words ("Bar" [bar], "Paar" [pair]) that gradually varied in prosody (statement to question) and word-initial phoneme (/b/ to /p/) along orthogonal continua generated by audio morphing. Stimuli (spoken by one male and one female speaker) were centered on each participant's individual points of subjective equality and were categorized by the listeners both in terms of prosody and phoneme, in repeatedly alternating blocks. Neural activity evoked during the two tasks was localized by means of distributed source analysis (sLORETA). Activation time-courses were compared between tasks within pSTS, aSTS, IFG and PMC of the right hemisphere (regions of interest taken from Sammler et al., 2015). All four areas showed stronger activation during prosody than phoneme perception, yet with different time courses: Activation differences peaked first in pSTS and aSTS (~100 ms), decayed quickly in pSTS while they plateaued in aSTS up until ~600 ms after stimulus onset. Interestingly, pSTS showed sustained activation in a second time window between 400 and 800 ms post-onset, accompanied by activity in IFG and PMC. Multivariate linear discriminant analysis (LDA) confirmed these time courses and points to additional contribution from left-hemisphereic nodes. Overall, the present data propose different temporal dynamics within dorsal and ventral streams during prosody perception: Ventral stream areas showed temporal primacy, in line with early auditory categorization processes, e.g., the formation of a time-invariant prosodic Gestalt. Dorsal stream areas showed delayed activity, in line with higher-order cognitive evaluation

processes (IFG) or voluntary simulation of the speaker's vocal gesture (PMC) to sharpen prosody perception. The biphasic activation of pSTS may argue for its involvement in spatio-temporally (and functionally) distinct feed-forward and feedback loops that constitute the neural basis of prosodic pitch contour perception. References Sammler, D. et al. (2015). Dorsal and ventral pathways for prosody. Current Biology, 25, 3079-3085.

D68 Reduced sensorimotor responses to laughter in children with conduct problems and high callous-unemotional traits

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Listening to positive vocalisations such as laughter activates motor and premotor cortical regions also involved in the production of emotional expressions. Such auditory-motor interactions are thought to facilitate the mirroring of others' emotions, a mechanism for promoting affiliation during social interactions. Here we test whether auditory-motor responses to laughter are altered in children with conduct problems and high levels of callous-unemotional traits (CP/HCU), who show reduced empathy to others' distress, commit acts of instrumental aggression, and are characterized by a lack of lasting social bonds. Using fMRI, we examined neural responses during passive listening to laughter in three groups of children: CP/HCU (n = 32), CP with low CU (CP/LCU; n = 30), and typically developing children (TD; n = 31). Compared with TD children, those with CP/HCU (but not those with CP/LCU) showed decreased neural responses in the supplementary motor area and anterior insula, areas that form part of the auditory-motor system previously described in typical adults. In an off-line behavioural task, children with CP/HCU reported feeling less inclined to join in with others' laughter than TD children, i.e., they experienced laughter as less contagious. A mediation analysis indicated that group differences in anterior insula response to laughter partly explained group differences in experienced desire to join in with laughter between CP/HCU and TD children. Atypical processing of laughter may be an early marker indexing social-affiliative deficits conferring risk for adult psychopathy. Our findings also form the first demonstration that the engagement of sensorimotor systems by positive emotions is altered in atypical development.

Methods

D69 Signal-space-projection (SSP) methods for extracting single-trial time courses from EEG/MEG data

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Inferences in neuroimaging data are commonly based on amplitude data, while most computational models of perception and cognition are based on behavioural response latencies [1]. The reliable extraction of single-trial time courses from EEG/MEG data, for topographies reflecting a brain process of interest, would provide a link between computational models and brain activation data [2]. Here, we describe several signal-space-projection (SSP) methods that may increase the signal-to-noise ratio (SNR) for single-trial time courses associated with topographies of interest: single-component signal-space-projection (scSSP), maximum likelihood estimation (MLE), LDA beamforming (BF) [3], and DeFleCT [4]. In addition, we introduce a novel multi-component SSP (mcSSP) method. We applied these methods to previously published data from a visual word recognition study (Neuromag Vectorview, 306 MEG and 70 EEG channels) [5]. Words of different lexical and semantic categories were presented in different blocks in randomized order with an SOA of 2.5 s. In a Go/NoGo paradigm, participants had to indicate by eye blink whether a stimulus belonged to one of the two stimulus categories. We computed single-trial time courses for target topographies obtained from ERPs/ERFs in the N1 (150-200 ms) and N4 (250-500 ms) time window. Average SNR time courses were computed for scSSP, mcSSP, MLE and BF, separately for different sensor types (EEG, magnetometers, gradiometers). For the novel mcSSP method, noise topographies were extracted using singular-value decomposition of single-trial baseline intervals, as well as for the average eye-blink response. We computed distributions of single-trial latencies (based on peak and centre-of-gravity measures) for separate experimental conditions (lexical/semantic decision, words/pseudowords, living/non-living concepts), and compared average latencies across subjects using t-tests. All methods produced different time courses for N1 and N4 components, respectively, with SNR peaks in their respective latency windows. Thus, SSP methods can provide information about time courses for separate ERP/ERF components at the single-trial level. MLE and BF produced the largest average SNRs (up to 3 for N1, 2 for N4), and clearly outperformed scSSP (values about 1.5 for N1 and N4). For mcSSP, increasing the number of noise components in the model increased the average SNR to levels similar to MLE and BF. However, this appeared to be mainly due to a reduction of baseline amplitudes, which suggests that at the single-trial level noise is not stationary or additive. mcSSP and BF reduced activity from eye-blinks, indicating that they are able to reduce the effect of these noise sources that can be characterized by stable topographies. We did not find differences between experimental conditions with respect to component latencies. This is in line with previous results that suggested quasi-simultaneous lexical and semantic information retrieval [5], but also raises the question of how to link neural and behavioural responses in the presence of behavioural reaction time differences, such as for words and pseudowords. 1. Norris, D., Psychol Rev, 2009. 116(1). 2. Philiastides, M.G. et al., J Neurosci, 2006. 26(35). 3. Treder, M.S., et al., Neuroimage, 2016. 129. 4. Hauk, O., Stenroos, M., Hum Brain Mapp, 2014. 35(4). 5. Hauk, O., et al., Neuroimage, 2012. 60(2).

D70 Electrophysiological correlates of interference effects in the picture-word interference paradigm

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In the picture-word interference task, participants name a picture while ignoring a distractor word. Response latencies are typically longer in trials with a distractor than in trials without (e.g., Glaser & Düngelhoff, 1984). This paradigm is

frequently used in language research to study the processes underlying language production and their time course. Yet, very little is known regarding the cognitive mechanisms involved in this task. The aim of the present study is to describe the electrophysiological response associated with the picture-word interference task. It asks two questions. The first is whether the neural networks involved in naming a picture with a superimposed written distractor differ from those involved in naming a simple picture. The second question is whether the neural networks involved in naming a picture with a superimposed written distractor differ from those involved in reading the written word while ignoring the picture. Participants named pictures in four conditions. In the first, a written distractor (with no semantic or phonological relationship with the target word) was superimposed on the picture (interfering condition). In the second and third conditions, the distractor and target words shared the first and second phonological syllable, respectively. In the last condition, a line of Xs replaced the written distractor (control condition). After the picture naming task, the participants were presented with the same stimuli and were asked to read the written words aloud while ignoring the pictures. The present study focusses on the interfering and control conditions. Microstate analyses were performed on the Event-Related Potentials (ERPs) locked to the presentation of the picture as well as on the ERPs locked to the onset of the vocal response. Microstate analyses allow determining whether two or more conditions differ in electric fields. Changes in electric field result from changes in the configuration of the underlying generator (e.g., Michel, Koenig, Brandeis, Gianotti, & Wackermann, 2009). In turn, differences in underlying generators indicate that different brain networks are activated. The comparison between the interfering and control conditions for the picture naming task revealed the same set of stable electrophysiological patterns (i.e., maps) for the two conditions, with two additional maps in the interfering condition. These lasted respectively from about 240 ms to 270 ms, and from about 310 to 360 ms after picture onset (mean naming latencies were of 688 and 791 ms for these two conditions, respectively). This result suggests that picture naming in the two conditions recruit similar networks during most of the encoding process, with additional networks involved when a distractor is superimposed on the picture around 300 ms after picture onset. The comparison between the naming and reading tasks revealed the same set of maps in the two tasks, with differences in the durations of these maps. The latter result suggests that if the two tasks recruit different neural networks, the microstate analysis was not sensitive enough to detect this difference.

Writing and Spelling

D71 The brain regions that translate phonology into orthography during oral spelling

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Introduction: Using fMRI, we investigated the location and function of brain regions that are involved in translating phonological inputs into orthographic outputs during an oral spelling task. Previous studies suggest that translating phonology-to-orthography activates brain regions that are also involved in translating orthography-to-phonology during reading (Purcell et al., 2011; Rapp & Lipka, 2011). In the present study, we were also interested in whether translating phonology-to-orthography during oral spelling relies on brain regions involved in processes not engaged by reading. Methods: Forty-eight healthy subjects participated in a multi-task fMRI experiment. During oral spelling, participants heard short familiar words (e.g. “CAT”) and responded by overtly articulating the spelling of the heard word (i.e. “C”-“A”-“T”). We compared activation during this task to that observed during: (a) overt auditory word repetition (i.e. hear “CAT” – say “CAT”) that controlled for phonological inputs and outputs; and (b) reading aloud that involves translating orthography-to-phonology. This allowed us to test whether brain regions involved in translating phonology-to-orthography (1) overlapped with those involved in translating orthography-to-phonology; or (2) were not involved in either reading or repetition. Naming objects from pictures or their sounds (e.g. saying “CAT” in response to hearing a cat meowing) was also included in our experiment to test whether brain regions associated with translating phonology-to-orthography were also involved in accessing visual or semantic representations of objects. We used standard fMRI data analyses in SPM12 and report effects that are significant after correction for multiple comparisons across the whole brain. Results and Discussion: Spelling, but not reading or auditory repetition, activated the left calcarine cortex, left orbitofrontal cortex, and right hippocampus. Activation in these regions was not, however, unique to spelling and also observed when participants named the source of sounds. All three regions have previously been associated with visual imagery (Klein et al., 2000; Ishai et al., 2002). We therefore propose that our participants may have used visual imagery during oral spelling and naming objects from their sounds. Common activation for spelling (translating phonology-to-orthography) and reading (translating orthography-to-phonology) relative to auditory repetition was identified in the left superior parietal lobule. However, this region was not solely activated for spelling and reading but also for object naming that does not involve orthographic processing. In summary, our experiment illustrates how translating phonology-to-orthography during oral spelling increased activation in brain regions that are also involved in visual imagery but did not identify any regions that were specific to orthographic processing of short familiar words.

Poster Session E

Perception: Auditory

E1 Presentation rate is a constraint on neurobiological theories of sensitivity to regularity

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Detecting statistical regularities in the sensory environment licenses predictions that enable adaptive behaviors, including, notably, language comprehension. In previous fMRI work we observed sensitivity to the regularity of sequences of pure tones in inferior frontal, lateral temporal, and supplementary motor areas, as well as lateral visual and primary auditory cortex. We concluded that depending on the response profile, this sensitivity reflected either the monitoring of the disorder of the sequence or monitoring of the complexity of the system generating the sequences. But, as presentation rate was constant, we could not rule out an effect of the amount of information being presented over time. Here we report an fMRI experiment addressing this issue, where we manipulated presentation rate of the input stream and conditional entropy of the generating process. This allowed us to identify regions whose response varied as function of entropy and presentation rate, indicating sensitivity to the speed in which it was possible to reduce uncertainty (formally: bits/sec). Stimuli consisted of pure tone series in which non-deterministic transition probabilities enabled predictions about the pitch of the subsequent tone. There were 4 conditionally linked pure tones corresponding to notes C,D,G, and A. An additional (F) like 'pause tone' was used in-between tones and during breaks between sequences. Tone series (14sec) were presented at 3 levels of conditional entropy (0.5, 1.0, and 1.58 bits), which were each presented at 4 presentation rates (3.3hz, 5hz, 7.5hz, and 10 hz). The only task involved a catch trial, requiring participants to press a button when the persistent fixation cross changed color and spun. Five sessions were collected for each of the 15 participants. To evaluate the main effects and interactions between conditional entropy and presentation rate, a repeated measures ANOVA was performed. For the main effect of presentation rate, we found a significant (voxel $p<0.01$ cluster $p<0.05$) cluster in the right auditory cortex, replicating prior research. Surprisingly, no cluster was significant for the main effect of entropy. Two clusters (voxel $P<0.005$, cluster $p<0.05$) – one in right angular gyrus and one in the left cerebellum – survived for the interaction between entropy rate and presentation rate. This implicates the right angular gyrus and left cerebellum in the passive monitoring of regularities in the auditory sensory environment in a manner that is sensitive to the rate in which the audio is presented. The absence of main effects of series regularity suggests that cortical sensitivity to series regularity is highly dependent on presentation rate.

E2 The importance of white matter tract integrity in aging speech perception: moving beyond the auditory periphery.

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The ability to comprehend speech in the presence of background noise is often compromised in elderly populations. Traditionally this deficit has been ascribed to the biological aging of the auditory periphery, yet new research suggests this view is overly simplified with more focus now being placed on the role of brain senescence. The aging brain is associated with significant white matter deterioration brought about by the degeneration of myelin. Degeneration of this kind is known to impair conduction of neural signals throughout the brain resulting in slower or incomplete transmission of neural impulses. Here we investigated the relationship between the degeneration of the arcuate fasciculus, a tract involved with language processing, and speech perception skills in aging. Following a battery of audiometric tests, 14 young adults (average age: 29.4 years 10.5 SD; range: 19-46 years; 5 females) and 15 elderly adults (average age: 71.9 5.85; range: 65-84; 3 females) completed a two-alternative forced-choice speech perception task in differing levels of intelligibility. 360 pairs of syllables, half of which were identical, and half varied either in their consonant or vowel, were presented. Additionally, half of the syllable pairs were from the same speaker whilst the other half were produced by different speakers. Participants were told to ignore the speaker and focus on the consonants and vowels. Syllables were presented either in absence of background noise, at an SNR of +15 dB or at an SNR of -5 dB. After completion of this task all participants underwent an MRI scan (Philips Achieva 3.0T), including a standard high resolution T1 (1 mm3) and diffusion weighted scans (b=1500 s/mm2; 60 directions; 1.8 mm3). Crucially, even after controlling for differences in hearing sensitivity between the two groups, using both an audiological (pure tone averages) and a bioacoustical measure (DPOAE recordings), age differences in speech discrimination accuracy (assessed with d') were found ($F(1.46, 36.52)=4.037$, $p=0.038$, $\eta p^2= 0.139$, power=0.694). Analysis of the tractography data (using the SCILPY processing pipeline) is still ongoing but preliminary results (n=18; 9 younger participants) show a significant group difference in the direct segment of the left arcuate fasciculus ($t(16)=2.274$, $p=0.037$, Cohen's $d=1.07$) with lower average fractional anisotropy (FA) values in the older age group. No age difference was found for the right arcuate tract ($t(16)=0.76$, $p=0.46$, Cohen's $d=0.36$). The present results are consistent with previous studies that reported an impact of age-related changes in cortical thickness and brain function on speech perception skills (e.g. Bilodeau-Mercure et al, 2015; Wong et al, 2009). Our results suggest, for the first time, that behavioural decline may also be affected by changes in the arcuate fasciculus, a key white matter language tract. Additional analyses focusing on uncovering the mediating role of a decline in the different segments of the arcuate fasciculus (i.e. the direct and indirect anterior and posterior segments) on the relationship between age and speech perception are currently underway

and will contribute to broadening current understanding of the aging of speech and language functions, which are important determinants of life quality at all ages.

E3 Word-frequency and phoneme-frequency differentially modulate predictive processing of speech

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There is growing evidence that speech processing benefits from predictive neural mechanisms. These mechanisms enable the temporal anticipation or the content-based expectation of specific speech sound events. Recently, predictive neural mechanisms during speech processing have been probed by omissions of speech sounds embedded in words. These omissions commonly elicit an automatic change detection response, the "omission mismatch negativity" (OMMN). Importantly, it could be shown that the amplitude of the OMMN is positively correlated with the predictability of the omitted speech sound. However, it is not clear what other factors – particularly, lexical variables - would modulate the OMMN. We expect that the OMMN also depends on the frequency of occurrence of the omitted speech sound, and on the frequency of the word in which the omission occurs – both factors that are likely to exert predictive top-down influences onto processing. For this reason, we employed a 2-by-2 design, using monosyllabic German high- and low-frequent nouns (word-frequency) with high- and low-frequent final consonants (phoneme-frequency). Word stimuli were presented in a passive oddball paradigm, where they occurred as standards, while rare deviants were fragments of these words with their final consonants omitted. During stimulus presentation, brain electric activity was recorded from 20 participants, using 64 active electrodes. Overall, standard and deviant responses significantly differed between 80 and 160 ms post deviance onset. The OMMN as amplitude difference between the deviants' and standards' wave forms showed a fronto-central topography with sources in left superior temporal gyrus. Mean amplitudes from a 40-ms window centered around the OMMN peak were subsequently analyzed in a repeated-measures ANOVA that included the effects of phoneme- and word-frequency. The results showed a significant main effect of word-frequency, with omissions in low-frequency words to yield significantly larger OMMNs than omissions in high-frequency words. Furthermore, the effect of word-frequency interacted with phoneme-frequency. The interaction revealed that within high-frequency words, OMMNs were smaller for omissions of high-frequency consonants than for omissions of low-frequency consonants. In low-frequency words, OMMNs did not differ as a function of phoneme-frequency. These results illustrate that the OMMN is sensitive to both word- and phoneme-frequency. The interaction pattern suggests that phoneme-frequency only plays a role for high-frequency words, where the omission of a high-frequency consonant in a high-frequency word-context elicits the least severe prediction violation. Apparently, when both phoneme and word provide strong top-down information, the omission of the word-final consonant is more readily tolerated than when this joint information is not available. Altogether, the findings imply that during speech perception, predictive processes operate both on a phoneme and on a word-level, and are in-line with a hierarchical architecture of the neural speech recognition system.

E4 Bilingual perception of language code-switching: Auditory event-related potentials for different exposure times to second language

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Highly proficient bilinguals can control command of languages. The unique phenomenon of code-switching (CS) can be seen in utterances between bilinguals if the interlocutor also has the same bilingual language background. However, there is no clear border line of when is the certain exposure time to second language (L2) to become a bilingual in multiple dimensions, such as phonology, morphology, grammar, and calligraphy. Also it should be noticed that to acquire L2 knowledge depends on linguistic distance from native language. Considering these issues, our study was to investigate how bilinguals perceive language CS among 3 groups of subjects whose exposure time to L2 differed. Languages used were Japanese and English, which are far apart in linguistic distance in every dimension. Group 1 subjects (n=13; mean age:22) were native Japanese who have learned English as a foreign language for at least 6 years in the Japanese school system from 12 years old (JM), and Group 2 (n=13; mean age:22) were native Japanese but they have been exposed to L2 as early as 3 years old (exposure age mean: 6 y/o) and continuously received bilingual education (LB). Finally, group 3 subjects (n=13, mean age:22) were all exposed to both languages from birth and consecutively had contact with both languages (EB). In other words, for group 3, both English and Japanese are their native languages (De Houwer, 2009). Electroencephalogram was used to examine event-related potentials (ERPs) applying auditory stimuli which included CS. Also the reaction time (RT) was compared for content selection of auditory information. The auditory ERP results showed that when English switched to Japanese, JM had a significant effect on P1 at F4 cite ($p<.05$) and LB as well. As for Japanese to English CS, JM had a significant effect on N1 at frontal, parietal-temporal, and occipital region ($p<.01$). LB had a significant effect on N1 at frontal and parietal-temporal region ($p<.01$) and also on P1 at parietal-temporal region ($p<.01$). On the other hand, EB had a significant effect on P1 at frontal, parietal-temporal, and occipital region. In regard to the result of RT, there was a significant difference between JM and EB, and also between LB and EB. EB responded faster on both Japanese and English than JM and LB. Furthermore, regarding the percentage of correct answers for contents, although Japanese target had a similar rate among 3 groups, JM had a much lower rate for English target than LB and EB. Consequently, the outcome of RT suggested that EB had higher cognitive command than JM and LB. Moreover, although LBs were exposed to L2 in early childhood, they had different neural responses from those who were exposed to two languages from birth.

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E5 Orthographic influence on spoken word identification: Behavioral and fMRI evidence

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Orthography affects speed and accuracy of spoken word recognition, as shown by the facilitatory influence of spelling consistency or orthographic neighborhood density in auditory rhyme, lexical decision, shadowing, and priming tasks. Phonological neighborhood density also influences spoken word recognition, with poorer recognition of words from dense, as compared to sparse, neighborhoods. The small extant fMRI literature on lexical neighborhood effects has not converged on a set of brain regions where activity covaries with lexical features. Greater activation has been reported for dense phonological neighborhoods in primarily temporal-parietal regions [3,4], whereas orthographic neighborhood density effects for words have been difficult to obtain reliably with some suggesting that orthographic effects are based in phonology [8]. However, reading tasks sometimes elicit differential activity in medial prefrontal or IFG/opercular regions with neighborhood density [1, 2, 8], implying that cognitive control mechanisms may be recruited by varying task demands (monitoring, response selection, inhibition of competing lexical candidates). In the current study, we sought behavioral and fMRI evidence for orthographic influence on phonological neighborhood effects. We examined how the overlap between orthographic and phonological neighborhoods affects spoken word processing, predicting that orthographic neighbors would potentiate the effects of phonological neighbors. We also varied the signal to noise ratio (SNR) based on evidence that neighborhood effects are enhanced under challenging listening conditions [5]. Thirty-seven normal hearing native English speakers (20 female; mean age = 40.9 yrs.) participated in a sparse-sampling fMRI study of auditory word identification in multitalker babble (+3 and +10 dB SNR; TR = 8.6 ms, TE = 35 ms, 3 × 3 × 3 mm voxels; see [6,7]). Stimuli included 120 monosyllabic CVC words. Orthographic and phonological neighborhood density was calculated for each item (http://elexicon.wustl.edu), noting which words were both phonological and orthographic neighbors (i.e., orthophonic neighbors). The orthophonic overlap ratio (OPOR) was estimated for each item by dividing the summed log frequencies of the orthophonic neighbors by the summed log frequencies of all the phonological neighbors (OPOR range 0 - .80). Word recognition was poorer for words with high orthophonic ratios in the +3 dB SNR ($t = -12.39$, $p < 0.001$), but was not significantly related to OPOR in the +10 dB SNR ($t = 1.80$, $p = 0.07$) (logistic regression, generalized linear mixed model). Main effects of SNR ($t = 22.35$, $p < 0.001$) and an SNR × OPOR interaction ($t = 9.66$, $p < 0.001$) were also observed. Consistent with behavioral OPOR results, cingulo-opercular BOLD contrast increased for higher OPOR words in the + 3dB SNR and for lower OPOR words in the +10 dB SNR condition (FWE corrected cluster level $p < 0.001$). Because OPOR was modeled independently from task condition and errors, item-level variation in recognition difficulty most likely drove BOLD changes in cingulo-opercular cortex. The collective findings indicate that more extensive overlap between orthographic and phonological neighborhoods increases word recognition difficulty and the need for cognitive control under challenging listening conditions. The orthophonic ratio provides a sensitive measure of orthographic influences on spoken word identification.

E6 In search of the kiki-bouba effect

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The kiki-bouba effect, where people map round shapes onto round sounds (such as [b] and [o]) and spiky shapes onto "spiky" sounds (such as [i] and [k]), is the most famous example of sound symbolism. Many behavioural variations have been reported since Köhler's (1929) original experiments. These studies examine orthography (Cuskley, Simner, & Kirby, 2015), literacy (Bremner et al., 2013), and developmental disorders (Drijvers, Zaadnoordijk, & Dingemanse, 2015; Occelli, Esposito, Venuti, Arduino, & Zampini, 2013). Some studies have suggested that the cross-modal associations between linguistic sound and physical form in the kiki-bouba effect are quasi-synaesthetic (Maurer, Pathman, & Mondloch, 2006; Ramachandran & Hubbard, 2001). However, there is a surprising lack of neuroimaging data in the literature that explain how these cross-modal associations occur (with the exceptions of Kovic et al. (2010)and Asano et al. (2015)). We presented 24 participants with randomly generated spiky or round figures and 16 synthesised, reduplicated CVCV (vowels: [i] and [o], consonants: [f], [v], [t], [d], [s], [z], [k], and [g]) nonwords based on Cuskley et al. (2015). This resulted in 16 nonwords across four conditions: full match, vowel match, consonant match, and full mismatch. Participants were asked to rate on a scale of 1 to 7 how well the nonword fit the shape it was presented with. EEG was recorded throughout, with epochs timelocked to the auditory onset of the nonword. There were significant behavioural effects of condition ($p<0.0001$). Bonferroni t-tests show participants rated full match more highly than full mismatch nonwords. However, there was no reflection of this behavioural effect in the ERP waveforms. One possible reason for the absence of an ERP effect is that this effect may jitter over a broad latency range. Currently oscillatory effects are being analysed, since these are less dependent on precise time-locking to the triggering events.

E7 Decoupling activity in auditory cortices caused by the detection of categorical phoneme changes

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Speech perception relies on the accurate identification of phonemes, the smallest contrastive speech sound unit. By modelling cortical generators of MEG responses, Schofield et al. (2009) demonstrated that modulatory activity between the left and right superior temporal gyri (STG) was observed only in Mismatch Negativity (MMN) produced by deviants where existing words vary by one phoneme. The results were interpreted to indicate that during speech perception, a change in word meaning (always concurrent with a change in phoneme) causes coupling changes within higher-level regions of the cortical hierarchy, as opposed to lower-level regions such as the primary auditory cortices (PAC). However, MMN has been known to document language-specific phonemic

representations regardless of word meaning, even in non-words (Näätänen et al., 1997). Our current study disentangles the phoneme-meaning relationship implicated by previous modelling efforts. Evoked MMN responses were acquired in EEG, and source-level activity was analysed using Dynamic Causal Modelling (DCM) for unintelligible speech and pseudo-words in addition to pure tones and words. Twenty-four right-handed monolingual (non-rhotic) Southern British English speakers served as participants. There were four conditions: i) pure tones, ii) words, iii) pseudo-words, and iv) unintelligible speech; the former two replicated exactly Schofield et al.'s stimuli. Both the word and pseudo-word conditions consisted of tokens which differed by only one phoneme; there were three deviants to the standard, with two of which being a between-category deviant. e.g., in the word condition, the word "Bart" was the standard, and there was a within-category deviant "Bart" which differed acoustically at behavioural threshold, and two between-category deviants: "Burt" and "beat". The unintelligible speech condition was generated by spectrally rotating the word stimuli. Pure tones were perceptually matched from the second formant frequency of the word condition vowels. MMN responses were recorded for each condition. EEG sources were reconstructed using a Variational Bayes Equivalent Current Dipoles approach. DCM models were specified to account for 0 to 250ms peristimulus time, for data reduced into 16 spatial modes singular value. The cortical architecture of tested models was four-sourced with bilateral Heschl's gyri (HG, containing PAC), and bilateral STG. Five-source models with a frontal source were excluded because functionally distinct activations are observed in frontal and temporal regions (Rinne et al., 2000; Deouell, 2008). All models had thalamic input into bilateral HG, and were fully connected with endogenous connections in all regions. Model selection for system architecture employed Bayesian Model Averaging. Variation was permitted within the modulatory activity (effective connectivity) of architecturally defined connections. Results showed that in both word and pseudo-word conditions, only between-category deviants displayed significant changes in effective connectivity. There was identical modulatory activity in both conditions: a decrease in connection strength from the right to left STG. This indicates a decoupling of the right and left STG upon phoneme (not meaning) identification. STG are located within higher levels of the auditory cortical hierarchy. Although also implicating STG, deviants in unintelligible speech did not exhibit this exclusive lateralisation-driven modulation, while pure tones displayed right-lateralised coupling starting from a lower level (right HG).

E8 Is a high tone sharp or smooth? Sound symbolism and the limits of 'perceptual tuning' to tone in language

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Given two visually contrastive shapes (e.g., spiky versus curved), and two acoustically contrastive labels (e.g., 'takete' versus 'maluma'), the majority of people agree that certain words 'go better' with certain shapes (Köhler, 1929:1947; Ramachandran & Hubbard, 2001). This effect has been replicated in a variety of linguistic and cultural backgrounds, including non-literate, non-Western communities, pre-literate children and even pre-verbal infants, leading many researchers to conclude that the effects are universal, and possibly innate (Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015; Imai & Kita, 2014). However, we propose that where language-use brings about perceptual adaptation to the auditory structure of a spoken language, the multisensory experience of language will also be shaped by uni-modal sensory tuning processes. We recently demonstrated that when people are asked to match shapes (spiky, curvy) to vowels (/i/ and /u/) articulated in the tones of Mandarin Chinese (T1, T2, T3, T4), Chinese speakers and English speakers with no experience of Mandarin Chinese show different mapping preferences for tones – Non-Chinese speakers prefer T1-spiky T3-curvy (consistent with mapping higher pitches to spikier shapes), while Chinese speakers prefer T1-curvy T4-spiky (2014, in prep). We argue that this mapping is consistent with the attentional requirements of online speech-processing for Mandarin, and arises from the phonological/tonological adaptation processes which are known to occur during childhood language acquisition (c.f. Kuhl, 2010; Werker & Tees, 1984). Here we report four tests of automated processing of shape/sound mappings for Mandarin tones, using a modified version of the Implicit Association Task (IAT). For participants attending to the identity of a tone in an IAT task which mapped visual shapes (curvy, spiky) to speech (vowels articulated in tones 1 and 4), if the unattended vowel mismatched the shape (e.g., i-curvy), Chinese speaking participants were significantly faster when the tone was congruent (T1-curvy: $F(1,9)=3.98$, $p=.004$, $p\text{-}\eta 2=.63$). A second group of participants performed the same task with the spectral quality of the vowel removed (the original pitch and amplitude re-synthesized as a sine wave), and the effect was reversed (T1-spiky: $t(9)=2.34$, $p=.044$), suggesting a pattern more like non-tone speakers' pattern. When two groups were tested on re-synthesized contours from the more-contrastive high-low pair (Tone1, Tone3) Chinese speakers performed the same way as English speakers with no experience of Chinese tones (T1-spiky, Chinese: $F(1,9)=10.51$, $p=.010$, $p\text{-}\eta 2=.54$; Non-Chinese: $F(1,9)=$, $p=.024$, $p\text{-}\eta 2=.45$). Thus, when listeners encounter the pitch contours of spoken Chinese outside the context of speech, the effects of linguistic adaptation are no longer observed, and all participants map higher-pitched sounds to spikier shapes, consistent with general patterns of cross-modal perception. By investigating sounds that are perceived differently by speakers of different languages, we show that neural adaptations to language influence perception outside the uni-modal processing of the speech stream, as linguistic category tuning bleeds over into the cross-modal domain. By showing that these effects disappear when the spectral properties of speech are absent, we further demonstrate that perceptual adaptation to the pitch architecture of Chinese tones is a narrow adaptation, only influencing the multimodal perception of pitch-in-speech.

E9 Incremental processing of Chinese spoken words and the influence of different tonal contrasts on lexical competition effects: Evidence from eye movements

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Visual world eye-tracking studies have demonstrated that words sharing phonetic segments compete for recognition, with early/large effects for onset segmental overlap and later/weaker

effects for rhymes (e.g., Allopenna, Magnuson, & Tanenhous, 1998). These segmental competitions have also been replicated in a tonal language, Mandarin Chinese. Several studies have observed not only sub-syllabic segmental competition effects when the target-competitor pair sharing the same tone (e.g., Tsai, Su, & Magnuson, 2015), but also competition effects when the target-competitor pair sharing the same syllable with different tones (e.g., Su, Tsai, Chang, & Tzeng, 2015). The present study extended these previous works to an examination of segmental-tonal competition in Chinese spoken words, and investigated whether minimal tone pairs with similar pitch contour or pitch height might increase lexical competition. In Mandarin Chinese, the four lexical tones are categorized phonologically as a high-level tone (tone 1), a middle-rising tone (tone 2), a low-dipping tone (tone 3), and a high-falling tone (tone 4). It has been suggested that pitch contour and pitch height are critical for identifying Mandarin tones (e.g., Gandour, 1983), and so we tested whether tonal contrasts with similar pitch contour or pitch height might increase lexical competition. Specifically, we examined whether lexical competition would increase when target-competitor pairs were: 1) tone 2 versus 3 contrast (with similar pitch contour), compared with 1vs3 contrast (with dissimilar pitch contour) pairs, and 2) tone 1 versus 4 contrast (with similar onset pitch height), compared with 2vs4 contrast (with dissimilar onset pitch height) pairs. Forty-eight sets of monosyllables, each with four possible tones, were selected as the target-competitor pairs, and were assigned into four tonal contrast conditions (1vs3, 2vs3, 1vs4, or 2vs4) across different lists. We hypothesized that listeners will increase eye fixations to the tone-mismatch competitors when the target-competitor pairs share similar pitch features. In the experiment, each trial began with a fixation on the screen, followed by the carrier phrase ("please move the cursor to…") played via headphone. An array of four characters was displayed on the monitor for a preview of 200 ms before the onset of the auditory target. Participants were instructed to use the touchpad to click on the character that matched the auditory target. Each visual display comprised a target character, a syllabic-match but tone-mismatch competitor, and two phonologically unrelated distractors (e.g., 2vs3 target-competitor pair: 鼻 /bi2/ "nose" & 筆 /bi3/ "pen"; unrelated distractors: 驅 /qü1/ "drive" & 肅 /su4/ "respect"). Results showed that participants increased eye fixations at competitors when the target-competitor pairs were 2vs3 tonal contrast, compared with when they were 1vs3 tonal contrast. Compared with 2vs4 tonal contrast, a small but significant effect was found for 1vs4 tonal contrast, and participants tended to look more at competitors when the pairs were 1vs4 tonal contrast. To conclude, the results support Chinese spoken word recognition is an incremental process, in which pitch contour and pitch height are used to distinguish syllables with different tones.

Signed Language and Gesture

E10 The neural systems supporting phonological processing of British Sign Language (BSL): the effect of the age of BSL acquisition and phonological parameters

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Just like spoken languages, signed languages can be described at the phonological level (Sandler, 2012) and are typically described in terms of three core parameters: 'handshape', 'location' and 'movement'. In a previous study we examined the similarity between phonological processing of sign and speech (MacSweeney et al., 2008). We showed that phonological judgement engaged a similar left fronto-parietal network for British Sign Language (BSL – location judgement) in deaf people and English (rhyme judgement) in hearing people. We also found greater left inferior frontal gyrus (IFG) activation during performance of a BSL phonology task in deaf non-native than native signers. The current study had two aims. Our first aim was to determine whether phonological activation in BSL signers differed according to whether the phonological parameter was based on location or handshape. The second aim was to investigate whether the previously observed effect in left IFG (deaf non-native > native) was due to (A) the age of sign language acquisition and/ or (B) impoverished early access to language as a consequence of acquiring spoken English in the absence of auditory input, with delayed access to a signed language. To distinguish these possibilities, we included hearing native and non-native signers. If the increased response in the IFG was due to (A) age of sign language acquisition, then both deaf and hearing non-native signers should show this increased IFG activation. Alternatively, if (B) increased IFG activation is the consequence of impoverished early access to language, then it should be greater in deaf than hearing non-native signers. We used a mixed design with Deafness (deaf/ hearing) and Age of BSL Acquisition (native/non-native) as within participant factors and Parameter(handshape/location) as a between participants factor. fMRI data were collected while forty-six participants viewed pairs of line drawings of objects and decided whether the BSL signs for the objects shared the same location or handshape. In line with our previous study, BSL phonological judgements (regardless of parameter) activated a predominantly left lateralised network including frontal, inferior parietal and occipitotemporal regions. When phonological parameter judgements were contrasted we found greater activation for location than handshape judgements in the angular gyrus and cuneus bilaterally, and also in the right middle occipital gyrus. No regions were found for the opposite contrast. These findings suggest that the greater activation we previously reported for BSL phonological judgments based on location compared to English rhyme judgments (MacSweeney et al., 2008) may only be observed when the location parameter is tested. With regard to the age of BSL acquisition, an ROI analysis showed that deaf non-native signers activated the left IFG more than all other groups. In contrast, the responses of hearing non-native signers here were not significantly different from hearing native or deaf native signers. These findings suggest that activation in the left IFG during phonological processing of BSL is influenced, not by absolute age of acquisition of BSL, but by whether a primary language is fully accessible or not.

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E11 Phonological specification of spectral change in Australian English front vowels

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Both nominal monophthongs and diphthongs display spectral change in English and it has previously been shown to improve vowel identification. In this study, we investigate Australian English (AusE) listeners' sensitivity to spectral change in front vowels to determine its possible role in phonology. Although the first (F1) and second (F2) formant frequencies of /iː, ɪ, ɪə/ show considerable overlap, there are distinct patterns of frequency change over time. AusE /iː/ and /ɪə/ – conventionally named diphthongs – show large magnitudes of change but differ in the direction of change (i.e., either falling or rising frequencies). Additionally, the magnitude – but not direction – of spectral change in /iː/ may vary according to a speaker's AusE accent. On the other hand, the nominal monophthong /ɪ/ displays the same direction of spectral change as /ɪə/ but its magnitude is smaller. We predict that AusE listeners will be sensitive to spectral change, as reflected by mismatch negativity (MMN) amplitudes, if it contributes to the phonological specification of AusE front vowels. Eight monolingual AusE individuals participated. Event-related potentials were elicited in four oddball blocks in which one of four deviants was interspersed among repetitions of a standard, followed by four short blocks presenting each deviant on its own (controls). Auditory vowel stimuli were created with the same duration and midpoint F1, F2 and F3 values. The standard's formant frequencies remained static over time, whereas the four deviants' formant frequencies varied: F1 decreased and F2 increased in dev-A and dev-B, and F1 increased and F2 decreased in dev-C and dev-D; within these deviant pairs, one had a moderate magnitude of change (dev-A and dev-C) and one had a large magnitude of change (dev-B and dev-D). Per deviant type, responses to controls were subtracted from responses to interspersed deviants. A negative peak between 100 ms and 300 ms after stimulus onset was located in the grand average waveform per deviant type and MMN amplitudes were obtained from a 40 ms window centred around this peak. To test whether listeners were sensitive to a change from a stimulus without spectral change to one containing it, one-sample t-tests showed MMN amplitudes were significantly less than zero for dev-A, dev-B and dev-D ($ps < 0.05$) but not for dev-C ($p > 0.05$). Comparing the stimuli with naturally produced AusE vowels, dev-A and dev-B exhibit the same direction of spectral change as /iː/ and their differing magnitudes may correspond to accent variation. Dev-C and dev-D show the same direction of spectral change as both AusE /ɪ/ and /ɪə/, while dev-C's magnitude is comparable to /ɪ/ and dev-D's to /ɪə/. Consequently, the above MMN results indicate listeners were sensitive to patterns of spectral change only when it corresponded to nominal diphthongs (i.e., dev-A and dev-B for /iː/; dev-D for/ɪə/) and not a nominal monophthong (i.e., dev-C for /ɪ/). Thus, despite all three AusE front vowels showing distinct patterns of spectral change in production, only /iː/ and /ɪə/, but not /ɪ/, seem to be phonologically specified for "diphthong".

E12 Gestural enhancement of degraded speech comprehension engages the language network, motor and visual cortex as reflected by a decrease in the alpha and beta band

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Face-to-face communication involves the integration of speech and visual information, such as iconic co-speech gestures. Especially iconic gestures, that illustrate object attributes, actions and space, can enhance speech comprehension in adverse listening conditions (e.g. Holle et al., 2010). Using magnetoencephalography (MEG), we aimed at identifying the networks and the neuronal dynamics associated with enhancing (degraded) speech comprehension by gestures. Our central hypothesis was that gestures enhance degraded speech comprehension, and that decreases in alpha and beta power reflect engagement, whereas increases in gamma reflect active processing in task relevant networks (Jensen & Mazaheri, 2010; Jokisch & Jensen, 2007). Participants (n = 30) were presented with videos of an actress uttering Dutch action verbs. Speech was presented clear or degraded by applying noise-vocoding (6-band), and accompanied by videos of an actor performing iconic gesture depicting actions (clear speech+ gesture; C-SG, degraded speech+gesture; D-SG) or no gesture (clear speech only; C-S, degraded speech only; D-S). We quantified changes in time-frequency representations of oscillatory power as the video unfolded. The sources of the task-specific modulations were identified using a beamformer approach. Gestural enhancement, calculated by comparing (D-SG vs DS) to (C-SG vs CS), revealed significant interactions between the occurrence of a gesture and degraded speech particularly in the alpha, beta and gamma band. Gestural enhancement was reflected by a beta decrease in motor areas indicative of engagement of the motor system during gesture observation, especially when speech was degraded. A beta band decrease was also observed in the language network including left inferior frontal gyrus, a region involved in semantic unification operations, and left superior temporal regions. This suggests a higher semantic unification load when a gesture is presented together with degraded versus clear speech. We also observed a gestural enhancement effect in the alpha band in visual areas. This suggests that visual areas are more engaged when a gesture is present, most likely reflecting the allocation of visual attention, especially when speech is degraded, which is in line with the functional inhibition hypothesis (see Jensen & Mazaheri, 2010). Finally we observed gamma band effects in left-temporal areas suggesting facilitated binding of speech and gesture into a unified representation, especially when speech is degraded. In conclusion, our results support earlier claims on the recruitment of a left-lateralized network including motor areas, STS/MTG and LIFG in speech-gesture integration and gestural enhancement of speech (see Ozyurek, 2014). Our findings provide novel insight into the neuronal dynamics associated with speech-gesture integration: decreases in alpha and beta power reflect the engagement of respectively the visual and language/motor networks, whereas a gamma band increase

reflects the integrations in left prefrontal cortex. In future work we will characterize the interaction between these networks by means of functional connectivity analysis.

Multilingualism

E13 Cross-language phonological activation through translation in Chinese-English bilinguals: Evidence from brain potentials and brain oscillations

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Bilinguals are able to translate words from one language into another. This process is not necessarily always conscious because research has shown that when Chinese-English bilinguals are reading English words silently the Chinese translations of these words are activated (e.g., Thierry & Wu, 2007; Zhang, van Heuven & Conklin, 2011). Brain potentials further suggest that Chinese-English bilinguals activate the phonology rather than the orthography of the equivalent Chinese translations (Wu & Thierry, 2010). However, because Chinese phonology contains both segmental (consonants and vowels) and tonal information, it is unclear whether the segmental and/or tonal information becomes available when the Chinese translation of the English word is activated. To investigate this, Chinese-English bilinguals (N=32) conducted a semantic relatedness judgment task with English word pairs. Critically, the repetition of segmental (S) and tonal (T) information of the Chinese translations was systematically manipulated in semantically and orthographically unrelated English word pairs: +S+T e.g., media-rose [媒体-玫瑰 (mei2ti3-mei2gui4)]; +S-T e.g., tail–scarf [尾巴-围巾 (wei3ba1-wei2jin1)]; -S+T e.g., black-editor [黑色-编辑 (hei1se4-bian1ji2)]; -S-T e.g., card-frog [卡片-青蛙(ka3pian4-qing1wa1)]. Stimuli were selected using an English-Chinese translation norming study (Wen & van Heuven, under review) and they were carefully matched in word frequency and word length. During the task, EEG was recorded and we analysed both the event-related brain potentials and brain oscillations to study the repetition of segmental and tonal information. The results revealed that when segmental information of the Chinese translations was repeated (+S+T, +S-T), ERP data showed a N400-like effect. No ERP effects were found for only tone repetition (-S+T). These findings indicate that hidden segmental repetition is the major contributor of N400 reduction observed in previous studies (Thierry & Wu, 2007; Wu & Thierry, 2010). Importantly, time-frequency analyses found higher beta band (20-30 Hz) power changes only when repetition involved both segment and tone (+S+T), indicating that there is no functional dissociation between segmental and tonal information in the oscillatory EEG data. Furthermore, in contrast to the oscillatory patterns in through-translation phonological repetition, semantic related filler words showed greater theta power changes (5-7 Hz) compared to semantically unrelated pairs. This finding is consistent with studies suggesting that theta power changes are linked to lexical-semantic retrieval (e.g., Bastiaansen et al., 2008; Bastiaansen et al., 2005; Mellem et al., 2013). Taken together, the different oscillatory patterns in through-translation phonological repetition and the semantic relatedness suggest a frequency-based segregation of these two processes. In sum, the present results indicate that brain potentials and oscillations capture different underlying mechanisms of Chinese phonological activation during English word reading.

E14 One brain, one language, two codes? The curious case of Norwegian

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Bilingualism and multilingualism is becoming the norm and not the exception in today's pluralistic societies. It is widely accepted that bilingualism provides a number of cognitive advantages, such as better executive control and attention, better problem-solving abilities, better meta-linguistic awareness (Bialystok, 2009). The effects of bilingualism on language competence are less clear, however. The evidence we have from research suggests that literacy skills acquired in the context of one language can transfer positively to another language (Bialystok, Luk & Kwan, 2005). This is a question we set out to investigate in an experimental study of performance on tasks involving the two standard written languages in Norway, Bokmål and Nynorsk, both of which are present in the media, at schools and elsewhere in the public sphere. The Norwegian language situation is characterized by multiple diglossia, both at the level of the written language (through Bokmål and Nynorsk), and at the level of the spoken language (by multiple dialects). Still, many aspects of this situation remain largely understudied. Since Bokmål and Nynorsk are highly similar variants of Norwegian we also sought to study whether the two varieties are really processed by the brain as two linguistic codes, as in the case of other bilingual language processing, or one only code. We used a cross-language primed lexical decision task where participants encountered target words in Bokmål paired with primes in Nynorsk, and target words in Nynorsk with primes in Bokmål. Each prime-target word-pair could fall into one of the following categories: related form with stem change (eg. melk-mjølk), related form with morphological change (eg. kvikkhet-kvikkleik) or unrelated form with the same meaning (eg. spice-ete). We found bidirectional priming effect for Bokmål and Nynorsk; however, Bokmål primes aided the recognition of Nynorsk words by decreasing the response time for Nynorsk target words more than the other way around. That is, Nynorsk primes did not have the same magnitude of effect on Bokmål targets. This asymmetric cross-linguistic priming effect has been described in the literature in non-proficient L2 speakers. These results suggest that the two written varieties of Norwegian are processed as two linguistic codes.

E15 Won't get fooled again? Lie production and lie perception in native and non-native languages.

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Lies are an everyday occurrence in our society, yet we are notoriously bad at recognizing them. Lie detection is a complex task with typically low accuracy rates and generally governed by different heuristics, the most common of which is the truth bias - perceivers' belief that most statements are truthful. Remarkably, recent studies have shown that laypersons and

trained professionals (e.g. law enforcement officers) alike are at chance level at discriminating lies from the truth, despite several kinds of visual and verbal cues exposing the liar, who may subconsciously produce revealing cues due to the cognitive load elicited by lying. Still, to this day very little is known about how the relationship between deception and language context can modulate both our ability to lie and identify lies in others. Our first study explores the interaction between deceptive language and non-native foreign language processing. One hundred native Spanish speakers with a conversant level of English were asked to produce truthful and false statements either in their native or foreign language. We measured their pupil size, speech onset latencies and utterance durations. Results showed additive effects of statement veracity and the language in which these statements were produced. False statements elicited larger pupil dilations and longer naming latencies compared with truthful statements, and statements in the foreign language elicited larger pupil dilations and longer speech durations as compared to first language. Importantly, these two effects did not interact, suggesting that the processing cost associated with deception is similar in a native and foreign language. In the second study we explored how perceivers' lie detection performance and truth bias are modulated when individuals perceiving and producing lies are native or non-native speakers of the language. Spanish-English bilinguals and English monolinguals listened to auditory statements either in their native or foreign language (produced in the first experiment) and judged them for their veracity. Results replicated the most consistent finding in lie detection research, showing a significant truth bias of similar magnitudes across all groups. Also, native-speaking perceivers of non-native speakers' statements showed the poorest lie detection performance. These findings suggest the universality of some mechanisms that govern lie detection regardless of the language context, while also highlighting important differences as a function of nativeness. Keywords: deception, bilingualism, lie perception, truth bias, pupil dilation, emotional distance, foreign language effect

E16 Age of language acquisition influences the cortical language organization in multilingual patients undergoing awake brain mapping

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Objectives. Most knowledge regarding the anatomical organization of multilingualism is based on aphasiology and functional imaging studies. However, the results have still to be validated by the gold standard approach, namely electrical stimulation mapping (ESM) during awake neurosurgical procedures. In this ESM study we describe language representation in a highly specific group of 13 multilinguals, focusing on how age of acquisition may influence the cortical organization of language. Methods. Thirteen highly proficient multilingual patients harboring lesions within the dominant, left hemisphere underwent ESM while being operated on under awake conditions. Demographic and language data were recorded in relation to age of acquisition (native language/early/late acquired languages), neuropsychological pre/postoperative language tests, number and location of language sites, and overlapping distribution in terms of language acquisition time. Analysis included lesion growth pattern/histopathology, location, and size. Results The functional language-related sites were distributed in the frontal (55%), temporal (29%), and parietal lobes (16%). Of these sites, 38% were located outside the areas predicted by classical models. The total number of native language sites was 47. Early acquired languages (including native) were represented in 97 sites (55 overlapped) and late acquired languages in 70 sites (45 overlapped). The overlapping distribution was 20% for early-early, 71% for early-late, and 9% for late-late acquired languages. Average lesion size was 3.3 cm, comprising five fast and seven slow growing lesions. Conclusions. Cortical language distribution in multilingual patients is not homogeneous, and it is influenced by age of acquisition. Early acquired languages are represented across a larger anatomical region than are those acquired later. The prevalent early acquired languages are largely represented within classical areas. Late acquired languages are less represented and mostly overlapped with the former. A large percentage of cortical, functional language sites are located away from the theoretical anatomical location and are not overlapped.

E17 Mean Diffusivity reveals white matter microstructural differences between monolinguals and bilinguals

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Recent hypotheses about the effect of second language experience on neuroplasticity have suggested possible differences in white matter microstructure between bilinguals and monolinguals. In this context, mean diffusivity (MD) has emerged as a sensitive measure of neural plasticity. Given that neural plasticity is an important consequence of bilingualism (Green & Abutalebi, 2013), the primary objective of this study was to use MD and associated components axial and radial diffusivity to compare white matter microstructure of bilinguals with monolinguals based on a prediction that exposure to a second language leads to neuroplasticity connecting specific brain regions. Eighteen Hindi-English bilinguals (mean age & SD: 23.94±1.5years) and 18 Italian monolinguals (mean age & SD: 23.45±2.1 years) closely matched for age, levels of education, literacy and SES (Socio Economic Status) were examined. Language proficiency assessments revealed that bilingual subjects were equally proficient in Hindi and English. Diffusion weighted images were acquired using a transverse multi-slice, single-shot, spin echo-planar imaging (EPI) sequence with 35 gradient directions at b-value = 1000 s/mm2 and one b = 0 reference image. After preprocessing, diffusion

tensor was fitted onto the corrected images using FMRIB's FDT toolbox (http://www.fmrib.ox.ac.uk/fsl/) which generated diffusion image maps (eigen values ($\lambda 1$, $\lambda 2$, and $\lambda 3$)), fractional anisotropy (FA) and MD, AD $\lambda || = \lambda 1$, RD ($\lambda \perp = (\lambda 2 + \lambda 3)/2$)). Voxel-wise statistics were carried out at major tract centres common to all participants using Tract Based Spatial Statistics (TBSS),(Smith et al., 2006).In order to generate additional preliminary insights into the geometry of the underlying white matter structure in bilingual speakers, distributions for mean diffusivity values for bilinguals and monolinguals were also estimated. Higher mean diffusivity (MD) for bilinguals in white matter tracts such as forceps minor and bilateral superior longitudinal fasciculus (p=0.05) were observed. There was a high degree of concordance with the tracts seen in MD and RD indicating that the increased mean diffusivity was due to a higher rate of diffusion along the perpendicular as compared to the parallel direction.MD and RD distributions of bilateral SLF in monolinguals and bilinguals showed similar trends as the FA distribution comparison. Our results demonstrate for the first time changes in mean and radial diffusivity, specifically in the right superior longitudinal fasciculus and the forceps minor in bilinguals as compared to monolinguals. We attribute these results to structural neuroplasticity in the bilingual brain as a consequence of consistent and daily use of cognitive systems involved in language control. We speculate that the structural differences found in the SLF reflect to the effects of richer articulatory repertoire required from bilinguals.

Meaning: Lexical Semantics

E18 Task-related effects on visual word recognition. A MEG study.

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The majority of fMRI studies investigating visual word recognition processes reported higher activation for pseudowords compared to words in the left ventral occipitotemporal cortex. Conversely, few studies reported similar levels of activation for both kinds of stimuli or even the opposite pattern. These apparently conflicting findings might have two non-mutually exclusive causes. The first possible explanation resides in task demands and how these can affect the involvement of relevant brain regions during visual word recognition. The second possible cause resides in differences in stimulus presentation durations, which may affect the depth of processing. For the present experiment we focused on task-related effects during visual word recognition. We asked twenty participants to perform a lexical decision task and a brightness judgment task. The only difference between the tasks was in the instructions, alternatively focusing participants' attention on linguistic (lexical decision) or nonlinguistic (brightness judgment) properties of the stimuli. Varying task demands while keeping experimental settings constant across tasks, should predispose the ideal settings to investigate task related effects on brain activation patterns. Two different sets of five letters stimuli (each including 160 words and 160 pseudowords) were used for the tasks. Stimuli appeared at the center of the screen for 100 ms and were presented in individually adjusted shades of gray. Brain activity was recorded using a 306-channel MEG Vectorview system (Elekta-Neuromag Oy, Helsinki, Finland). Continuous data was filtered with a band-pass filter of 1 – 45 Hz and epoched between -1 s and 2 s time locked to stimulus onsets'. Spectral estimates were computed using fast Fourier transform (FFT) with a single Hanning taper, for time windows of 500 ms (from -1 s to 2 s in steps of 50ms) and frequencies between 4 and 40 Hz. Statistical analyses of time–frequency representations at sensor level were performed using a non-parametric cluster-based permutation test in the time window between 0 and 600 ms after stimulus onset. In the lexical decision task, comparison between words and pseudowords revealed two significant clusters in the alpha (8-12 Hz) and beta (13-30 Hz) band. Effects emerged at ~400 ms after stimulus onset and were mainly left lateralized. The same comparison in the brightness judgement task evidenced a significant cluster in the beta band (13-30 Hz) which emerged at ~200 ms after stimulus onset and lasted up to ~450 ms. In this case, the topographical distribution of the effect was mainly localized around medial parietal sites. Previous studies associated alpha band activity to lexical access and semantic knowledge retrieval processes. Accordingly, in the alpha band, we observed power differences only in the lexical decision task, where participants had to focus their attention on linguistic properties of the stimuli. Furthermore, both for the lexical decision and brightness judgement task we observed significant changes in beta band power. Oscillatory activity in the beta range was identified as a possible mechanism for the propagation of top-down predictions from higher to lower cortical levels. Beta band activity might therefore reflect - task independent - automatically generated top-down predictions.

E19 The semantic representations of words reflect co-occurrence statistics and conceptual taxonomies in distinct brain regions.

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The semantic relationships among words are essential to language comprehension. They are structuring components of semantic memory, play a critical role in the formation of children's lexicon during early language learning and impact language deficits in clinical conditions. The meaning of words relate to each other along a taxonomy of concepts (e.g. peach and plum, which belong to the same category), or because of their association with a common event, whereby they are frequently used together (e.g. peach and knife, harp and to play). These word links dissociate both behaviourally and neurally in the linguistic production of aphasic patients, with category-based naming errors arising from lesions in the left anterior temporal cortex and association-based naming errors linked with damage to temporo-parietal junction and angular gyrus. Despite this neurocognitive relevance, recent advances in identifying the distributed brain networks that support language comprehension did not elucidate how these word links are represented in the brain. We investigated how brain semantic systems reflect the conceptual relationships and associative relationships among words of different semantic types (actions and objects). We measured whole-brain activity

patterns with functional magnetic resonance imaging (fMRI) while subjects were silently reading each of 96 words. Using searchlight representational similarity analysis (RSA), we assessed to what extent different computational models could account for the brain representations. The models captured either conceptual similarity in taxonomies (Framenet, Wordnet) or associative similarity in co-occurrence frequencies (LSA, COALS). Models based on co-occurrence statistics better predicted representational similarity in general semantic regions including pars orbitalis (BA 47) of inferior frontal gyrus bilaterally and right angular gyrus. Category-based models significantly explained representations in higher-level visual object-processing regions, and dominated over co-occurrence models in the case of food words. Extending current distributed accounts, these results shed light on the information content of words and their semantic relationships in the human semantic systems, suggesting that that the underlying semantic space reflects qualitatively different, fine-grained semantic information about words and their conceptual and contextual relationships.

E20 FMRI dissociations between subclasses of abstract nouns in left motor areas during passive reading

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Previous research showed that modality-preferential sensorimotor areas are relevant for processing of words referring to concrete objects or actions. However, whether modality-preferential areas also play a role for abstract words is still under debate. Whereas recent fMRI studies suggest an involvement of motor cortex in processing the meaning of abstract emotion words as, for example “love”, other non-emotional abstract words, in particular ‘mental words’ such as “thought” or “logic”, are believed to exclusively engage ‘amodal’ semantic systems. To test this, we conducted a passive reading, event related fMRI paradigm on 28 native speakers. This approach thereby applied nouns from different semantic categories, including concrete hand action related tools, face action related food items, as well as words referring to abstract emotional and abstract mental/non-emotional concepts. Semantic categories were confirmed using extensive semantic ratings and were matched for a range of lexical and sub-lexical psycholinguistic variables to assure that any observed dissociations in neuronal activity between word types can indeed be attributed to differences in word semantics. In addition, participants performed a motor localizer task to identify foci of hand and face motor processing. Contrary to expectation, the results indicate a specific involvement of face motor areas in the processing of mental nouns, closely resembling that seen for face related action words. This result was confirmed when subject-specific face and hand motor regions were used in analysis. We conclude that a role of motor systems in semantic processing is not restricted to concrete words but extends at least to some abstract ‘mental’ symbols previously thought to be ‘disembodied’. Furthermore, the observed dissociations between different types of abstract words within the motor system highlight the importance to consider fine grained semantic subclasses when testing for a role of modality specific brain areas in the processing of abstract words.

E21 Semantic hub or convergence zones? EEG/MEG evidence for the central role of the Anterior Temporal Lobe in semantic processing

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Introduction: The organization of semantic networks in the brain has been a controversial topic in cognitive science for decades. With theories ranging from fully symbolic and amodal to entirely embodied semantic cognition, brain imaging in recent years has provided evidence mostly for theories that take an intermediate position. But it remains to be determined whether there exists one main semantic hub or several heteromodal convergence zones. Here, we utilized the fine temporal resolution of source-estimated Electro- and Magneto-EncephaloGraphy (EEG/MEG) recordings to test: 1- the hypothesis of a single hub versus several convergence zones (potentially appearing at different times during semantic word processing) and 2- whether any of the most commonly suggested hub locations shows connectivity to other semantic areas. Methods: The experimental paradigm included a lexical decision (LexD) task followed by a semantic decision (SemD) task of categorizing visually-presented single words as abstract or concrete. We conducted whole-cortex evoked and time frequency (TF) analyses to assess the time course of lexicality and concreteness effects across different brain areas. Furthermore, we computed seed-based functional connectivity with seeds in four potential hub regions including left anterior temporal lobe (ATL), middle temporal gyrus (MTG), inferior frontal gyrus (IFG) and Supramarginal/Angular Gyrus (AG). We computed three connectivity measures including Coherence, de-biased weighted Phase Lag Index and Mutual Information in four frequency bands (Theta (4-7Hz), Alpha (8-12Hz), Beta (13-30Hz) and Gamma (31-45Hz)). All results were corrected for multiple comparisons across vertices and time by means of spatio-temporal cluster-based permutation. Results: In the evoked analysis of LexD, words showed larger amplitudes than pseudowords in the left ATL; for SemD, abstract words yielded higher amplitudes than concrete words in bilateral ATL and anterior IFG. This difference was largest in the time window of 350-450ms but started as early as 100ms. TF results in LexD showed higher Beta power for words than pseudowords in the left medial temporal and orbitofrontal lobes with earliest modulation of the ATL (~100ms) and later modulation of orbitofrontal cortex. Words additionally showed higher Alpha power in the right frontal and parietal lobes (starting at ~100ms) and right motor cortex (~400ms). SemD did not reveal significant TF differences. In the seed-based connectivity analysis with potential hubs, only the seed in the left ATL produced significant results and solely in the SemD task. This included higher Beta band connectivity for concrete words between left ATL and right ATL/IFG which was reflected in all three connectivity measures, and was most pronounced for Coherence. LexD did not show any robustly significant connectivity results. Conclusions: In evoked analysis, the ATL

showed sensitivity to lexicality and concreteness, especially in early latency ranges of visual word processing, but TF results were less conclusive. Interestingly, whole-brain seed-based connectivity with four candidate hub or convergence zone areas only highlighted bilateral ATL connectivity and in the SemD task. These results could provide evidence for the role of the ATL as a semantic hub, particularly during the early stages of semantic processing.

E22 Evidence for Inner Speech: Orthographic and Phonological Effects without Words N. Zur1, N. Binur1, Orna Peleg2 and Zohar Eviatar1 1 Institute of Information Processing and Decision Making, Haifa University 2 Program of Cognitive Studies of Language and Its Uses, Tel-Aviv University

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The Dual Hemispheric Reading model (Peleg & Eviatar, 2009) posits different functional architecture in the cerebral hemispheres for accessing meaning from print. This is supported by many studies using lateralized lexical and semantic decisions with ambiguous words, showing different behavioral patterns in the visual fields (e.g., Beeman, 1998). Previously we took advantage of the abjad orthography of Hebrew to examine the relative roles of orthography and phonology, using homonyms (bank) and homographs (tear) in the two hemispheres. We found support for the hypothesis that in the LH, phonological and orthographic representations are highly inter-connected, allowing direct access to semantic representations from phonology. In the RH, there are no direct connections between orthographic and phonological representations, resulting in initial meaning access via orthography. The goal of the present experiment was to test whether the effects of phonology and orthography can be seen when reading is not necessary. Participants were presented with two sequential centrally presented pictures of objects, and decided whether they were semantically related. ERP and behavioral measurements were recorded. There were three types of stimuli reflecting ambiguity of the object labels: homonyms (same orthography and phonology, bank), homophones (different orthography, same phonology, mail/male), and homographs (same orthography, different phonology, tear). If phonological or orthographic relations between object labels affect semantic decisions, we expect longer RTs and smaller N400 for unrelated pairs that have ambiguous than those that have unambiguous labels. The behavioral results revealed an interaction between ambiguity and relatedness, with ambiguity affecting responses to homonyms and not to the other types of ambiguous pairs. For ERPs, we compared mean amplitude from electrodes in three Regions of Interest (ROI: LH=C1, C3, FC1, FC3, F1, F3; C=Cz, FCz, Fz; RH= C2, C4, FC2, FC4, F2, F4) in the interval 350-450 ms after onset of the second picture (the N400). The results revealed different patterns in the cerebral hemispheres: in the LH, homonyms showed a significantly smaller N400, whereas homophones and homographs, showed N400s equivalent to pairs with unambiguous labels. In the RH, both homonyms and homophones resulted in smaller N400s than their unambiguous controls. Homographs did not differ from unambiguous pairs in any of the ROIs. Amplitude of the N400 component has been considered an indication of semantic incongruency. The ambiguity effect in this study reflects difficulty in recognizing this incongruency, defined as the difference in N400 amplitude between pairs of pictures with ambiguous and unambiguous labels. We show that this difficulty is largest over the LH for homonyms, such that when one aspect of the label is different (orthography for homophones, phonology for homographs), that is, if either phonology or orthography are not ambiguous, then the ambiguity effect disappears. Over the RH, this difficulty is smaller overall, but it is still significant with phonological ambiguity (homonyms and homophones).

E23 How Serious are Games? Electrophysiological evidence of rapid L2 learning

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Can playing games promote language learning? While both on and offline language-learning games have gained commercial success, there is little empirical evidence concerning their efficacy. Nevertheless, both Young et al. (2012) and Peterson (2010) suggest that "serious games" are beneficial for language learning. Statistically reliable gains in both vocabulary (Ranalli, 2008) and writing skills (Toyoda & Harrison, 2002; Zhang, Young, Wagner & Brewer, 2009) have been reported for various types of game play. More recently, O'Neil, Lagarrigue, Newman & Frenck-Mestre (2015) showed that computerized games both enable L2 vocabulary learning and allow learners to incorporate newly acquired words into their existing semantic network. The current study used a computerised learning paradigm to test L2 learning. In collaboration with the Virtual Reality Centre in Marseille (CRVM), we designed four computer games through which French natives learned a limited vocabulary in Brazilian Portuguese during a longitudinal 6-day study. On each of 3 consecutive learning days, participants learned 3 new verbs and 12 new nouns in 30-minute "serious game" sessions. All linguistic materials were presented exclusively auditorily. The games involved figures performing actions and pre-recorded declarative sentences. First, participants watched the figure perform actions as they heard the corresponding sentences; they then reconstructed these sentences using a set of possible words; then they identified the correct verb out of three, and finally they played a memory game, to select the pair of cards that matched the action described. We assessed learning both pre- and post-training, using behavioural and electrophysiological measures. Pre-training, participants heard 60 auditory nouns, with 30 match and 30 mismatch trials. Post-training, an additional 60 trials were added. The latter trials comprised line drawings that were semantically-related (n = 30) or unrelated (n = 30) to the learned nouns. ERPs were recorded as participants saw a line drawing followed by an auditory noun and judged whether the auditory word matched the image. Behavioral responses were collected at the end of each trial. Results showed lexical learning. At the pre-training session, N400 amplitudes were comparable for match and mismatch trials.

The post-training session revealed greater N400 amplitudes for mismatched than matched pairs. Importantly, results also showed lexical priming, with an N400 effect for nouns paired with images of objects that were semantically related, indicating that the learned vocabulary extended to existing semantic networks. Behavioural results also showed evidence of lexical learning. However, both the match-mismatch effect and semantic priming depended upon the overlap of lexical gender across the L1 and the learned L2 vocabulary. Words that shared the same gender in L1 French and L2 Portuguese were better integrated than opposite-gender words. The cortical changes observed after only a few days, associated with L2 learning through "serious games", as well as the behavioral results, argue for the benefits of alternative language-learning methods, specifically game-playing. More generally, this study provides insight into adult L2 learning and how information is integrated at a cognitive level.

E24 Spoken words can make the invisible visible: Testing the involvement of low-level visual representations in spoken word processing

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The notion that processing spoken (object) words involves activation of category-specific representations in visual cortex is a key prediction of modality-specific theories of representation that contrasts with theories assuming dedicated conceptual representational systems abstracted away from sensorimotor systems. Although some neuroimaging evidence is consistent with such a prediction (Desai et al., 2009; Hwang et al., 2009; Lewis & Poeppel, 2014), these findings do not tell us much about the nature of the representations that were accessed. In the present study, we directly tested whether low-level visual cortex is involved in spoken word processing. Using continuous flash suppression we show that spoken words activate behaviorally relevant low-level visual representations and pin down the time-course of this effect to the first hundreds of milliseconds after word onset. We investigated whether participants (N=24) can detect otherwise invisible objects (presented for 400ms) when they are presented with the corresponding spoken word 200ms before the picture appears. We implemented a design in which all cue words appeared equally often in picture-present (50%) and picture-absent trials (50%). In half of the picture-present trials, the spoken word was congruent with the target picture ("bottle" -> picture of a bottle), while on the other half it was incongruent ("bottle" -> picture of a banana). All picture stimuli were evenly distributed over the experimental conditions to rule out low-level differences that can affect detectability regardless of the prime words. Our results showed facilitated detection for congruent vs. incongruent pictures in terms of hit rates ($z=-2.33$, $p=0.02$) and d'-scores ($t=3.01$, $p<0.01$). A second experiment (N=33) investigated the time-course of the effect by manipulating the timing of picture presentation relative to word onset and revealed that it arises as soon as 200-400ms after word onset and decays at around word offset. Together, these data strongly suggest that spoken words can rapidly activate low-level category-specific visual representations that affect the mere detection of a stimulus, i.e. what we see. More generally our findings fit best with the notion that spoken words activate modality-specific visual representations that are low-level enough to provide information related to a given token and at the same time abstract enough to be relevant not only for previously seen tokens (a signature of episodic memory) but also for generalizing to novel exemplars one has never seen before.

E25 The effect of word predictability and its relation to reading proficiency: A fixation-related fMRI study

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During reading, the predictability of a word – based on the prior sentence context – facilitates visual word recognition. Behavioral evidence from eye movement research, however, showed that the effect of word predictability is much more pronounced in less proficient compared to proficient readers. This finding indicates that less proficient readers rely more on sentence context to compensate for their difficulties with visual word recognition. Evidence from neuroimaging studies regarding the effect of word predictability, however, is limited and even less is known about the individual differences of such context effects. The present study investigated the effect of word predictability and its relation to reading proficiency on participants' brain responses during reading of whole sentences by means of simultaneous eye-tracking and functional magnetic resonance imaging (i.e., fixation-related fMRI). At the behavioral level, we observed a strong relationship between reading proficiency (indexed by a measure of words per minute) and the individual effect of word predictability. To be specific, the individual effect of word predictability – that is the extent of facilitation as indexed by participants' fixation durations – increased with decreasing reading proficiency. At the neural level, we observed that increasing word predictability was associated with a decrease in activation within bilateral occipito-temporal, left posterior-to-anterior middle temporal and inferior frontal regions which have been implicated in orthographic and lexico-semantic processing. Reading proficiency was associated with the peak voxel activation within the anterior proportion of the left middle temporal gyrus. Specifically, proficient readers exhibited a stronger effect of predictability than less proficient readers (which is surprising in the light of the rather minor effect of predictability on their fixation durations). This relationship between left anterior middle temporal gyrus activation and participants' reading proficiency might indicate that proficient readers do rely on sentence context in the sense that relevant lexico-semantic information becomes pre-activated within predictive contexts. This, in turn, could result in a facilitated access to such stored lexico-semantic information and hence is reflected by a more pronounced effect of word predictability when a predicted word is eventually fixated. Counter to the strong behavioral association of the effect of word predictability with reading proficiency, we did not observe such a modulatory effect of reading proficiency at the neural level. One might speculate that

the behavioral facilitation due to word predictability for less proficient readers could stem from a stronger involvement of semantic processing on orthographic processing as envisioned by the lexical quality hypothesis. Specifically, it is assumed that in less proficient readers such lexical representations are underspecified – preventing fast "context-free" visual word recognition. Thus, top-down, context-based processing has the time to exert its influence which is reflected by a beneficial effect of word predictability. To further investigate the role of word predictability in less proficient readers, we will administer appropriate connectivity analyses – providing novel insights into the complex interplay between sentence-level (contextual) processing and visual word recognition.

E26 Lexical and semantic processing explored using visual Mismatch Negativity

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Skilled reading appears to be so effortless and reflex-like that normally we take it for granted, suggesting that reading, at least in the early stages, may be largely automatic. In the psychology of language, however, to what extent the reading of words can be automatic remains debatable. Previous studies usually have employed presentations of varied linguistic stimuli in the fovea area and/or linguistic tasks such as lexical decision. However, in this type of design, controlled attention to language stimuli is inevitable and so the question of automaticity cannot be adequately addressed. One electrophysiological measure of automaticity, however, could be the visual Mismatch Negativity (vMMN) component, which has been confirmed as an index of early and automatic processing of visual features, although few studies have applied this to language studies. In recent work from our lab (Wei, Guo and Dowens, 2015), a vMMN enhancement effect at an early latency of 160-200 ms was observed for a group of real Chinese characters in comparison with carefully matched pseudo-characters. Building on this finding, in a series of experiments the current study further explores whether lexical frequency and semantic information can be processed early and automatically. The attentional load of a centrally presented distraction task was also manipulated. Specifically, matched high-frequency (HF) and low frequency (LF) characters were presented parafoveally in a low-load task (Exp1a) and a high-load task (Exp1b) and matched concrete and abstract characters were presented in a low-load task (Exp2a) and a high-load task (Exp2b). A visual standard-deviant-reverse paradigm was adopted in the experiments where vMMN effect was defined as a difference between the same type of characters acting as deviants and standards across oddball blocks. Larger vMMNs for HF characters and for concrete characters were found before 250 ms in Exp1a and Exp1b. However, in Exp2a and Exp2b where foveal distraction tasks demanded more attentional focus, the vMMN enhancements were found to occur later. Our vMMN studies provide evidence for early and automatic lexical-semantic processing of Chinese, which extends previous auditory MMN studies into the visual modality. However, the early dynamics seemed not to be immune to attentional modulation. Reference Automatic lexical processing of written Chinese as indexed by visual mismatch negativity effect. Wei, D., Guo, T. & Gillon Dowens, M. XII International Symposium on Psycholinguistics, Valencia, Spain July 1-4, 2015.

Language Development

E27 Processing of phonemes and prosody throughout infancy: two peas in a pod?

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In our previous work we have shown the trajectory of fine-grained developmental phoneme processing in three-, six-, and nine-month-old infants. Our results suggest that precise and rough speech processing appear to be shaped sequentially in early infancy and start operating in parallel in late infancy (Teickner et al., 2014). A related line of parallel processing regards phonemes and prosody. Children and even infants as young as nine months appear to process phonemes and prosody in parallel (Schild et al., 2014, Becker et al., 2014), whereas phoneme-free prosodic processing dominates in six-month-olds (Becker, 2014). The aim of the current study is to investigate whether the trajectories of phoneme and prosody processing in infancy are linked or whether they develop separately. Therefore, we recorded event-related potentials (ERPs) of three-, six-, and nine-month-old German-hearing infants, while presenting them with syllables (primes) and dysillabic German words (targets) that differed in the degree of phoneme and stress overlap (complete, e.g. MA-MAma; partial phoneme and stress overlap, e.g. NA-MAma; partial phoneme, no stress overlap, e.g. na-MAma; no phoneme but stress overlap, e.g. VO-MAma; no overlap, e.g. vo-MAma). Since adult German listeners match words according to their phonemes as well as their prosody to avoid misunderstandings (e.g., when two words share the same initial syllable but differ in their word-initial stress; MOdern [to rot] and moDERN [modern]), our fragment priming design is an eligible tool to assess infants' prosody and phoneme processing. Replicating earlier findings, the current results indicate massive parallel processing in infancy. We find (i) that precise and rough speech processing appear to be shaped sequentially in very early infancy and begin to operate in parallel towards the end of infancy. In agreement with this our results also suggest (ii) developmental trajectories displaying separate processing of phonemes and prosody and emerging interactions between those systems.

E28 Beginning readers process more speech details than prereaders

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A main challenge for beginning readers lies within the transfer from small units of spoken words (phonemes) onto their written counterparts (graphemes) and vice versa. Here we ask whether readers use their newly acquired orthographic knowledge to process phonemes in more detail. Non-reading preschoolers (prereaders), reading 2nd graders (beginning readers) and adult controls conducted an auditory word onset priming experiment. In an identity condition, primes were the first syllables of the following target words (e.g. in the prime-target pair 'ta – taxi'). In a control condition, prime-target combinations were unrelated (e.g. 'bru – taxi'). In a variation condition, prime-target pairs varied in the initial phoneme. We created three different types of the variation condition, from

which each participant received only one, respectively. In the PLACE ONLY variation, trials varied in their initial place of articulation (e.g. 'pa – taxi'). In a VOICE ONLY variation the prime-target pairs differed in their initial voicing (e.g. 'da – taxi'). In a PLACE & VOICE variation, we manipulated both features (e.g. 'ba – taxi'). We expected readers to be more sensitive than prereaders to small variation in the speech signal. That is, readers but not prereaders should notice one-feature variation (PLACE ONLY and VOICE ONLY). We hypothesized that prereaders notice only two-feature variation (trials with PLACE & VOICE variation), but do not notice one-feature variation (PLACE ONLY and VOICE ONLY). For beginning readers as for adults a graded pattern of facilitation was obtained: Readers' responses were fastest in the identity condition, intermediate in the variation condition, and slowest in the control condition. This pattern was evident for all three types of variation. Prereaders showed intermediate response times for trials with PLACE & VOICE variation, and - contrary to our predictions - also for trials with PLACE ONLY variation. We only confirmed our assumption of prereaders' reduced sensitivity for VOICE ONLY mismatch. This later finding indicates that prereaders possess less fine-grained phonological representations than readers at least when voicing is involved. Beginning readers' enhanced sensitivity to voice variation might be linked to literacy acquisition and phonological improvement in early school years.

E29 Hemispheric lateralisation in school-aged children during picture naming.

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Language is predominantly processed in the left hemisphere in most adults and children. Functional Transcranial Doppler sonography (fTCD) is a portable, non-invasive neuroimaging technique, which is relatively tolerant of minor head movement compared to many other neuroimaging techniques. This makes it a good technique to investigate hemispheric language lateralisation in special populations and young children. However, current developmental research with fTCD typically focuses on only one task, the 'animation description' task (Bishop et al., 2009). This task involves children watching a non-verbal video and then describing what happened in the clip. Although this task shows reliable lateralisation, children are very variable in the number of words they produce during the task, which may contribute to the strength of lateralisation (Gutierrez-Sigut et al., 2014). There is also no clear way of measuring accuracy or proficiency in a narrative production task such as animation description. In the current study, fTCD was used to compare lateralisation for a paced object-naming task, which allows control over the number of words to be produced, with lateralisation for the established animation description task. Twenty-four 5-7 year old, right-handed children completed the fTCD tasks and offline measures of reading and speeded object naming. Performance on the offline measures of single word reading and object naming positively correlated with each other when controlling for age. Seven of 22 children showed significant left lateralisation for the object naming task and 17 of 24 children showed significant left lateralisation for the animation description task. In line with previous research, the animation description task resulted in significant left-lateralisation at the group level. However, the children did not show significant lateralisation for the paced object-naming task at the group level. Despite no significant lateralisation during this task, individual's lateralisation for object naming correlated with lateralisation for the animation description task. The strength of lateralisation for the paced object-naming task did not correlate with offline measures of reading and speeded object naming. These results suggest that the networks required to complete the object naming task are not as strongly left lateralised as those required for free speech production. It may be that there were too few items for the children to generate enough words to show a lateralisation effect or that a syntactic element to the task would increase observed lateralisation.

E30 Rapid neural memory-trace formation for novel words is independent of attention but influenced by individual language experience and reading ability

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The human ability to build large vocabularies in both native and non-native languages is crucial for our communication skills. Rapid development of neural memory-traces for novel word-forms has been shown to take place with intense perceptual exposure to such items that involves multiple (up to 160) repetitions within a short time (15-30 minutes). Here, we investigate a range of cognitive factors that are of potential importance for the functioning of this lexicon acquisition mechanism in the brain. We ask (1) whether such rapid memory-trace formation is dependent on or enhanced by attention; (2) whether and how previous experience in learning multiple languages affects the efficiency of online neural learning; and, finally, (3) if this rapid process of novel phonological form acquisition is compromised in developmental reading disabilities such as dyslexia, which is known to have a core phonological processing deficit. We recorded EEG and extracted event-related potentials relative to the divergence points (DPs) of known words and phonologically matched novel word-forms. Healthy adults listened to sets of known native, novel native, and novel phonologically non-native word-forms which were repeated 150 times over 30 minutes either in a passive exposure condition while watching a silent film, or in an attend condition where they were instructed to carefully listen to the stimuli and memorise them. Our results indicated that the first negative-going response peak at ~50 ms after DP shows an amplitude increase for native novel word-forms between the early and late stages of exposure, this learning-related dynamics taking place similarly in attend and non-attend conditions. Responses to novel non-native word-forms, however, did not increase significantly, while responses for known words were suppressed by repetition. These adults were native Finnish speakers with a variable number of other languages learnt at school to different proficiency levels. When the number of learnt non-native languages and their average age of acquisition

(AoA) were regressed against the individual ERP changes, we found that the more languages with earlier average AoA one had learnt, the larger was the magnitude of non-native response increase. Average AoA also had a significant influence on the native novel word-form response development such that the later the non-native languages had been acquired on average, the larger was the response increase for the phonologically native novel input. To address the influence of reading skill and its impairment in dyslexia on this neural learning dynamics, EEG was recorded from 9-12–year-old dyslexic children and controls exposed to a novel native word-form in a passive listening session. The first negative ERP peak at ~65 ms post-DP showed a significant difference between the groups early on in exposure: whereas the response in controls increased with repetition, there were no comparable ERP dynamics in the dyslexic group. In conclusion, rapid formation of neural memory circuits for novel phonologically native words appears to be a largely automatised process. This neural mechanism, on one hand, is shaped by previous language-acquisition experience, and, on the other hand, impaired in dyslexia, which might be associated with its underlying phonological processing deficit.

E31 Early active acoustic experience with non-speech may confer a phonemic mapping advantage at 7- and 9-months-of-age.

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Over the first year of life, via the interplay between maturation and experience, infants construct language-specific phonemic maps within auditory cortex. In adults, theta oscillatory activity (4-8Hz) has been shown to track syllabic information and assist in temporally organizing phoneme-level response, whereas gamma activity (~30-100Hz) is reported to facilitate processing of linguistic segmental information. High gamma-band power (>70Hz), elicited in Superior Temporal Gyrus in response to native phonemes, is thought to represent a neural signature of phonemic mapping. Interactive acoustic experience using temporo-spectrally modulated non-speech stimuli (i.e. containing acoustic cues important for speech), has been shown to enhance the efficiency of infants' acoustic processing. Significant effects of acoustic experience were seen on the accuracy and speed of discrimination of key pre-linguistic acoustic cues; this enhanced processing generalized to discrimination of novel non-speech stimuli (Benasich et al. 2014). To explore neural mechanisms that may underlie such generalization effects, the longitudinal impact of inter-active nonlinguistic auditory experience on processing of speech syllables was examined at 7- and 9-months-of-age. Infants who had received active non-speech acoustic experience (AEx) between 4- and 6-months-of-age were presented with a consonant-vowel contrast varying in voice-onset time (VOT) using a passive auditory oddball paradigm. These infants were compared at each age to cross-sectional groups comprised of 7- and 9-month-old naïve controls (NC) with no such experience. Dense-array EEG (128-sensor net) was collected and mapped onto age-appropriate brain templates. Source modeling placed dipoles in both auditory cortices. Temporal-spectral analyses were conducted in source space, within the 2 to 90Hz frequency range, using 1Hz-wide frequency bins and time resolution of 50ms. Changes in frequency band amplitude, as a function of time relative to stimulus presentation, and consistency of phase alignment across trials were evaluated using TSE (temporal spectral evolution) and ITPL (inter-trial phase locking). Permutation testing combined with cluster analyses were followed by repeated-measures ANOVAs. Significant differences in the gamma range were found between groups at both ages, when processing the standard stimulus. The AEx group generated significantly more high-gamma power at both 7- and 9-months-of-age than the NC group. Greater high-gamma phase synchronization was seen in left auditory cortex for the AEx group whereas the NC group showed greater ITPL in right auditory cortex at both 7- and 9-months. At 7-months only, the NC group showed increased phase synchrony within the low-gamma range (<70Hz), as compared to the AEx group. These results demonstrate that effects of early non-speech acoustic experience generalize to speech and appear to enhance mapping of consonants varying in VOT. This is most clearly seen in response to the standard stimulus, which is critical to the construction of the cortical representation/map that supports rapid discrimination of incoming deviant stimuli. Thus, active auditory exposure during early infancy to non-speech stimuli, which contain linguistically-relevant acoustic cues, appears to confer a significant phonemic processing advantage, as compared to infants without such experience. Active auditory experience may facilitate neural plasticity and support more efficient left auditory cortex processing during the developmental period when infants are establishing their phonemic maps.

Grammar: Syntax

E32 What verbs can do: an ERP study on Basque

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A generally accepted view holds that agreement is a monolithic syntactic phenomenon that is based on asymmetrical feature-sharing between e.g. subject and verb. Inconsistent subject-verb features generate processing perturbations, normally signaled by late positive effects (P600), sometimes preceded by an early negativity. In this ERP study we go beyond this view by investigating the relation between agreement and discourse and focusing on the asymmetry between 1st and 3rd person plural forms. The composite makeup of 1st person plural - a group including speaker and non-participants (e.g. we=I+they) - contrasts with the homogeneous non-participant composition of the latter (they=he+he). This asymmetry is reflected in grammatical mismatches that some languages like Basque allow: 3rd person plural subjects can be followed by 1st person plural verbs, as in "japoniarrek.3.pl euskara ikasi dugu.1.pl "(We Japanese studied Basque with pleasure), where the speaker invoked by verb morphology is integrated in the group the subject refers to, deriving the overall "We Japanese" interpretation. We used a distinctive property of Basque - the proximity plural suffix –ok - which, unlike the fixed 3rd person interpretation of –ek suffixes (e.g. japonarr-ek, the Japanese), shifts nouns interpretation from 3rd to 1st person plural (e.g. japonarr-ok, we Japanese). If discourse influences agreement

interpretation, we expect qualitative differences between 1st and 3rd person mismatch processing, and specifically in the topography of the P600. Previous studies indicate frontal P600s as reflecting discourse-update and complexity-related mechanisms (Kaan & Swaab, 2003; Kaan et al. 2000), as opposed to repair-related parietal P600 effects (Friederici, 2002; Hagoort, 2005). We combined 1st- and 3rd-person affixes in Subject [S1, S3] and Verb [V1, V3] morphology to create grammatical (S3-V1) and ungrammatical (*S1-V3) mismatches. To assess 1st person mismatch effects, S3-V1 (Ikastaroan japoniarrek3.pl euskara ikasi dugu1.pl gustora, In class we Japanese learnt Basque with pleasure) was compared to S1-V1 (Ikastaroan japoniarrok.1.pl euskara ikasi dugu.1.pl gustora, In class we Japanese learnt Basque with pleasure) while 3rd person mismatch impact was measured by contrasting S1-V3 (*Ikastaroan japoniarrok.1.pl euskara ikasi dute.3.pl gustora, *In class we Japanese learnt Basque with pleasure") and S3-V3 (Ikastaroan japoniarrek.3.pl euskara ikasi dute.3.pl gustora, In class we Japanese learnt Basque with pleasure). 160 experimental sentences (40 per condition) and 80 fillers were presented word-by-word to 33 participants. ERPs were time-locked to subject (japoniarrek, japoniarrok) and auxiliary verb position (dute, dugu) and analyzed in two temporal windows: 300-500ms for early negative effects and 500-700ms for late positive effects. While no difference emerged between japoniarrek and japoniarrok, an N400-P600 pattern emerged at verb position. Critically, 1st-person mismatches elicited a frontally-distributed P600, as opposed to the parietal positivity generated by 3rd-person mismatches.These data highlight a dissociation between 1st and 3rd person agreement that is compatible with our hypothesis about their different underlying discourse complexity, and suggest that agreement comprehension spans beyond purely syntactic analysis. Moreover, they highlight the relevance of verbal morphology for the assignment of person interpretation. Taken together, these results call for a revision in the analysis of agreement relations from a theoretical and a processing perspective.

E33 Shared and distinct cognitive resources for syntax and prosody: a sentence comprehension study

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There is no consensus regarding the neural resources required for sentence comprehension. It is however, well established that sentences with canonical syntactic structure (e.g. subject-verb-object) are easier to comprehend than those with non-canonical syntactic structure (e.g. subject-object-verb), and that regular sentence prosody facilitates comprehension compared to monotone prosodic patterns. The sentence "complexity" effect may be in part due to additional cognitive resources that are required for comprehension of the non-canonical sentences such as working memory and/or cognitive control. The prosody effect may also be related to cognitive resource recruitment, in that prosodic cues may reduce the cognitive load required for comprehension. However, it is unclear how the cognitive resources engaged by prosodic and syntactic information interact. The present study identifies how prosody affects sentence comprehension as a function of syntactic complexity. Thirty-four cognitively-typical adults completed a sentence-picture matching task adapted from Wilson et al. 2010. Sentences varied in terms of sentence structure: canonical sentences contained subject-verb-object word order with a color modifier in one of two positions (e.g. 'The boy who is green is kissing the girl' and 'The boy is kissing the girl who is green'). Non-canonical sentences were of subject-object-verb word order in conjunction with either an active (e.g. 'The girl who the boy is kissing is green') or passive clause (e.g. 'The boy who the girl is kissed by is green'). Sentences were presented with either typical sentence prosody or word-list prosody (i.e. equal emphasis and timing for all words). Reaction times and accuracies were collected and each analyzed in a within-subjects 4x2 repeated measures ANOVA with four levels of syntactic complexity and two levels of prosody. Our accuracy results replicated previous work: there was a significant main effect of syntax with higher accuracies being observed on canonical structures compared to non-canonical structures; the non-canonical sentences containing a passive clause yielded the lowest performance. The main effect of prosody and the syntax x prosody interaction were not significant. The reaction time results, which are likely a more sensitive indicator of cognitive effort, were as follows: there were significant main effects for both syntactic structure ($F(3, 99)=106.75$, $p=<.0001$) and prosody ($F(1, 33)=8.84$, $p=.005$), with canonical sentences eliciting faster reaction times than non-canonical sentences and sentence prosody eliciting faster reaction times than word-list prosody. The syntax x prosody interaction was also significant, $F(3, 99)=3.08$, $p=.031$. This suggests that prosody facilitates comprehension of certain types of sentence structures, namely the canonical sentences with a color modifier placed at the end of the sentence and the non-canonical sentences containing an active clause. Both of these sentence types require working memory resources to maintain information about the subject to complete the task, so perhaps prosodic cues are facilitating that maintenance via chunking. Neuroimaging is necessary to determine if the functional anatomical correlates of the syntactic and prosodic effects overlap, but these preliminary results suggest that prosodic cues may reduce the cognitive resources required for sentence comprehension, particularly for certain sentence structures.

E34 A neurocomputational mechanism for parsing: Finding hierarchical linguistic structure in a model of relational processing

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Hierarchical representations are the hallmark of human language (Chomsky, 1957); thus forming them from linear input over time is a core computational problem for language processing (Embick & Poeppel, 2014; Giraud & Poeppel, 2012; Martin, 2016). But what are the computational origins of such an ability? One possibility is that the brain repurposed a mechanism already at its disposal when hierarchy in representation become an efficient solution to a problem posed by the environment. Recent compelling evidence suggests that hierarchical linguistic structure can be tracked in a cortical oscillatory signal (Ding et al., 2016). Strikingly, DORA (Discovery of Relations by Analogy; Doumas, Hummel, & Sandhofer, 2008), a symbolic connectionist model built to process and to learn structured (i.e., symbolic) representations of conceptual relations from unstructured inputs, predicts a

similar spiking pattern in the frequency domain of unit firing in response to the same stimuli. We tested the hypothesis that, without any formal or structural changes to the model, DORA could parse and would show a pattern similar to humans as observed by Ding et al. (2016). We simulated oscillatory unit data in DORA using Ding et al.'s Grammatical English sentences (modifier-noun-verb-noun, "new plans give hope", "dry fur rubs skin"), as well two additional conditions: Jabberwocky, where syntactic relations were intact without compositional meaning, and Word Salad, where neither syntactic nor semantic relationships existed between words. We tested whether DORA parsed the sentences correctly, and we observed the corresponding unit firing. The pattern of firing in DORA mirrored the pattern observed in humans. Specifically, DORA showed an activation burst that lasted throughout the processing of the sentence (i.e., firing at 1Hz range), activation bursts at twice the rate of the whole sentence burst corresponding to noun and verb phrases (i.e., firing in at 2Hz range), and activation bursts at 4 times the rate of the whole sentence burst corresponding to words (i.e., firing at 4 Hz range). The model showed this spiking pattern for Jabberwocky (same as Grammatical), but not for Word Salad (4Hz only), suggesting that the 1, 2, 4Hz firing pattern reflects formation of syntactic structure. DORA also formed different representations in response to Jabberwocky, which lacked the semantic organization seen in response to the Grammatical sentences. In sum, the model showed activation that was highly similar to the human cortical response to the same stimuli. Our model is an existence proof that this class of computational mechanisms (forming structured representations via temporal asynchrony of firing) can parse while expending energy in a brain-like way. Furthermore, the fact that the model showed spiking similar to humans for both grammatical sentences and jabberwocky supports the interpretation that both the model and the human data reflect generation of hierarchical syntactic structure. Such results are particularly compelling because they shine nascent light on two crucial questions for cognitive science: (1) how the brain might parse discrete structured representations from continuous unstructured input, as in language comprehension, and (2) how abstract linguistic structures might have come to be the way there are.

E35 Granularity of Prediction for English Verb Complements

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Previous neuroimaging evidence indicates the human brain is sensitive to the syntactic properties of verbs, even when encountered in isolation (Thompson et al., 2007, 2010; Meltzer-Asscher et al., 2015). Using magnetoencephalography (MEG), Linzen and colleagues (2013) showed that entropy over a verb's possible subcategorization frames (SCFs) was negatively associated with activity in the left anterior temporal lobe (LATL) between 200 and 300 milliseconds after word onset. This measure is an index of uncertainty regarding the category of a verb's complement, and thus also indexes the ease of selecting or predicting a complement when comprehending natural language. Still, complement selection/prediction is poorly understood. SCFs are defined by the syntactic constituents (e.g. noun phrase, prepositional phrase, sentential complement) that follow a verb, but some argue that complement selection relies on interaction of syntactic frames and their semantic subtypes (Grimshaw, 1979). Thus, entropy over a more granular set of "frames" may better reflect complement selection in the brain. With the goal of investigating this possibility, we developed a new, more granular measure of SCF entropy in which each individual preposition a verb selects is treated as a unique frame. Verbs vary greatly in the distribution of prepositions they select, and different prepositions may carry different semantic content. Therefore, prepositional phrases were an ideal source for introducing granularity, as we could treat each preposition as a different semantic subtype. We also developed a measure of entropy over the individual lexical items that follow a verb, representing an extremely fine-grained distribution in which SCFs are entirely irrelevant. To assess the validity of the new measures (Granular SCF entropy and Bigram Entropy, respectively) versus traditional SCF entropy, we conducted behavioral and MEG experiments using a visual lexical decision task, with 400 English verbs and 400 non-words. Linear mixed models fit to reaction time data, collected via Amazon Mechanical Turk, showed that Granular SCF Entropy and Bigram Entropy were both significant predictors of reaction, with higher entropy eliciting faster responses. No such effect was found for traditional SCF Entropy. MEG data, analyzed using distributed source analysis in MNE Python, revealed similar results. Spatiotemporal cluster tests, using fixed signed orientation and confined to the left temporal lobe, showed effects of Granular SCF Entropy in the inferior LATL around 150 ms. Activity was negatively correlated with Granular SCF Entropy. No effects of Bigram Entropy, or traditional SCF Entropy, were found. These data suggest that Granular SCF Entropy far outperforms traditional SCF Entropy as a predictor of lexical decision response time and brain activity. Thus, complement selection/prediction in the brain may be more granular than previously assumed. Importantly, including Bigram Entropy in the linear model did not wash out our effects of Granular SCF Entropy; our measure accounts for variance beyond simple next-word prediction. The results of this study shed light on the nature of complement selection and prediction, showing that the brain takes into account more than just SCFs when making decisions about upcoming complements.

E36 The eyes have it: cross-method and cross-linguistic patterns

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Predictive language processing has been investigated in various languages using event-related potentials (ERPs) and eye movements (EM). Languages differ on which cues predictions are predominantly based (MacWhinney, Bates, & Kliegl, 1984; Bornkessel-Schlesewsky & Schlesewsky 2009), but relative cue strength across languages has not been statistically contrasted. Moreover, the two methods often show different patterning of effects (Kretzschmar et al. 2015), thereby making inferences on cue strength difficult. We re-analyzed three sentence-reading experiments to capture variance in cue strength as induced by factors 'language' (English with dominant word-order

cue vs. German with dominant case cue) and 'method' (ERP vs. EM). There were 37 participants for German ERP, 84 for German eye-tracking (due to an additional between-subjects manipuation) and 16 for English eye-tracking. We focused on animacy as a universally available cue. All experiments examined the same interaction of animacy for the subject NP with the semantic verb bias, e.g. "A ballerina/feather danced/floated across the stage." While all four combinations are possible, the verb "dance" is biased towards an animate subject. As such, we expect the first argument to generate a prediction about the animacy (bias) of the second argument. In eye-tracking data from both German and English, we observed an increase in go-past time in the sentence region following the second argument when there was a mismatch. In ERP data from German (with RSVP), we observed an N400 effect on the second argument for the mismatch. The effect was always strongest for an inanimate subject with an animate verb. These experiments form a meta-experiment in two ways: the eye-tracking data form a between-subjects design for the 'language' factor, while the German data form together a between-subjects design for the 'method' factor. The combined eye-tracking data can be used to examine the variation in animacy cue-strength across languages. Using mixed-effects models, we found no main effect nor any interactions for language, indicating that the animacy effect was equally strong across both languages. We combined eye-tracking and ERP data by aggregating one measure across participants (who differed between methods) to provide a numeric predictor for the other with mixed-effects models. Interestingly, the models based on the aggregate data provide nearly as good a fit as models based on the factorial experimental manipulation. Moreover, the eye-tracking data (go-past times) seem to better predict the EEG data (N400 amplitude) than the other way around (the t-ratio of estimate-to-error is larger). Taken together, these data support the role of animacy in predictive processing even in languages where sentence processing is more strictly based on linear word-order. Despite the lack of alternative interpretations in English, a less than ideal subject or Actor argument still elicits as strong a prediction error in English as in German. Finally, we have demonstrated a quantitative relationship between the eyes and the brain in which go-past time is a better predictor of brain activity than a single ERP component is of eye movements. This suggests a complex hierarchy of predictive processes, which are differentially covered by particular ERP components and EM measures.

E37 The P600 behaves like a P3: adding MVPA to the evidence from skin response, event-related desynchronization, response time alignment, and heart period

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Syntactically ill-fitting words are often followed by a late, centro-parietal positive deflection of the EEG. It has traditionally been assumed that this P600 effect is an index of syntactic, or, since the discovery of so-called "reversal anomalies", general combinatoric, or structural processing. This perspective has had great impact on neurocognitive models of sentence processing. Alternatively, it has been suggested that the P600 is in fact a P3 component, i.e., a late, centro-parietal scalp-positive ERP component that indexes salience across modalities and levels of processing (e.g., Coulson & Kutas, 1998; Bornkessel-Schlesewsky et al., 2011). Counter this domain-general explanation, it has often been argued that the P600 does not reliably follow semantic violations, whereas it does reliably follow syntactic violations. We question both lines of evidence for a structural processing account: First of all, beginning with, but not restricted to "reversal anomalies", semantic violations have repeatedly been observed to elicit late positivities (e.g. Szewczyk & Schriefers, 2011), depending on factors such as task relevance and salience, that are also known to influence both the P3 and the 'syntactic' P600. Furthermore, syntactic violations do not necessarily elicit late positivities once salience per se has been factored out (e.g., Batterink & Neville, 2013). Across four pre-registered EEG experiments of sentence processing, we have attempted to falsify the alternative P600-as-P3 hypothesis, employing a uniquely broad range of dependent measures, some of which are novel in the context of linguistic research. However, rather than falsifying this hypothesis, we consistently observed results that are compatible with the interpretation of the P600 as being a P3 that is elicited in a language context. (1 & 2) Like the P3 (cf. Verleger, 2005), we found the P600 to be temporally aligned to the time of response execution in auditory ($n=20$, $r > .5$, $p < .01$, Sassenhagen, Schlesewsky & Bornkessel-Schlesewsky, 2014) and visual ($n=20$, $r > .5$, $p < .01$, Sassenhagen & Bornkessel-Schlesewsky, 2015) sentence processing, when using paradigms with immediate manual responses. (3) In a visual sentence processing task without immediate responses ($n=25$), the P600 following syntactic violations was accompanied by an increase in skin impedance ($p < .05$), a decrease in heart period ($p < .05$), and a desynchronisation of EEG alpha band activity – much like it was previously observed for the P3 (Nieuwenhuis et al., 2005). (4) Finally, in a new study, 20 subjects took part in both a standard visual syntactic violation (modelled after Osterhout & Morley, 1995) and a visual oddball experiment. Using time-generalization multivariate pattern analysis/MVPA (King & Deheane 2014), a novel, but conceptually simple technique that can decode shared neural patterns of brain responses with different temporal profiles, we show that the P600 is reliably classified as a P3 (AUC ROC >65%, $p < .01$). In conclusion, we demonstrate across a wide range of novel measures that the P600 behaves like a P3. This has potentially far-reaching implications for models of language processing relying on the assumption that the P600 is an index of combinatoric or structural processing.

Language Disorders

E38 Acute cerebral perfusion does not predict long-term recovery from aphasia

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Among individuals with stroke-induced aphasia, there is great diversity in terms of etiology, attributes of the stroke itself, and importantly, the prognosis. One of the many challenges facing clinicians pertains to accurately estimating prognosis for

individual patients. Clinicians can utilize a variety of factors to inform this prediction including demographical factors such as gender and age as well as stroke-related factors such as the location and size of the lesion. Accordingly, the aim of the current study was to determine whether baseline neuroimaging and clinical data can be utilized to predict long-term recovery from aphasia. The clinical factors under consideration included cerebral perfusion, lesion location, lesion size, and initial severity of aphasia as indicated by performance on clinical tests. Participants included 54 patients, all of whom incurred a single left hemisphere ischemic stroke. All participants provided informed consent to be included in the study. The mean age at initial examination was 67.0 years (SD=11.1 years, range=40 – 86 years). Follow-up behavioral data were available for 33 of the 54 patients. The mean age at follow-up was 67.8 years (SD=10.1 years, range=42.9 – 82.3 years) and mean interval between initial examination and follow-up testing was 4.0 years (SD=0.9 years, range=2.4 – 5.4 years). Participants completed the Bedside Evaluation Screening Test, 2nd edition (BEST-2) and the Apraxia Battery for Adults – Second edition (ABA-2). MRI data were acquired including T1-weighted imaging, axial diffusion-weighted imaging (DWI), FLAIR, and contrast enhanced T2* perfusion weighted MRI. Data were analyzed using support vector regression. The first set of analyses focused on the prediction of acute behavior based on lesion size and location as well as from the combination of lesions and perfusion data (mean transit time [MTT] and time to peak [TTP]). Independently, the lesion data were moderately predictive of BEST-2 scores, including object naming (r=.40), object description (r=.49), and overall aphasia severity (r=.57). Similar results were found for acute performance on the ABA-2: diadochokinetic rate (r=.46), oral apraxia (r=.42), and utterance time for polysyllabic words (r=.46). Cerebral perfusion data did not improve prediction of acute behavior beyond lesion size and location. The second set of analyses focused on prediction of chronic scores from acute clinical test scores, from the lesion and perfusion data, and from the combination of acute scores and lesion and perfusion data. Prediction accuracy of chronic clinical scores varied widely: Six scores were predicted from initial clinical scores with greater than r=.60 correlation between actual and predicted values (conversational expression (r=.75) and quotient score (r=.72) on BEST-2; diadochokinetic rate (r=.75), increasing word length (r=.69), repeated trials (r=.62), and inventory of articulation characteristics of apraxia (r=.85) on the ABA-2). Acute lesion data and/or perfusion data did not improve prediction of chronic behavioral scores beyond what was accomplished with acute behavioral scores. These preliminary results indicate that so far, lesion data provide the best prediction of acute scores and baseline clinical performance provides the strongest prediction of chronic scores. Further analyses will elucidate whether perfusion information can still be incorporated to refine predictions of prognosis in aphasic patients.

E39 Rhythm processing deficits in the non-fluent variant of primary progressive aphasia

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Introduction: We studied non-linguistic auditory processing in primary progressive aphasia (PPA) to gain insight into the mechanisms underlying aphasia as well as to probe the biological relationship between auditory processing and speech in the human brain. Methods: A consecutive series of 18 cases of PPA (8 semantic variant, 6 non-fluent variant, 4 logopenic variant) were recruited via the memory clinic of the University Hospitals Leuven. Twenty-eight community-recruited elderly controls performed the same testing battery. One of the inclusion criteria was a normal pure-tone audiogram. Subjects underwent a battery of 12 psychoacoustic tests of pitch, rhythm and timbre. During the 4 pitch tests, subjects had to detect pitch differences between 2 tones or during a sequence of tones. During the 4 rhythm tests, subjects had to detect the longer gap in pairs of tones or in a sequence of tones. Also, they had to discriminate between rhythmic sequences of 7 tones with a strongly or weakly metrical beat. During the timbre tests, subjects had to discriminate between pure and modulated tones, and between different types of modulation. Ten of the tasks were based on an adaptive staircase procedure to determine just noticeable difference thresholds, the remaining two were based on a same-different paradigm measuring accuracy for a given difficulty level. First, we evaluated differences in auditory processing between the 3 main clinical phenotypes using Kruskal-Wallis ANOVA. Second, we tested whether we could reliably distinguish between phenotypes based on the psycho-acoustic profile. For this purpose, we used a machine learning approach (linear support vector machines). We evaluated the vector weights to determine which psycho-acoustic tests were most important for classification. Results: The comparison of the psycho-acoustic test scores for the 3 phenotypes revealed between-phenotype differences for the discrimination of rhythmic sequences with a weakly metrical beat (chi2(2)=9.36, P=0.009). Post-hoc comparisons demonstrated that this task was significantly more impaired in the non-fluent variant compared to the other 2 phenotypes (Tukey-Kramer P < 0.05). At the individual level, 3 of 6 non-fluent PPA patients displayed a significant impairment on discrimination of rhythmic sequences with a weakly metrical beat and 3 of 6 displayed a significant impairment on discrimination of rhythmic sequences with a strongly metrical beat (corrected for number of tests and fluid intelligence measured by Coloured Progressive Matrices). Solely based on the psycho-acoustic test scores, we were able to reliably distinguish between the non-fluent and logopenic variant using support vector machines (classification accuracy: 77.6%, P=0.026). Vector weights were highest for discrimination of rhythmic sequences with a weakly metrical beat and detection of pitch differences during a sequence of 7 tones. Conclusions: We report impaired discrimination of rhythmic sequences in the non-fluent variant of PPA. This is particularly striking because this phenotype is clinically characterized mainly by a speech production deficit. The common underlying mechanism might be localized to

the auditory timing pathways, which contribute to processing of acoustic input and speech output. Reference: Grube M, Bruffaerts R, Schaeverbeke J, et al. (2016), Core auditory processing deficits in Primary Progressive Aphasia, Brain (DOI: http://dx.doi.org/10.1093/brain/aww067)

E40 "quack" and duck : processing environmental sounds and auditory speech comprehension in aphasia.

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Introduction Verbal and non-verbal stimuli have been shown to rely on a similar network of brain regions in both brain damaged and healthy individuals1,2. More recent research has shown that language and environmental sounds share perceptual and informational features3,4. The aim of the present study was to investigate environmental sounds identification in chronic aphasic stroke patients with a range of auditory comprehension abilities. Method 16 chronic aphasic stroke patients (10 males) took part in the study. All were English dominant language speakers, pre-morbidly right handed and had a left hemispheric stroke. The mean age was 61 years (s.d. = 12 years). The mean time post stroke at testing was 8 years (s.d. = 7 years). They completed a tailor-made environmental sounds identification test adapted from Leech and colleagues3 4. This required patients to press a button as quickly as possible when a previously heard target sound e.g., dog barking, appeared in a stream of background noise e.g., street noise. Accuracy and reaction time data were collected. To detail their language performance patients completed the Comprehensive Aphasia Test (CAT) battery. They also had a high resolution T1 volumetric MRI brain scan. A lesion overlap map for the group indicated that the most common area of brain damage was left temporo-parietal cortices, in the vicinity of Wernicke's area, (n= 9/16). Behavioural data were analysed using SPSS Statistics Version22. All reported results are significant at p=0.05 corrected. Results As a group the patients scored significantly worse than healthy age matched controls. The patient group's mean accuracy was 76% (s.d.= 21%) correct. Normative data (n=15) was 91% (s.d = 7%). Within the patient group there was a significant positive correlation between performance on the environmental sounds test and single word auditory comprehension scores on the CAT (r = 0.517, p=0.040). There were no other significant correlations with other language scores from the CAT. Conclusion In this group of patients following left hemisphere brain damage, involving Wernicke's area patients with single word speech comprehension deficits also had environmental sound deficits. These data suggest that there is a significant relationship between language and non-language auditory processing skills, at least at the single word level (further to Saygin et al., 2003). Further analyses in a larger group of aphasic stroke patients will investigate the role that Wernicke's area may play not only in speech comprehension but also naturalistic auditory scene analysis and auditory object detection. References: 1. Saygin, A.P et al (2003). Brain, 126, 928-945. 2. Dick, F. et al. (2007). Journal of Cognitive Neuroscience, 19(5), 799–816. http://doi.org/10.1162/jocn.2007.19.5.799 3. Leech, R. et al. (2009). Journal of the Acoustical Society of America, 126, 3147-3155. 4. Aydelott, J. et al. (2010). Trends in Amplification, 14 (4), 218-232.

E41 Verbal and non-verbal auditory processing impairments in Primary Progressive Aphasia: an event-related potential investigation

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Primary progressive aphasia (PPA) is a disorder of declining language caused by neurodegenerative disease. As an aphasic syndrome, auditory word processing is impaired in PPA, but previous behavioral results (Goll JC, 2010) showed that processing of object sounds (e.g. a dog's barking) can also be abnormal in PPA, suggesting that auditory agnosia often accompanies aphasia in PPA. In this study we investigated the processing of complex non-verbal and verbal sounds in 12 patients with PPA and 13 healthy age-matched controls, at both the behavioral and electrophysiological levels. Participants completed a test in which they first heard a sound, which was either verbal (the name of the object, e.g. "dog") or non-verbal (the sound the object makes, e.g. "barking"), followed by a picture, and then judged whether the sound and picture matched. Behavioral results showed that PPA patients were slower and less accurate at this task, in both the verbal and non-verbal conditions. Electrophysiological activity was also examined during the task via the event-related potential (ERP) technique, in which electrical activity on the scalp is measured in response to stimuli. The PPA patients generated lower amplitude N400 ERPs than controls in both conditions, providing further electrophysiological evidence that both verbal and non-verbal auditory processing is impaired in PPA. This suggests that patients with PPA often have a secondary auditory agnosia in addition to aphasia. Future studies can help determine whether auditory agnosia in PPA has an apperceptive (sensory) or associative (conceptual) basis.

E42 Progressive aphasias as disorders of auditory information processing: behavioural signatures and structural neuroanatomy

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Impaired processing of speech in primary progressive aphasias (PPA) may be underpinned by more fundamental deficits of acoustic signal decoding that remain to be fully defined. We used a novel neuropsychological battery to probe the processing of acoustic information in patients with semantic dementia and progressive nonfluent aphasia relative to elderly controls; and assessed group neuroanatomical correlates using voxel-based morphometry. In a series of two-alternative forced-choice tasks, participants were required to discriminate between short sequences of spoken phonemes manipulated for three basic characteristics: phoneme intelligibility (natural vs spectrally rotated speech); temporal regularity (isochronous vs anisochronous); and signal entropy (highly predictable sequences vs sequences with low predictability). Both patient groups were impaired relative to controls across all three tasks, with no significant differences between patient groups. However, voxel-based morphometry correlating behavioural task scores with regional grey matter volume in the patient

cohort revealed separate syndromic profiles of grey matter loss affecting dominant anterior temporal cortices (correlated with processing temporal regularity), amygdala (phoneme intelligibility) and posterior cingulate (signal entropy) in SD, and a frontoinsular network in PNFA (correlated with processing temporal regularity) with atrophy also affecting the supramarginal gyrus (correlated with phoneme intelligibility). Our findings suggest that PPA syndromes are underpinned by generic mechanisms of impaired speech signal decoding with differentiable neuroanatomical substrates. The findings have implications for the clinical diagnosis and nosology of PPA as more fundamental disorders of cortical information processing.

E43 Dyslexic brain activation abnormalities in deep and shallow orthographies: a meta-analysis of 28 functional neuroimaging studies

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There has been considerable effort in understanding the neurobiological basis of developmental dyslexia. During the last two decades a substantial number of studies using neurocognitive methods such as fMRI and PET were conducted in order to reveal the neural systems linked to difficulties in learning to read. The present coordinate-based meta-analysis aimed to clarify whether the functional neuroanatomical manifestation of dyslexia is similar in written alphabetic languages differing in orthographic depth. We selected one set of neuroimaging studies conducted in a deep orthography (English) and a second set of studies conducted in shallow orthographies (Dutch, German, Italian, Swedish). In order to identify and localize universal reading-related brain activation abnormalities in dyslexia, separate meta-analyses were computed for the two orthography-specific sets. To further identify orthography-specific abnormalities, these separate maps were directly compared in a meta-analytic difference map. We selected fMRI and PET studies that met the following criteria: (1) visual stimuli were letter strings of words or nonwords, (2) tasks were reading or reading-related (e.g., rhyme judgments, phonological lexical decision), and (3) whole brain analyses of group comparisons (dyslexic vs. non-impaired readers) were reported in a standard stereotactic space (Talairach or MNI). Furthermore, we restricted the study selection to studies of alphabetic writing systems. On the basis of these criteria, we identified 14 studies with English-speaking participants (deep orthography) and 14 studies with Dutch-, German-, Italian-, or Swedish-speaking participants (shallow orthographies). In sum, 28 studies (23 fMRI and 5 PET) with a total number of 907 participants were included in the meta-analysis. We used Seed-based d Mapping software (http://www.sdmproject.com), version 4.31. The meta-analytic maps were thresholded using the recommended voxel-level (height) threshold of $p < 0.005$ (uncorrected) and a cluster-level (extent) threshold of 10 voxels. In line with the idea of a universal neurobiological origin, we found common underactivation in dyslexic compared with non-impaired readers in left middle, inferior temporal, and occipito-temporal regions. Higher meta-analytic convergence of underactivation in deep compared with shallow orthographies was identified in the bilateral intra-parietal sulcus, right superior temporal sulcus, left precuneus, and inferior frontal gyrus pars triangularis, whereas higher meta-analytic convergence of underactivation in shallow compared with deep orthographies was found in the left fusiform gyrus, temporo-parietal cortex, inferior frontal gyrus pars orbitalis, and frontal operculum. Higher meta-analytic convergence of overactivation in deep compared with shallow orthographies was found in the left anterior insula, whereas higher meta-analytic convergence of overactivation in shallow compared with deep orthographies was found in the left precentral gyrus. The present coordinate-based meta-analysis provides an objective quantification of commonalities and differences of dyslexic functional brain abnormalities (relative to non-impaired readers) between alphabetic languages varying in orthographic depth. Dysfunctions and compensatory mechanisms of dyslexic readers in deep (English) and shallow orthographies (Dutch, German, Italian, Swedish) were reflected in the degree, spatial extent, and exact anatomical location of under- and overactivation clusters. The present meta-analysis broadens our understanding of the functional neuroanatomical signature of dyslexia and provides insights into compensatory mechanisms that may support remediation across languages varying in orthographic depth.

E44 Can you play with fire and not hurt yourself? A comparative study in idiom comprehension between individuals with and without Autism Spectrum Disorder

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Individuals with High functioning autism (HFA) are distinguished by relative preservation of linguistic and cognitive skills. However, problems with pragmatic language skills have been consistently reported across the autistic spectrum, even when structural language is intact. Our main goal was to investigate how individuals with HFA process idioms as a type of figurative language, and, specifically, how they integrate information from multiple sources (e.g. visual modality and language) in this process. In this study, we were interested in the extent to which visual context, e.g., an image corresponding either to the literal meaning or the idiomatic meaning of the expression can facilitate responses to such expressions. Four categories of figurative language expressions -3 idiom categories and 1 type of metaphors- were included: biological idioms, cultural idioms, instructive idioms (proverbs) and novel metaphors. Participants with HFA and their typically developing peers (matched on intelligence and language level) completed a sentence-picture matching task for idioms and their target meaning represented as images. On half of the trials, the expressions were presented visually on a computer screen, and auditorily via loudspeakers, on the other half. We hypothesized that since individuals with HFA have been reported to have a tendency for literal interpretation, they would have difficulties in appreciating the non-literal or extended nature of idioms and figurative language in general. Analyses of accuracy (ACC) and reaction times (RTs) showed clearly that the HFA participants performed at a lower level than their typically developing peers. In addition, the modality in which the stimuli were presented turned out to be an important variable in task performance for the more transparent expressions: The individuals with

HFA showed more errors and greater reaction latencies in the auditory modality compared to the visual presentation modality of the language stimulus, implying greater difficulty in oral language. We also found differences in performance depending on the category of the expression. Participants had more difficulties understanding the cultural and instructive idioms. This research highlights the importance of the modality the cues are presented in and the way the comprehension of figurative language can differ between typically developing individuals and highly verbal individuals with autism. In addition, this study can contribute to better understanding of the causes of pragmatic language problems in autism, and more broadly the well-attested comprehension and communication problems in that population. Keywords: autism, figurative language comprehension, idioms, visual and auditory modality

E45 Computer-based word reading training improves oral reading accuracy in patients with chronic central alexia

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Introduction: Central alexia is an acquired reading impairment in the context of a speech and language disorder (aphasia), and is a common consequence of stroke to the left middle cerebral artery (MCA) territory. The present study tested 'iReadMore', a reading training App designed to improve word reading accuracy in central alexia. Based on the triangle model of reading (Plaut, 1997), iReadMore presents repeated pairings of written words, spoken words and pictures to rebuild connections between orthographic, phonological and semantic representations. Methods: A group of 19 patients with left MCA stroke participated in the study. Participants were at least 1 year post-stroke (range: 1-13 years) and were impaired on tests of word reading and speech production, consistent with a diagnosis of central alexia. A baseline-controlled, repeated-measures design was used. Reading was tested at time-points T1, T2 and T3, at four week intervals. Training occurred between T2 and T3. Participants were asked to complete 35 hours of reading training over those four weeks. Participants attended three face-to-face sessions per week, each for forty minutes, and the remainder of training was done independently. The T1 reading assessment consisted of reading aloud 590 high frequency words between 3-6 letters long. Based on each participant's performance, two lists of 150 words were selected, one to be used in the training (trained words) and one not to be trained (untrained words). Each participant's customised trained and untrained lists were matched for psycholinguistic variables (word length, number of syllables, written frequency, imageability, N-size and regularity) as well as baseline reading accuracy. Results: Participants achieved an average training dose of 34h (range: 26-37h). A 3x2 repeated-measures ANOVA with factors time (T1, T2, T3) and word list (Trained, Untrained) was performed. Both main effects were significant and, critically, so was the time by list interaction ($F(2,36)=16.3$, $p<.00001$). Further analysis revealed that between T1-T2 reading accuracy improved by an average of 3%, but this test-retest effect did not differ between trained and untrained words. Between T2 and T3 there was a significant therapy effect, with an average improvement for trained words of 9% and a non-significant change for untrained words of 1%. A separate linear regression analysis revealed that, out of a range of demographic predictors, (baseline reading ability, training dose, age, time since stroke and lesion volume) only time since stroke had a significant influence on training effect size (Model $R2=.25$, $p<.03$): the greater the time since stroke, the greater the treatment effect. Discussion: This study demonstrates that intensive computer-based word reading therapy improves reading accuracy for trained words in patients with central alexia. The item-specificity effect is in line with previous therapy studies for speech production in aphasia: training does not tend to generalise to untrained items. In addition, this study provides strong evidence that patients continue to benefit from aphasia therapy long after their stroke occurred. References: Plaut, DC (1997). Structure and function in the lexical system: insights from distributed models of word reading and lexical decision. Language and Cognitive Processes, 12:765-805.

E46 Lesion and fMRI data reveal the contribution of right-hemisphere subcortical regions to auditory sentence comprehension

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Introduction: We investigated (1) which language tasks are frequently affected by right hemisphere damage, (2) which brain regions are most consistently damaged in those with impaired performance, (3) how consistently these regions are activated when healthy right-handed participants perform the same tasks and (4) the functional contribution of these regions. Methods: Patients were selected from the PLORAS database [1] according to the following inclusion criteria: right-hemisphere stroke as attested by a neurologist and defined by an automated lesion identification algorithm [2]; patients with lesions larger than 1cm3; native speakers of English; right-handed prior to their stroke; > 1 month and < 10 years since stroke. These criteria were met by 70 RH stroke patients, who were all assessed using the Comprehensive Aphasia Test [3]. In 50 healthy, right-handed, native-English speakers, we used fMRI data to investigate the brain areas activated during single word and sentence production and comprehension (Experiment 1; n=25) and during one-back matching on stimuli that varied in the demands on sensory (auditory or visual), semantic (pictures or sounds of objects) and phonological (words and pseudoword) processing (Experiment 2; n=25). We used standard fMRI data analyses in SPM12 and report effects that are corrected for multiple comparisons within regions of interest from the lesion study. Results: We found that: (1) The task most affected by right hemisphere damage was auditory sentence-to-picture matching. This was impaired in 14 out of 70 patients. Difficulties performing this task were observed even when picture/scene recognition was intact and the patients were unimpaired in auditory sentence repetition and digit span. (2) Out of 14 patients who had impaired auditory sentence-to-picture matching, 6 had damage to the right thalamus, putamen, caudate and surrounding white matter. Conversely, out of 14 patients who had >95% damage to the above right

subcortical regions, 6 had impaired auditory sentence-to-picture matching. Therefore the incidence of difficulties after damage to the right subcortical regions was 42.8% (6/14). (3) In healthy right handed participants, the right thalamus and putamen (not the caudate) were activated for sentence-to-picture matching relative to rest in the majority of subjects. However, group activation was not specific to tasks involving sentence production and/or comprehension (Experiment 1). (4) Activation in the right thalamus and putamen was significantly higher for one-back matching on auditory or visually presented pseudowords relative to the same task on semantic stimuli (Experiment 2). Conclusions: (1) The language task that was most frequently affected by right hemisphere damage was auditory sentence-to-picture matching. (2) The incidence of impaired sentence-to-picture matching after damage to the right thalamus, putamen and caudate was 42.8% (6/14). (3) Right thalamus and putamen were activated by but not specific to auditory sentence-to-picture matching. (4) Activation in the right thalamus and putamen was higher for one-back matching on phonological than semantic stimuli or sensory processing. Sentence-to-picture matching difficulties after damage to these regions may therefore reflect impaired phonological short term memory that differentially affects sentence comprehension more than other tasks.

Meaning: Combinatorial Semantics

E48 Metaphor initiates semantic changes: Evidence from an fMRI study on Chinese verbs

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Aims: Non literal meaning of a word can be extended from its literal meaning via semantic changes along language using. In brain imaging studies on Indo-European languages, the motor areas were also found to be activated in access to the non literal meaning of a verb (e.g., non literal meaning "The public grasped the idea" in contrast to literal meaning "The daughter grasped the flowers"). During this processing, a mapping from literal meaning to non literal meaning was proved to occur as a metaphor cognitive pattern. However, it was unclear for Chinese verbs. Methods: In a block designed fMRI experiment, 17 right-handed Chinese speaker made a semantic decision, "YES" for semantic legitimacy phrases (e.g., literal meaning: 挖地道, Wa1 Di4dao4, excavate a tunnel; non literal meaning: 挖新闻, Wa1 Xin1wen2, extract the news), "NO" for semantic illegitimacy phrases (e.g., *喝电影, He1 Dian4ying3, *drink the movie), with an arrow direction decision as the baseline task. The familiarity and Chinese character strokes of the materials were controlled. Results: For behavior data, a shorter reaction time and lower accuracy were shown for verb phrases with non literal meaning (RT: 582±84ms; Accuracy: 89±6%) compared to verb phrases with literal meaning (RT: 566±91ms; Accuracy: 92±7%). For fMRI data, cuneus(BA18), precentral gyrus (BA46), and inferior frontal gyrus (BA45) on the left hemisphere were activated for both literal and non literal meaning verb phrases, but with stronger activation for the latter. In contrast, more brain areas including sub-gyral, lingual gyrus (BA30) on the left hemisphere, and cuneus (BA18), precentral gyrus (BA46), postcentral gyrus (BA123) on the right hemisphere were activated only for non literal meaning verb phrases compared to literal meaning verb phrases. Conclusions: Non literal meaning of the verb is more difficult to be accessed than its literal meaning, which was reflected by longer reaction time, stronger activation and more brain areas involved for the former compared to the latter. Especially, besides Broca's area, bilateral motor area were activated in the processing of non literal meaning verb phrases. It indicated that a mapping from literal meaning to non literal meaning occurs in the access to the non literal meaning of Chinese verbs. In summary, the present fMRI study provided a neurobiological evidence that semantic changes are initiated by metaphor.

E49 Early Sensitivity to Argument Structure in the Left Inferior Parietal Lobe

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Several cognitive neuroscience studies have implicated the left inferior parietal lobe (LIPL) in the processing of the argument structure of linguistic stimuli. Hemodynamic data have shown LIPL activity to be associated with the number and complexity of arguments taken by a verb across several types of task (Thompson et al. 2007, 2010; Meltzer-Asscher et al., 2015; Shetreet et al., 2007). However, much of the previous work on the role of the IPL does not preclude the possibility that this region is sensitive to the structure of events rather than relational processing, nor does it address whether the activity in question is specific to verb processing. To complicate matters, the LIPL has been proposed as a locus underlying the representation of event concepts, and has been reported in both verb vs. noun and event vs. object noun contrasts (Binder and Desai, 2011; Bedny et al., 2008; Bedny et al., 2014). To disentangle the functional role of the LIPL in language processing, we conducted a magnetoencephalography experiment with class-ambiguous words that varied in their argument structure and eventivity. Each word was presented once in a noun context and once in a verbal context, embedded at the beginning of generic sentences on which participants performed true-false judgments. Noun phrases began with the indefinite article "a", and verb phrases with the infinitive marker "to." The magnetic fields evoked by the target words were averaged by condition and their neural generators determined by minimum-norm estimates. Temporal cluster tests were conducted with Brodmann areas 39 and 40 (the angular and supramarginal gyri) as the region of interest. For verbs, we found a main effect of transitivity from 115-165 ms after onset of the target word, with transitive verbs eliciting more activity than intransitives. While not statistically reliable as an interaction, spatiotemporal clustering tests uncorrected for multiple comparisons suggest that this effect of transitivity was present for event-denoting but not for non-eventive nouns in the same time window. These results suggest that the LIPL is sensitive to the thematic relations entailed by events, regardless of grammatical class, and that this information is accessed extremely early in the process of word recognition.

E50 Metaphors are concrete: Evidence from ERP

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How is the metaphorical meaning of a word derived incrementally in a sentence? Does the verb 'grasp' in the sentence 'he grasped the idea' have two separate meaning representations ('understand' and 'physical hold'), or one

representation in which the two are related? In processing terms, according to one view, the processing of polysemous words involves the activation of all senses initially, with the relevant senses enhanced and the irrelevant senses suppressed later on (Gernsbacher et al., 2001). According to another view, an underspecified purport of a word with multiple related senses is activated initially, and is then homed in to the intended sense through context (Frisson & Pickering, 2001). Here we proposed a grounded cognition view: The metaphorical sense is not a separately represented entry that gets activated. Rather, it is directly based on the concrete senses. This proposal has received support from some fMRI studies showing that motor regions are engaged during the processing of action-related metaphors (Desai et al., 2011). However, it is unclear whether the observed fMRI activation was due to the initially activated, irrelevant, literal senses. The current study used ERP to further examine the time course of the initial activation of the metaphorical and literal senses of a word embedded in sentences. Participants were 28 native-English-speaking undergraduates. Stimuli consisted of 88 triplets of sentences, with the verb being the target word: [Metaphor] 'The community church bent the rules'; [Concrete-literal] 'The mean bodyguard bent the rod'; [Abstract-literal] 'The community church altered the rules'. The psycholinguistic properties of the target words and sentence familiarity were matched between conditions. The conditional probabilities of the target words given the word before them were also matched using the Microsoft Web N-gram service. In the EEG session, sentences were presented word by word, with a length-dependent duration. Participants were instructed to read silently and attentively. A yes-no comprehension question appeared after 25% of the trials to verify participation. The resulting ERPs were time-locked to the target words. ERP differences between conditions emerged at ~200 ms, consistent with the timeline of semantic activation. Concrete-literals elicited larger negativity than abstract-literals from 200-400 ms, frontally distributed, similar to word concreteness ERP effects (Barber et al., 2013). Metaphors elicited larger negativity than concrete-literals from 300-500 ms, centrally and posteriorly distributed, similar to metaphor ERP effects (Lai et al., 2013). Metaphors also elicited larger negativity than abstract-literals from 200-500 ms at all locations. Thus, throughout the 200-500 ms window, metaphors were either similar to or more negative than concrete-literals, and never more similar to abstract-literals. The results indicate that concrete senses are more semantically rich than abstract senses, and that concrete senses, when used in a metaphorical way, are exploited further and made semantically richer for grounding the abstract concept of interest. This supports the grounded cognition view rather than the suppression view. The findings are also consistent with the underspecification view, provided that the underspecified meaning is concrete, and hence part of both the literal and metaphorical senses.

Meaning: Discourse and Pragmatics

E51 To plan or to listen? The trade-off between comprehension and production in conversation.

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Transitions between speakers in conversation are usually smooth, lasting around 200 milliseconds. Such rapid response latencies suggest that, at least sometimes, responders must begin planning their response before the ongoing turn is finished. Indeed, evidence from EEG suggests that listeners start planning their responses to questions as soon as they can, often midway through the incoming turn [1]. But given substantial overlap in the neural hardware for language production and comprehension, early response planning might incur a cost on participants' concurrent comprehension of the ongoing turn. Do early responses come at the expense of less careful listening? We performed an EEG study in which participants played an interactive game with a confederate partner. Participants saw two pictures on their screen (e.g., a banana and a pineapple), then heard a (prerecorded) question from their partner, and then responded verbally by naming the correct picture. Participants were made to believe that their partner spoke to them live. Examples of the conditions in the experiment: 1. Early planning: 'Which object is curved and is considered to be fruit/healthy?'; 2. Late planning: 'Which object is considered to be fruit/healthy and is curved?' (response: 'the banana'). The questions were designed such that participants could start planning their response early (Example 1) or late (Example 2) in the turn. Crucially, in another part of the turn, we included either an expected word (e.g., 'fruit') or an unexpected one (e.g., 'healthy') to elicit a differential N400 effect. Our aims were two-fold: replicating the prior planning effect [1] and testing the effect of planning on comprehension. First, our results largely replicated the earlier study [1], showing a large positivity in the ERPs and an alpha/beta reduction in the time-frequency domain, both immediately following the onset of the critical information when participants could have first started planning their verbal response (i.e., 'curved'). As before [1], we interpret these effects as indicating the start of response planning. Second, and more importantly, we hypothesized that the N400 effect (the ERP difference between 'fruit' and 'healthy') would be attenuated when participants were already planning a response (i.e., in early vs. late planning). In contrast, we found an N400 effect of similar size in both the early and late planning conditions, although a small late positivity was only found in the late planning condition. Interestingly, we found a positive correlation between participants' overall response time and the size of the N400 effect after planning had started (i.e., in early planning), illustrating a trade-off between comprehension and production during turn taking. That is, quick responders showed a smaller N400 effect. We argue that their focus on production planning reduced their attention to the incoming audio signal and probably also their predictive processing, leading to a smaller N400 effect. Slow responders focused instead on the audio signal, preserving their N400 effect but delaying their response.

Reference [1]: Bögels, S., Magyari, L., & Levinson, S. C. (2015). Neural signatures of response planning occur midway through an incoming question in conversation. Scientific Reports, 5: 12881.

E52 Mismatch Negativity Differences Reflect Community-based Conventionalization of Conceptual Metaphors in Taiwanese Mandarin

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One heated debate among grammarians over the past decades has centered on the relationship between linguistic knowledge in the minds and linguistic usage in the society. In view of this, this study examines how the sociopragmatic factor of community-based conventionalization may influence brain language processing [1]. An event-related brain potential (ERP) experiment was conducted to measure mismatch negativity (MMN), an ERP component reported to index language-related long-term memory traces [2]. Two groups of participants were tested: (1) native Taiwanese Mandarin speakers in a specific speech community in Taiwan (i.e., members of the local churches; N=13) and (2) native Taiwanese Mandarin speakers in the general society of Taiwan who never contacted the specific speech community (i.e., outsiders; N=15). Meanwhile, two bimorphemic metaphorical verb-noun expressions in Taiwanese Mandarin were alternatingly presented as the standard and deviant stimuli in two blocks using an auditory passive oddball paradigm: (1) the community-specific metaphorical expression, chī zhǔ 'eat the Lord', instantiating the conceptual metaphor (A PERSON/GOD IS FOOD), which is highly conventionalized in the specific speech community but not in the general society in Taiwan, and (2) the community-general metaphorical expression, chī bǔ 'eat nutritious food', instantiating the conceptual metaphor (REPAIR IS FOOD) occurring across the specific speech community and the general society in Taiwan, but only rarely used and thus frequency-matched to the community-specific metaphorical expression for outsiders. Sensor-space multilevel linear modeling analyses revealed significantly reduced MMN amplitudes for the community-specific metaphorical expression among members compared to those among outsiders and those for the community-general metaphorical expression among both groups within 210 ms at frontocentral sites. In addition, a similar pattern emerged in a later N400 time window (250-450 ms) at midline/right lateral sites. Source-space analyses localized neural generators to right hemisphere areas, including the inferior temporal/prefrontal lobes and the temporoparietal junction (rTPJ, implicated for communicative intention processing for metaphors; [3]). The results indicate highly conventionalized conceptual mapping schemas, but not unfamiliar ones, may reduce the efforts to establish associations between concepts across different conceptual domains. The neural activity patterns further suggest a possible need to avail rich pragmatic, situational (in this case church-related) information for the inference of appropriate metaphorical meanings. Most importantly, these findings demonstrate that language processing varies among native speakers of the same language due to their specific social interactive experiences, thus implying the critical influences of linguistic usage on linguistic knowledge, as well as the dynamic, emergent nature of mental grammar. References [1] H.-J. Schmid, "A blueprint of the Entrenchment-and-Conventionalization Model," in Yearbook of the German Cognitive Linguistics Association. vol. 3, A. Stefanowitsch, Ed., ed Berlin, Boston: De Gruyter Mouton, 2015, pp. 3-25. [2] F. Pulvermüller and Y. Shtyrov, "Language outside the focus of attention: The mismatch negativity. as a tool for studying higher cognitive processes," Progress in Neurobiology, vol. 79, pp. 49-71, May 2006. [3] B. G. Bara, I. Enrici, and M. Adenzato, "Chapter 54 - At the Core of Pragmatics: The Neural Substrates of Communicative Intentions," in Neurobiology of Language, ed San Diego: Academic Press, 2016, pp. 675-685.

E53 I spy with my little eye: ERP signatures of perspective taking in referential communication

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In everyday communication, the listener is sometimes confronted with ambiguous linguistic expressions that can be resolved by taking the speaker's perspective. This requires considering common ground (CG) information, that is, mentally or perceptually shared information of both interlocutors. Yet competing accounts about the use of perspective taking during communication exist. Theories claim that the speaker's perspective is evaluated immediately with ease (e.g., Hanna et al., 2003; Nadig & Sedivy, 2002), integrated late with effort (e.g., Apperly et al., 2010; Keysar et al., 2000), or anticipated early with ease, but integrated late with effort (Barr, 2008). The timeline of perspective taking has been studied by means of eye-tracking (e.g., Barr, 2008), but the neurophysiological underpinnings are less well examined. We used event-related potentials (ERPs) to identify the cerebral correlates of perspective taking to further clarify when and how CG information affects reference resolution during utterance comprehension. 34 healthy adults played a computerized version of the referential communication game (Keysar et al., 2000). The participants saw a 4x4 grid containing two sets of three different sized objects (i.e., small, medium, big) and two single distractors. A virtual "director" behind the grid provided auditory instructions (e.g., "Move the big star to the top."). The crucial feature of this paradigm was the manipulation of visual access to the objects. In conflict trials, the object that fit the director's request best from the perspective of the listener ("competitor"; e.g., the big star) was occluded from the director's view. Thus, participants had to consider CG information to select the correct object ("target"; e.g., the medium-sized star). The experiment also entailed a no-conflict condition (targets visible for director and participant), a no-hidden condition (no occlusions at all), and filler trials. Participants were instructed to mind the director's perspective and underwent a practice phase with corrective feedback (2-step instruction similar to Wang, 2015). During the test phase, ERPs were recorded with a 32 active electrode system (BrainProducts, Gilching). Reaction times (RTs) and accuracy rates were measured. The results revealed an overall high accuracy rate (99.6 ±0.5 %). Thus, participants mastered integration of CG information even in a conflict condition. However, perspective taking has its costs: RTs showed that participants were on average 195ms (SD ±7.2ms) slower in the conflict condition compared to the no-conflict and no-hidden conditions. In the ERPs, increased processing costs in the conflict condition vs. no-conflict and no-hidden conditions were reflected by enhanced late positivities in posterior (600-1200ms) and anterior (800-1400ms) regions, relative to the onset of the noun (e.g., "star"). The different peak latencies and the distinct topography point to different underlying functional mechanisms. According to McCleery et al. (2011), the posterior positivity might correspond to the calculation of the self- vs. other-perspective, while the anterior positivity might signal

the resolution of conflict. In sum, this study shows that CG information is integrated with effort right after the presentation of the critical noun during utterance comprehension. It also points to a number of processes involved in perspective taking that need to be further examined.

Perception: Orthographic and Other Visual Processes

E54 The Label Feedback Effect: Speech Modulates Visual Search, but Language Isn't the Culprit

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The label-feedback hypothesis (Lupyan, 2007) proposes that language (such as knowledge of category names) can modulate low-level and high-level visual processing. Lupyan and Swingley (2012) found that repeating target names aloud facilitates visual search, resulting in shorter RTs and higher accuracy. However, a procedural limitation made their results challenging to assess. Specifically, only two conditions were compared, speaking target names versus silence, which means comparing a single-task to a dual task. Moreover, by using only search times, they could not evaluate whether self-directed speech influences target locating (i.e. attentional guidance) or target identification after location (i.e. decision time). In this study, we aimed to determine whether the Label Feedback Effect reflects changes in visual attention, or some other mechanism (e.g. template maintenance in working memory) by using both search RTs and eye movements. To allow more direct comparisons, we had participants simultaneously speak while performing visual search in all conditions, varying the content of their speech. Four within-subjects, blocked conditions were tested: 1) Participants repeated target names during search, as in Lupyan and Swingley (Target condition), 2) Participants repeated nonwords during search (Nonword condition), 3) Participants repeated the names of real objects, not in the display (Distractor Absent condition), and 4) Participants repeated the names of distractor objects that were present on-screen (Distractor Present condition). The Target condition was expected to show most efficient search, reflecting improved guidance and/or perceptual classification. The Nonword condition served as control, allowing us to equate the challenges of performing a dual-task, without true linguistic content. The Distractor Absent condition activated true object labels, but no visual distraction of those competing objects on-screen. Therefore, attention could not be guided to those objects, nor would perceptual classification be challenged by fixating repeatedly named non-target items. Finally, the Distractor Present condition entailed both challenges, as language could drive attention to the named distractor, and could make perceptual decisions more difficult. Two experiments were conducted, a behavioral study (N=54) and an eye-tracking study (N=19). The behavioral results showed a strong label-feedback effect, with faster RTs in the Target condition, relative to all other conditions. Differences among the three other conditions were not significant. The eye-tracking data were illuminating: Repeating target names had little effect on attentional guidance or perceptual decisions, with results equivalent to the nonword condition. However, speaking distractor names had powerful effects on guidance and decision-making. This was especially clear in distractor-present trials, when people actually fixated the named distractor. In those trials, when the eyes eventually found targets, it took nearly a full extra second to initiate a response. Taken together, the results suggest that speaking target names does not facilitate visual search, but speaking different names can inhibit search. The effect is not apparently due to language, as the Label Feedback Hypothesis claims, but instead reflects attention and/or working memory. Specifically, repeating target names may help people maintain search templates, avoiding capture by background objects, whereas speaking unrelated (or intentionally misleading) names does the opposite.

E55 Investigating the role of linguistic and attentional processes in lexicality judgements in Alzheimer's disease

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Determining whether a letter string has a lexical status is a core component of reading during visual word recognition. With age, time taken to distinguish words from word-like stimuli increases. Moreover, individuals with Alzheimer's disease (AD) are not only slower, but may also exhibit a deficit in processing word-like stimuli. To better understand this deficit, we explored changes in lexicality judgements in AD using event-related potentials (ERPs). Lexicality judgements can be performed within an ERP oddball task (rare words presented among frequent nonwords or pseudowords, or vice-versa) and this paradigm is known to elicit the P3 component for rare trials. However, since oddball tasks rely on attention, tasks measuring attentional processes can help elucidate whether deficits observed in the ERP lexical decision tasks are primarily due to an attentional deficit, a linguistic deficit, or both. Methods: To address this issue, a combination of ERP lexical decision tasks and attention screening was used. The latter comprised two attention tasks: number Stroop and Useful Field of View (UFOV). The lexical decision oddball task, consisted of four blocks of infrequent stimuli (20%) among frequent stimuli: words among nonwords (W-Nw); words among pseudowords (W-Ps); nonwords among words (Nw-W); pseudowords among words (Ps-W). Participants: 10 individuals with probable AD aged 70-83 (MMSE: 21-29/30); 17 older adults aged 55-85. All were English dominant with similar education. Results: Mean A' score in the number Stroop was 0.98 (range: 0.94-1) for older adults and 0.95 (range: 0.88-1) for those with AD. For the UFOV, when compared to norms for age and education, one older adult and three with AD had a three-test total score below norms. To examine whether lexical decision oddball tasks evoked a P3, we compared mean amplitude of rare and frequent trials in the 500-650 ms window (Pz electrode). Older adults showed a P3 in blocks contrasting words and nonwords (W-Nw: $p=0.01$; Nw-W: $p<0.01$). Those with AD showed a P3 only in blocks where words were the frequent trials (Ps-W: $p=0.02$; Nw-W: $p=0.08$). Discussion: In blocks where rare and frequent stimuli were most distinct (W-Nw; Nw-W), a P3 was elicited for older adults. However, they did not show a P3 in the more difficult blocks, i.e. those with overlap in stimulus orthographic/phonological legality (W-Ps; Ps-W), suggesting that sensitivity to the overlap interfered with their ability to create effective

"word" and "not a word" categories early in the course of lexical processing. Those with AD showed a P3 only to blocks where words were the frequent stimuli suggesting that they were no longer sensitive to the orthography/phonology of the stimuli, but rather to a difference in lexical status. Although an attenuation of P3 amplitude can occur due to a disturbance in attention, the absence of a P3 component cannot be explained by such a deficit since results from the attention screening suggest that neither group showed a marked deficit in this domain. We propose that a linguistic deficit, likely an alteration in early orthographic/phonological processing, underlies the P3 results observed in the individuals with AD.

E56 Hemispheric lateralization of early ERP components in deaf and hearing readers with low and high vocabulary size

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The N170 component for visual word recognition is lateralized to the left hemisphere in occipitotemporal regions for hearing, right-handed individuals and has been associated with highly automatic orthographic processing in accomplished adult readers (Maurer, Zevin, & McCandliss, 2008). Deaf individuals have distinct developmental experiences with written word acquisition due a lack of access to auditory language, and early neurophysiological studies suggest greater right hemisphere involvement in word reading for deaf individuals (e.g., Neville et al., 1984). We examined whether the lateralization of early visual ERP components, namely P100 and N170, differ for deaf and hearing readers and whether these effects are modulated by English vocabulary knowledge. Twenty hearing participants (M age = 24 yrs) and 20 deaf participants (M age = 29 yrs; all fluent users of American Sign Language) made same-different judgments to pairs of four-letter words (192 trials), where the first word was presented centrally and the second word was presented to either the left (LH) or right hemisphere (RH) (see Dundas et al., 2014). EEG was recorded to the centrally presented words (750ms) and referenced to the average of all 32 electrode sites. The P100 and N170 were measured by taking the average amplitude between 80 and 120 ms, and between 130-230ms in the occipitotemporal sites respectively in both hemispheres. Participants also completed an offline measure of vocabulary size (Peabody Picture Vocabulary Test, Dunn & Dunn, 2007) adapted for use with deaf participants (written rather than spoken words were presented). A median split was used to categorize the participants into high and low vocabulary groups. The preliminary results revealed a larger N170 amplitude in LH over RH in hearing readers ($F(1, 18) = 37.4$, $p < .001$), but no effect of vocabulary skill on N170 lateralization was found ($F(1, 18) = 1.1$, $p = .319$). For deaf readers, the N170 was also LH-lateralized ($F(1, 18) = 12.1$, $p = .003$), but interestingly, only the low vocabulary group showed a significantly greater N170 in LH than RH ($p = .009$). The deaf high vocabulary group showed a more bilateral N170 response ($p = .13$). This pattern suggests that deaf readers with larger vocabulary recruit both hemispheres during word recognition, in contrast to both deaf readers with smaller vocabulary and hearing readers with a similar vocabulary size who show a left hemisphere bias. The P1 amplitude was bilaterally distributed for hearing readers which is in line with previous studies suggesting that LH bias is specific to the N170 component. For deaf readers, the laterality of the P1 was impacted by vocabulary size. The high vocabulary deaf group exhibited a larger P1 in the RH over LH ($p = .01$), while the low vocabulary group showed a trend for a larger P1 in the LH over RH ($p = .103$). These unique P1 asymmetries suggest that for deaf readers vocabulary knowledge modulates early visual feature analysis of orthographic stimuli.

E57 Literacy acquisition drives hemispheric lateralization of reading

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Reading functions beyond early visual precessing are known to be lateralized to the left hemisphere, but how left-lateralization arises during literacy acquisition is an open question. Bilateral processing or rightward asymmetries have previously been associated with developmental dyslexia. However, it is unclear at present to what extent this lack of left-lateralization reflects differences in reading ability. In this study, a group of illiterate adults in rural India (N=29) participated in a literacy training program over the course of six months. fMRI measures were obtained before and after training on a number of different visual stimulus categories, including written sentences, false fonts, and object categories such as houses and faces. This training group was matched on demographic and socioeconomic variables to an illiterate no-training group and to low- and highly-literate control groups, who were also scanned twice but received no training (total N=90). In a cross-sectional analysis before training, reading ability was positively correlated with increased BOLD responses in a left-lateralized network including the dorsal and ventral visual streams for text and false fonts, but not for other types of visual stimuli. A longitudinal analysis of learning effects in the training group showed that beginning readers engage bilateral networks more than proficient readers. Lateralization of BOLD responses was further examined by calculating laterality indices in specific regions. We observed training-related changes in lateralization for processing written stimuli in a number of subregions in the dorsal and ventral visual streams, as well as in the cerebellum. Together with the cross-sectional results, these data suggest a causal relationship between reading ability and the degree of hemispheric asymmetry in processing written materials.

Phonology and Phonological Working Memory

E58 Do skilled deaf readers access phonological codes?

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Most deaf people never achieve a good reading level compared with hearing peers (Conrad, 1979). Many studies have highlighted the importance of phonological coding and awareness for the development of reading skills in deaf individuals (Hanson & Fowler, 1987; Perfetti & Sandak, 2000). Some studies have suggested that phonological

coding is an automatic and necessary step during reading in a transparent language, such as Spanish (Frost & Katz, 1989; Carreiras, Perea, Vergara & Pollatsek, 2009). The present study explored the electrophysiological correlates of phonological coding in skilled deaf Spanish readers. The ERPs elicited by pseudohomophones were compared to those elicited by control nonwords, as well as to those elicited by real words embedded in a visual lexical decision task. The ERP activity of 14 severely to profoundly deaf skilled Spanish readers who used Spanish Sign Language as their main language for communication was compared to that of 14 hearing Spanish skilled readers who served as a control group matched on age, IQ and reading level. The ERPs revealed no differences between the two nonword conditions in skilled deaf readers, as well as an identical N400 effect for both nonword conditions compared with words. In contrast, the hearing group showed differences between the two types of nonwords (larger N400 for control nonwords than for pseudohomophones), as well as an N400 effect for control nonwords but not for pseudohomophones as compared to words. These findings suggests that the absence of phonological coding activation does not necessarily lead to reading difficulties when deaf individuals learn to read in transparent languages, since skilled deaf readers did not activate phonological codes during word recognition in Spanish. Hence, efficient phonological processing is not a prerequisite step for word identification in languages with transparent orthographies.

E59 Fiber pathways important for early literacy in young children

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The development of fluent reading is an extended process that requires the recruitment of a comprehensive system of perisylvian brain regions connected by an extensive network of fiber pathways. The goal of the present study was to characterize potentially important fiber pathways associated with early literacy skill in young children 5-8 years old. These fiber pathways include the vertical occipital fasciculus (VOF), inferior longitudinal fasciculus (ILF), arcuate fasciculus (AF) and its 3 components, splenium (SP), tapetum (TP) and inferior fronto-occipital fasciculus (IFOF). Diffusion-weighted images were collected in 20 children (10 females, 10 males; age range = 5-8 years, M age = 6.9 years, SD = 1.1 years). We manually identified all tracts based on established methods (Catani et al., 2012; Hofer & Frahm, 2006; Rathore, 2011; Takemura et al., 2015). The diffusion tensor in each voxel was determined using a weighted least-square method, and the following metrics were computed: fractional anisotropy (FA), average diffusion coefficient (ADC), radial diffusivity, and axial diffusivity (Basser, Mattiello, & LeBihan, 1994; Hasan & Narayana, 2006). These indices were calculated for each individual tract, bilaterally. We also assess each child's speech and early literacy ability. Speech was assessed using the articulation and phonology subtests of the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Hua, Crosbie, Holm, & Ozanne, 2010). Early literacy was assessed using Word Attack (Test 3), Sound Awareness (Test 7), and Sound Blending (Test 8) subtests of the Woodcock-Johnson III Diagnostic Reading Battery (W-JIII; Woodcock, Mather, & Schrank, 2004). To relate the white matter microstructure of the examined perisylvian fiber pathways to early literacy we constructed robust linear models for each white matter quantification (i.e., FA, ADC, axial diffusivity, radial diffusivity). The following effects survived after controlling for age in months, non-verbal ability (as measured by block design), sex, and whole brain white matter microstructural properties. The results show that the left ILF FA and axial diffusivity positively predicted (and left ILF radial diffusivity negatively predicted) phonological awareness. In contrast, the left and right VOF FA and axial diffusivity negatively predicted phonological awareness. The left AF Posterior Segment (for axial diffusivity), left AF Long Segment (for axial diffusivity), right AF Posterior Segment (for ADC and axial diffusivity), and right AF Anterior Segment (for axial diffusivity) all negatively predicted early literacy measures. Right IFOF radial diffusivity negatively predicted decoding. Only one interhemispheric pathway, the tapatum, was related to early literacy (ADC and radial diffusivity negatively predicted decoding), but no significant effects were revealed for the splenium. Taken together, our data support the idea that the ILF and IFOF ventral fiber pathways becomes increasingly important for the processing of phonological information as skills in phonological awareness and decoding are acquired, and these skills become less associated with the dorsal AF route and with the VOF pathway connecting the ventral and dorsal visual streams. The data thus have important theoretical implications for the neurobiology of literacy development.

Signed Language and Gesture

E60 Why short term memory span for signs is lower than for speech?

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Short term memory (STM) span is smaller in sign language, as compared to spoken language (for speakers, STM span means are7±2, for signers 4±1): it is a robust finding that has been documented in different languages and populations using a variety of experimental paradigms. For bimodal bilinguals (persons proficient in both sign language and spoken language) the STM span for signs is shorter than the span for speech. But these findings only regard the cases when items need to be recalled in a specific order. In free recall tasks, signers perform equally with speakers. The span difference may therefore be attributed to a more precise and efficient serial position encoding in verbal STM (used for speech) than visuospatial STM (used for signs). We tested whether the reduced STM capacity with signs stems from a lack of positional encoding available in STM for spoken words. The method for investigating the positional encoding is based on the error analyses. The task is ordered recall of a sequence of stimuli. After identifying the intrusion errors (elements present in the response but not in the stimulus), we then identify the errors that can be qualified as perseverations (intrusions that are repetitions of elements present in previous responses), and then evaluate how many of the perseverations maintain their position. Observed patterns are compared with Monte-Carlo simulations of an entirely random perseveration distribution.

Thus we can see if the perseverations in the actual data match certain positions more often than expected by chance. Previous studies show that for verbal material the positions within a sequence are encoded with relation to their distance from both the start and the end of the sequence (both-edges positional encoding scheme). For the visuospatial material, however, the encoding scheme appears to be based only on the start of the sequence. If sign language material is encoded through visuospatial STM, we should expect the same results for signs as for visuospatial stimuli. Alternatively, if sign language is processed the same way as spoken language, then the encoding scheme would be the same for signs as for spoken words. We conducted a study on Italian sign language speakers, presenting them with ordered sign sequence repetition task, and analysed their errors and perseverations. We found that the STM representation of signs is characterized by the both-edges positional encoding scheme, which is the same as the scheme used by speakers for encoding spoken material. Therefore, the reduced STM span for signs is not due to a different type of positional encoding. Previous studies demonstrated that the signers demonstrate equal performance in free recall and in working memory tasks; therefore we cannot make a conclusion that their memory capacity is reduced. The present results indicate that the cause of the STM disadvantage is not the type of positional encoding but, possibly, the difficulties in binding of items in visuospatial STM to specific positions in a sequence.

Speech Motor Control and Sensorimotor Integration

E61 Neural mechanisms underlying auditory feedback processing during speech production

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Speech production is one of the most complex motor skills, and involves close interaction between perceptual and motor systems. One way to investigate this interaction is to provide speakers with manipulated auditory feedback during speech production. Using this paradigm, investigators have started to identify a neural network that underlies auditory feedback processing and monitoring during speech production. However, to date, still little is known about the neural mechanisms that underlie feedback processing. The present study set out to shed more light on the neural correlates of processing auditory feedback. Participants (N = 39) were seated in an MEG scanner and were asked to vocalize the vowel /e/ continuously throughout each trial (of 4 s) while trying to match a pre-specified pitch target of 4, 8 or 11 semitones above the participants' baseline pitch level. They received auditory feedback through ear plugs. In half of the trials, the pitch in the auditory feedback was unexpectedly manipulated (raised by 25 cents) for 500 ms, starting between 500ms and 1500ms after speech onset. In the other trials, feedback was normal throughout the trial. In a second block of trials, participants listened passively to recordings of the auditory feedback they received during vocalization in the first block. Even though none of the participants reported being aware of any feedback perturbations, behavioral responses showed that participants on average compensated for the feedback perturbation by decreasing the pitch in their vocalizations, starting at about 100ms after perturbation onset until about 100 ms after perturbation offset. MEG data was analyzed, time-locked to the onset of the feedback perturbation in the perturbation trials, and to matched time-points in the control trials. A cluster-based permutation test showed that the event-related field responses differed between the perturbation and the control condition. This difference was mainly driven by an ERF response peaking at about 100ms after perturbation onset and a larger response after perturbation offset. Both these were localized to sensorimotor cortices, with the effect being larger in the right hemisphere. These results are in line with previous reports of right-lateralized pitch processing. In the passive listening condition, we found no differences between the perturbation and the control trials. This suggests that the ERF responses were not merely driven by the pitch change in the auditory input and hence instead reflect speech production processes. We suggest the observed ERF responses in sensorimotor cortex are an index of the mismatch between the self-generated forward model prediction of auditory input and the incoming auditory signal.

E62 Role of the motor system in perceptual categorization of ambiguous speech sounds

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The role of sensorimotor interaction during speech perception is a long-standing research topic in neurobiology of language. Recent studies suggested a modulatory role for the motor system in speech perception, particularly in aiding perceptual categorization of speech sounds in adverse perception conditions (e.g., D'Ausillo et al., 2009). In the current study, we examined whether the involvement of the motor system is enhanced during the perception of non-native speech sounds that are acoustically ambiguous between two native sound categories and are hence more difficult to identify than prototypical exemplars of these categories. Participants listened to VC syllables that contained either a prototypical or an ambiguous vowel and were asked to perform phoneme recognition tasks on the vowel or on the consonant (which were always prototypical). Electroencephalogram was recorded during the experiment and the activation of the motor system was measured with event-related-desynchronization (ERD) of the mu rhythms (8-12 Hz and 14-20 Hz) at sensors over premotor cortices and supplementary motor areas. Our results (N=28) show that, in general, listening to stimuli with ambiguous vowels induces larger mu-ERD over left motor cortices than those with prototypical vowels. Moreover, the effect of ambiguity is greater in the vowel recognition task that requires explicit access to the vowel categories in order to resolve the perceptual ambiguity than in the consonant recognition task. These findings demonstrate that the activation of the motor system during speech perception is modulated by the perceptual difficulty that is due to the sound inventory of listeners' native language; specifically, they suggest an

involvement of the motor system in explicit perceptual mapping of ambiguous, non-native, speech sounds onto native categories.

E63 Sex-related sensorimotor processing differences during speech discrimination tasks revealed in EEG mu rhythms

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Oscillatory power in EEG mu rhythm has been used to index differences in empathy levels between males and females. Because activity within this rhythm has also been found to be sensitive to sensorimotor demands in speech processing, it is of interest to examine sex-related differences in this domain. 64-channel raw EEG data from 60 adults (30 males and 30 females), were collected from syllable discrimination tasks in quiet and noisy (SNR +4) conditions, in which participants responded with over 85% accuracy. Independent component analysis (ICA) was performed on data from accurate trials across all test conditions and a control condition. Mu components were identified by: (1) characteristic spectral peaks in the alpha (8-13Hz) and beta (15-25Hz) range, and (2) localized to primary sensorimotor (BA 1, 2, 3) primary motor (BA 4) or premotor (BA 6) regions. Female participants displayed stronger overall mu spectra, with statistically (pFDR<.05) differences in alpha and beta bands. Time-frequency analyses via event-related spectral perturbations (ERSP) were used to examine spectral changes in the mu rhythm across the time-course of trials. For both conditions, relative to the control condition, the time period prior to and during discrimination was marked by event-related desynchronization (ERD) in beta bands and event-related synchronization (ERS) alpha in alpha bands, similar to those reported in Jenson et al (2014, 2015). However, the alpha ERS was stronger in the noisy condition. These are findings are thought to reflect evidence of predictive coding in which internal modeling (beta ERD) co-operates with inhibitory activity (alpha ERS) of irrelevant stimuli. Thus, the stronger alpha ERS in the noisy condition may be explained as suppression of background noise while discriminating. Between-sex group comparisons showed that alpha ERS was stronger (pFDR<.05) in females and beta ERD was stronger (pFDR<.05) in males. Therefore, these data suggest sex-related differences in sensorimotor processing for speech. Notably, males appear to employ inhibitory processing less than females. These findings may be important because many disorders of speech and language (e.g. autism, stuttering, auditory processing disorder) are more prevalent in males than females. Such disorders have been linked to sensorimotor compromise.

Control, Selection, and Executive Processes

E64 Interpreting Experience Enhances Early Attentional Processing, Conflict Monitoring and Interference Suppression

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Interpreting is an intense bilingual experience that may help enhance executive functions. This issue of interpreter advantage has been investigated in a few behavioral studies but has not yet got satisfactory answers. To explore how interpreting experience may modulate young adults' inhibitory control and early attentional processing, the present ERP study recruited two groups of student interpreters that had received different amount of interpreting training. The Flanker task revealed that participants of more interpreting experience exhibited larger N1 and N2 amplitude than those of less experience in both congruent and incongruent conditions, but the difference waves between the conditions did not reveal group differences. As for the behavioral data of response time (RT), there was no group difference in either condition but a smaller interference effect for the group with more interpreting experience. The results can be integrated into a coherent whole with the help of "timeline" and suggest that interpreting experience may enhance early attentional processing (N1), conflict monitoring (N2) and interference suppression (RT).

E65 Effects of task demand and intelligibility on the cortical entrainment response

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It has been suggested that cortical entrainment plays an important role in speech perception by helping to parse the acoustic stimulus into discrete linguistic units. However, whether or not the intelligibility of speech contributes to the entrainment response remains an open question. For example, Howard & Poeppel (2010, J Neurophys) showed that entrainment response to backward speech did not differ from the entrainment response to forward speech, suggesting that the entrainment response reflects acoustic rather than linguistic neural processes (see also, Zoefel & VanRullen, 2016, NeuroImage). Conversely, Peelle et al. (2013, Cereb Cortex) showed that the strength of the entrainment was inversely related to the degree of vocoding distortion, suggesting that both acoustic and linguistic neural processes underlie the entrainment response. In these studies however, stimuli were acoustically altered in order to manipulate intelligibility, making it difficult to compare across "intelligible" and "unintelligible" conditions. Furthermore, a lack of matched behavioral tasks across conditions introduce an attentional confound In the current study, we use semantic priming to manipulate the intelligibility of vocoded speech. Specifically, vocoded target sentences are preceded by clear speech (non-vocoded) prime sentences that are either matched or mismatched to the vocoded target. On each trial, a target vocoded sentence is preceded by a clear speech prime and followed by a vocoded snippet, and listeners are asked to determine whether or not the snippet was cut from the target. The length of these snippets were adaptively varied based on listener response in a 2-down/1-up tracking procedure. The two factors we varied were (1) whether or not the prime and target were the same, and (2) whether or not the snippet was drawn from the target. Despite the fact that matching the prime and the target substantially increases the intelligibility of the target, a preliminary analysis suggests that the difference in entrainment between "matching" and "mismatching" targets is modest if present at all. This result suggests that when acoustic confounds

are removed and attentional confounds are mitigated, coherence between the stimulus envelope and neural response does not depend on intelligibility. However, a difference in entrainment is observed between the clear speech prime and the vocoded target, suggesting that the entrainment response is modulated by task demands. Specifically, the entrainment response to the clear speech prime was very modest, while the response to the vocoded target was robust, suggesting that entrainment is an active rather than obligatory response, and that the magnitude of entrainment reflects the degree of listening effort.

E66 Control adjustments in speaking: Electrophysiology of the Gratton effect in picture naming

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Accumulating evidence suggests that spoken word production requires different amounts of top-down control depending on the prevailing circumstances. Control adjustments have been extensively studied using Stroop-like tasks with incongruent and congruent stimuli, where the amount of top-down control is adjusted based on the previous trial type. In particular, the Stroop-like effect, i.e., the difference in response time (RT) between incongruent and congruent trials, is typically larger following congruent trials than following incongruent trials. This effect, called the Gratton effect, has been studied extensively in manual Eriksen flanker and Simon tasks and in colour-word Stroop, but not in picture-word interference (PWI). PWI is one of the work horses of word production research. In perhaps the only study of the Gratton effect in PWI, Van Maanen and Van Rijn (2010) obtained the effect in picture naming RTs during dual-task performance. Based on Gratton effect differences between dual-task conditions, they argued that the functional locus of the Stroop-like effect in PWI differs between post-congruent trials (i.e., locus in conceptualization) and post-incongruent trials (i.e., locus in lexical selection). However, the dual-task procedure may have contaminated the results. We therefore performed an EEG study on the Gratton effect in regular PWI. Naming RTs were longer on incongruent (~910 ms) than on congruent (~750 ms) trials, and this Stroop-like effect was larger following congruent trials (~170 ms) than following incongruent trials (~140 ms). The ERP waveforms over a broad range of fronto-central EEG channels deflected more negatively for the incongruent trials than for congruent trials between approximately 450–600 ms post-stimulus onset. Importantly, this N400 effect was larger following congruent than following incongruent trials, reflecting a Gratton effect in ERPs. No earlier effects were observed. These ERP results provide evidence that the functional locus of the Stroop-like effect is the same following congruent and incongruent trials, while the amount of top-down control changes depending on the previous trial type. The timing of the Gratton effect in the ERPs suggests that it arises (predominantly) during lexical selection rather than during conceptualization. To conclude, our electrophysiological findings suggest that speakers adjust the amount of top-down control over lexical selection depending on the prevailing circumstances.

Meaning: Prosody, Social and Emotional Processes

E67 Neural mechanisms for the perception of voluntary and involuntary emotional vocalisations

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Understanding other's intentions from non-verbal vocalizations is a central aspect of social interactions. For example, genuine or helpless laughs may differ in their meaning from more polite social laughs. A fundamental difference between genuine and social laughs is the degree of voluntary control exerted by the speaker: while social laughs can be voluntary/controlled to a significant extent, genuine laughs are more involuntary. Previous fMRI work has shown that involuntary laughter elicits greater activity than voluntary laughter over auditory regions, namely the superior temporal gyrus and Heschl's gyrus. On the other hand, voluntary laughter elicits greater activity in the anteromedial prefrontal cortex, an area associated with mentalizing (McGettigan et al., 2015). However, whether these cortical sensitivities are laughter-specific or extend to other types of emotional vocalizations remains unknown. In the current study, we examined neural responses while participants listened to a new set of voluntary and involuntary laughs, and also while they listened to voluntary and involuntary crying. Twenty-four healthy adults (14 women) took part in the experiment: they completed a passive listening task in the MRI scanner, as well an off-line behavioural task involving judgments of authenticity. Preliminary analyses of the imaging data suggest that the cortical differentiation of voluntary and involuntary vocalizations is partly distinct for laughter and for crying. For laughter, replicating previous findings, we found stronger activity in bilateral superior temporal gyri for involuntary as compared to voluntary laughter; the left caudate nucleus, left angular gyrus, and the left middle orbital gyrus, on the other hand, were more activated for voluntary than for involuntary laughter. For crying, the left middle temporal gyrus was more strongly activated in response to involuntary as compared to voluntary crying; and the left middle temporal gyrus, right temporal pole, middle frontal gyrus, and right thalamus were more strongly activated in response to voluntary crying. These results are suggestive of partly distinct networks for the processing of control in positive and negative nonverbal vocalizations.

E68 What can ERPs and neural oscillations tell us about emotional vocal change detection?

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Introduction: Human social communication is a complex process that relies on the dynamic interaction between verbal and non-verbal cues. The process of communicating in a social context involves, among other abilities, the detection

of emotional salience from the voice. Even though the study of social communication has been revolutionized by neuroscience methods, the brain mechanisms underlying social communication are not yet well understood. A question that remains is how the human brain automatically detects the salience of vocalizations that may represent a change in expected stimulus quality, and, how the valence expressed by the voice influences this process. We probed the interactions between valence and attention in vocal change detection. Event-related potentials (ERPs) and oscillatory analysis were applied as we aimed to obtain a more complete picture of the neural dynamics underlying vocal emotional perception. Method: Neutral, happy and angry vocalizations were selected from the Montreal Affective Voices set (Belin et al., 2008) and based on affective ratings obtained in a previous validation study. These stimuli were presented both as frequent and infrequent stimuli. Twenty one healthy volunteers participated in two experiments (12 female; mean age: 22.86 ± 2.97 years). In Experiment 1, we probed how predictions about the quality of emotional vocalizations and the actual sensory input are compared during pre-attentive voice processing. Participants were asked to watch a silent movie and to ignore the vocalizations. In Experiment 2, we tested how attention affects the processing of emotional vocalizations. Participants were asked to count the number of low-probability target vocalizations interspersed with high-probability standard vocalizations. Results: In Experiment 1, the Mismatch Negativity (MMN) amplitude was increased for happy compared to neutral and angry vocalizations. Induced pre-stimulus beta power was increased for happy vocalizations and predicted the modulation of ERP amplitude. In Experiment 2, task-relevant happy vocalizations were associated with an increased P300 amplitude, and induced power of alpha oscillations (200-600 ms). Conclusions: These experiments suggest that predictive processes in the listener are facilitated by positive vocal emotions (Experiment 1) and that positive salience can preferentially attract endogenous attention in voice processing (Experiment 2). Furthermore, they underscore the role of pre-stimulus activity patterns for incoming sensations and automatic vocal change detection, revealing enhanced top-down expectations for positive vocal cues. This implies that happy vocalizations may be of high social significance, which leads to preferential processing.

Methods

E69 From sound to syntax: Novel task-free EEG paradigm for registering multiple levels of language processing in the brain

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In evaluating the language function – whether for pre-surgical mapping or assessing effects of brain injuries – one has to rely on behavioural observations or on a combination of behavioural/verbal responses with some neuropsychological tools. This raises the problem of non-cooperative subjects, such as brain-damaged patients or speech-impaired individuals. Clearly, techniques that could reveal neural correlates of language processing without relying on overt responses could be beneficial in a variety of situations. Previous research has shown that the brain exhibits specific neural signatures of auditory stimulus processing in passive listening conditions, i.e. without behavioural tasks or attention on the auditory input. For instance, basic sound processing is reflected in the P1-N1-P2 complex. In a healthy brain, this obligatory response is reduced by stimulus repetition. On the other hand, unexpected surprising sounds are known to generate an enhanced response, including the P3 deflection linked to auditory attention shifts. For linguistic stimuli, the brain shows larger responses to unattended spoken words than to unattended meaningless pseudowords, reflecting automatic lexico-semantic access. Even higher-level linguistic processes such as syntax are reflected in task-free conditions as negative deflections automatically elicited by grammatically incorrect stimuli. Here, we build on these previous findings and present a novel paradigm in which we simultaneously assess acoustic, phonological, lexical and syntactic levels of spoken language processing in a single task-free electrophysiological recording. We presented experimental participants with a pseudorandom sound sequence incorporating: (1) native words, (2) phonologically native pseudowords, (3) non-native pseudowords, (4) morphosyntactically correct and asyntactic complex words, (5) non-speech complex sounds (musical rain), (6) infrequent novel sounds. The stimuli were balanced for their acoustic properties and had strictly controlled disambiguation points. The participants were instructed to ignore the sounds and concentrate on watching a silent video while their brain activity was recorded using a 75-channel EEG setup. We found that infrequent novel sounds (6) elicited a clear N1-P2 complex indicating obligatory sound processing in the auditory cortex. This response was, however, reduced for repetitive spoken items, reflecting inhibitory effects due to habituation. When contrasting meaningful words with meaningless pseudowords (1 vs 2), we registered an established index of automatic lexical processing: an enhanced negativity for real words around 200 ms after the disambiguation point, likely reflecting automatic activation of word memory traces. The level of phonological processing was indexed by (a) differential responses to speech stimuli and acoustical similar musical rain (1-4 vs 5), and (b) an early ERP difference between native and non-native spoken stimuli (1 vs 3). An ELAN-like deflection occurred around 200 ms after a syntactic violation, relative to syntactically correct stimuli (4). Finally, automatic auditory attention reorientation was reflected in a large P300-like positivity at 300 ms after the onset of novel sounds (6). In sum, we present a technique which can test sound and language processing at multiple levels of complexity in a single multi-layered passive EEG paradigm that requires no behavioural task or stimulus-directed attention. This paradigm may potentially be useful in clinical settings, especially when assessing the neurocognitive status of uncooperative/unresponsive individuals.

E70 Investigation of Depth-Dependent BOLD During Language Processing

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Neocortex is known to be histologically organized with respect to depth, and neuronal connections across cortical layers form part of the brain's functional organization[1]. Efferent (outgoing) and afferent (incoming) inter-regional connections are found to originate and terminate at different depths, and this structure relates to the internal/external origin of neuronal activity. Specifically, efferent, inter-regional connections are associated with internally directed, top-down activity; afferent inter-regional connections are associated with bottom-up activity originating from external stimulation. The contribution of top-down and bottom-up neuronal activity to the BOLD signal can perhaps be inferred from depth-related fluctuations in BOLD. By dissociating top-down from bottom-up effects in fMRI, investigators could observe the relative contribution of internally and externally generated activity to the BOLD signal, and potentially test hypotheses regarding the directionality of BOLD connectivity. Previous investigation of depth-dependent BOLD has focused on human visual cortex[2]. In the present work, we have designed an experiment to serve as a proof of principle that (1) depth-dependent BOLD can be measured in higher cortical areas during a language processing task, and (2) that differences in the relative contribution of the BOLD signal at discrete depths, to the total BOLD signal, vary as a function of experimental condition. Data were collected on the Siemens 7T scanner at the Hahn Institute in Essen, Germany. Submillimeter (0.8mm3), T1-weighted data were acquired using MP2RAGE, along with near whole-brain, submillimeter (0.9x0.9x0.943mm x112 slices) 3D-EPI task data. The field of view fully covered bilateral temporal and fusiform regions, but excluded superior brain areas on the order of several centimeters. Participants were presented with an event-related paradigm involving the presentation of words, pseudowords and nonwords in visual and auditory modalities. Only the visual modality is discussed here. Cortical segmentation was performed using FreeSurfer's surface-pipeline. We parcellated the gray matter volume into discrete depths, and the analysis of depth-dependent BOLD was performed with the Laminar Analysis Toolbox (van Mourik). Further analysis was performed using FreeSurfer, AFNI and in-house MATLAB code. Regions included in the depth-dependent analysis were determined by first-level analysis. We have presently collected data from 10 participants. 4 were excluded due to equipment malfunction. In the first-level analysis (volume registration, smoothing, GLM, and significance testing), we observe fusiform activation for Realword>Nonword and Pseudoword>Nonword contrasts. These contrasts additionally show activation along middle temporal gyrus. The depth-dependent analysis was performed on fusiform clusters generated during the first-level analysis. These clusters appeared to show depth-dependent signal differences as a function of experimental condition. We suspect these differences may be related to layer-specific activation and reflect the relative contribution of top-down and bottom-up activity in the observed signal. These are preliminary results, and part of an ongoing effort to establish novel, depth-dependent analysis techniques in higher cortical areas and within the language domain. Future analysis will investigate the nature of the depth-dependent differences and the connectivity profiles of depth-dependent variation among distal cortical regions.[1]DouglasR.J.&MartinK.A.C.(2004).Neuronal Circuits of the Neocortex.Annual Review of Neuroscience,27,419-551. [2]Kok,P.,et al.(2016).Selective Activation of the Deep Layers of the Human Primary Visual Cortex by Top-Down Feedback. Current Biology,26,371-376.

Writing and Spelling

E71 Componential and holistic processing of novel visual-verbal associations

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Reading is a critical skill that most children and adults are expected to master. Understanding the neural processes that underlie learning to read is important to improve the scientific foundations of literacy but studying them has proved challenging in real-world contexts. Here we use a laboratory-based learning paradigm to investigate one aspect of learning to read; the componential and holistic nature of visual-verbal mappings. Written words contain systematic mappings between letters and sounds, e.g. 'cat' and 'cap' share both letters and sounds. By contrast there is an arbitrary and holistic relationship between visual and verbal forms of objects – cats and caps don't look alike. Here we explore whether and when holistic and componential neural representations of written words contribute to literacy acquisition. Participants learned to read/name artificial words and objects over two days. On the second day we used functional MRI to ask whether the neural systems that support the componential visual-verbal associations for written words are the same as those that support the holistic and arbitrary visual-verbal associations for objects. To validate the use of this laboratory-based learning paradigm, activation for artificial items was further compared to activation during a functional localiser for reading familiar words, pseudowords, and naming familiar objects. Behavioural profiles, along with the ability to read untrained words, shows participants have acquired and can generalise componential spelling-to-sound mappings of the artificial words. However, behavioural results did not show evidence of whole-word reading since performance did not differ between trained and untrained items. Imaging results highlight the distinction between holistic and componential processing, showing increased activation in posterior ventral occipitotemporal (vOT), parietal, and frontal cortices when reading an artificial orthography (relative to naming artificial objects), whereas additional activation was seen in anterior vOT regions when naming artificial objects (compared to reading artificial words). The lack of expected differences in cortical activation between trained and untrained words suggests items are still being read componentially (i.e., whole-word cortical representations have not formed). However increased activation in a hippocampal ROI for day 2 compared to day 1 words offers evidence of overnight changes in episodic representations of learned items. As words from days one and two share the same letters, differences in activation must be attributable to changes to whole-word knowledge. Holistic and componential processing in the localiser was captured by the contrasts [objects > words] and [pseudoword > words] respectively. ROIs defined on the basis of these contrasts confirmed the overlap of neural activity for real and artificial words and objects. Participants

recruited functionally-distinct componential and holistic neural systems when learning to read words written in an artificial orthography and to name artificial objects. These findings suggest that initial stages of literacy education might similarly engage componential visual-verbal associations represented in posterior vOT, parietal and frontal regions. The finding that artificial words and objects activate the same neural systems as written words and objects known since childhood suggests laboratory-based learning paradigms may offer a useful way to study literacy acquisition while maintaining strict experimental control.

Poster Session F

Perception: Auditory

F1 Musicians and non-musicians show distinct spatiotemporal network activity while listening

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When participants complete language tasks, multiple spatiotemporal networks are known to be active, some of which relate to domain-general cognitive control and others that activate specifically for language. However, what does network activity look like in other auditory tasks and how is network activity shaped by learning? Listening to music has been shown to engage auditory, motor, and cognitive control regions, which resembles univariate activity during speech perception. We use an independent component analysis (ICA) based approach to identify spatiotemporal networks engaged during listening to music. We explore the effects of long-term auditory-motor learning on these networks, by studying two groups of musical experts, as well as non-experts. fMRI data was collected from 20 professional beatboxers, 20 professional guitarists, and 20 participants without musical experience. During these scans, participants passively listened to short and novel beatboxing and guitar pieces in the scanner. Univariate results reveal that all groups showed activity over the dorsolateral temporal lobes during listening, but musicians additionally activated sensorimotor regions, including bilateral inferior frontal gyrus, inferior parietal cortex and supplementary motor area. Increases in these regions were only observed when musicians listened to the music they could play; for the other style, their profile of functional responses was comparable to that exhibited by non-musicians. Using ICA, we find multiple spatiotemporal networks that are engaged when participants listen to music. Similar to results described in speech tasks, we find a left-lateralised fronto-temporo-parietal (FTP) network and a bilateral auditory-motor network that are active during listening. A right-lateralised FTP network is also observed, which is deactivated during listening, in addition to bilateral sensorimotor networks and the default mode network. Musical expertise affects activity in the auditory-motor network, as well as in the left-lateralised FTP network. These findings indicate sensorimotor and frontoparietal engagement in auditory perception is driven by long-term auditory and motor experience, which is relevant to studies of the neural bases of both music and speech. In addition, these results suggest that left-lateralised network responses are not unique to speech and language, but can be modulated by expertise in auditory object recognition and retrieval.

F2 The role of auditory cortex morphology in language aptitude

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Introduction: In the past years, research focusing on language aptitude and its various subcomponents has gained increasing interest in numerous fields such as pedagogy and neurosciences. Unfortunately, recent studies focusing on language aptitude have only partly succeeded in showing whether aptitude is a purely innate capacity and to what extent it contributes to language excellence. According to recent studies [1], intense musical training in childhood is related to the brain's linguistic organization and the functional interplay of right and left auditory cortex. Recently, a set of neuroanatomical markers has been identified in children with high musical expertise and aptitude, including (a) enlarged Heschl's gyri, (b) shorter latencies of the primary auditory evoked response complex and (c) a better synchronization of left and right auditory cortex activation. Studies on language have shown that the greater the general musical aptitude, the better the foreign language pronunciation skills [2]. L2 learners with high pronunciation aptitude also have significantly lower BOLD activation in speech-motor and auditory-perceptual networks. Objectives: Given that the gross morphology of the auditory cortex is also important for speech learning and expertise [3], we hypothesized that its macro-anatomic structure could give cues about the neuroanatomical correlates of speech-language aptitude. Methods: Using Brain Voyager QX software for semiautomatic segmentation of the auditory cortex (as in [1]) and cortical thickness analysis, we segmented and analysed T1 weighted MR images the primary auditory areas (bilateral Heschl's gyri and plana temporale) in a group of 26 special individuals of either very high or very low (n=13 per group) speech imitation aptitude based on extensive pretesting for linguistic, musical and psycho-cognitive abilities [2]). Results: We found characteristic macro-anatomic differences between individuals with high and low speech imitation aptitude. In line with previous findings that musical aptitude is related to neuroanatomical markers in auditory cortex (e.g. Heschl's gyrus, as shown in 1) we now identified similar markers in auditory cortex in individuals with high language aptitude for speech imitation/pronunciation. Moreover, systematic relationships were observed between structural anatomy and functional connectivity measures. Conclusion: This leads us to the conclusion that neuroanatomic markers of speech / language aptitude (oral speech imitation in this case) can be linked to classical auditory areas formerly connected to musical aptitude and expertise. This shows that abilities in the domains of music and speech (specifically in pronunciation) do not only overlap and correlate behaviourally, but also might share common grounds in the neuroanatomy of primary auditory areas. References: [1] Seither-Preisler, A., R.Parncutt, and P.Schneider (2014), 'Size and synchronization of auditory cortex promotes musical, literacy and attentional skills in children', Journal of Neuroscience, vol. 34, no. 33, pp. 10937-49. [2] Reiterer, S.M., et al. (2011), 'Individual differences in audio-vocal speech imitation aptitude in late bilinguals: functional neuro-imaging and brain morphology', Frontiers in Psychology, vol. 2, no. 271. [3] Golestani, N., C. J. Price and S. K. Scott (2011), 'Born with an Ear for Dialects? Structural Plasticity in the Expert Phonetician', Journal of Neuroscience, vol. 31, no. 11, pp. 4213-4220.

Perception: Speech Perception and Audiovisual Integration

F3 Native language status of the listener modulates the neural integration of speech and gesture in clear and adverse listening conditions

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Face-to-face communication consists of integrating speech and visual input, such as co-speech gestures. Iconic gestures (e.g. a drinking gesture) can enhance speech comprehension, especially when speech is difficult to comprehend, such as in noise (e.g. Holle et al., 2010) or in non-native speech comprehension (e.g. Sueyoshi & Hardison, 2005). Previous behavioral and neuroimaging studies have argued that the integration of speech and gestures is stronger when speech intelligibility decreases (e.g. Holle et al., 2010), but that in clear speech, non-native listeners benefit more from gestures than native listeners (Dahl & Ludvigson, 2014; Sueyoshi & Hardison, 2005). So far, the neurocognitive mechanisms of how non-native speakers integrate speech and gestures in adverse listening conditions remain unknown. We investigated whether high-proficient non-native speakers of Dutch make use of iconic co-speech gestures as much as native speakers during clear and degraded speech comprehension. In an EEG study, native (n = 23) and non-native (German, n = 23) speakers of Dutch watched videos of an actress uttering Dutch action verbs. Speech was presented either as clear or degraded by applying noise-vocoding (6-band), and accompanied by a matching or mismatching iconic gesture. This allowed us to calculate both the effects of speech degradation and semantic congruency of the gesture on the N400 component. The N400 was taken as an index of semantic integration effort (Kutas & Federmeier, 2011). In native listeners, N400 amplitude was sensitive to mismatches between speech and gesture and degradation; the most pronounced N400 was found in response to degraded speech and a mismatching gesture (DMM), followed by degraded speech and a matching gesture (DM), clear speech and a mismatching gesture (CMM), and clear speech and a matching gesture (CM) (DMM>DM>CMM>CM, all $p < .05$). In non-native speakers, we found a difference between CMM and CM but not DMM and DM. However, degraded conditions differed from clear conditions (DMM=DM>CMM>CM, all significant comparisons $p < .05$). Directly comparing native to non-native speakers, the N400 effect (i.e. the difference between CMM and CM / DMM and DM) was greater for non-native speakers in clear speech, but for native speakers in degraded speech. These results provide further evidence for the claim that in clear speech, non-native speakers benefit more from gestural information than native speakers, as indexed by a larger N400 effect for mismatch manipulation. Both native and non-native speakers show integration effort during degraded speech comprehension. However, native speakers require less effort to recognize auditory cues in degraded speech than non-native speakers, resulting in a larger N400 for degraded speech and a mismatching gesture for natives than non-natives. Conversely, non-native speakers require more effort to resolve auditory cues when speech is degraded and can therefore not benefit as much from auditory cues to map the semantic information from gesture to as native speakers. In sum, non-native speakers can benefit from gestural information in speech comprehension more than native listeners, but not when speech is degraded. Our findings suggest that the native language of the listener modulates multimodal semantic integration in adverse listening conditions.

F4 Lip movements entrain the observers' low-frequency brain oscillations to facilitate speech intelligibility

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Communication is one of the most fundamental and complex cognitive acts humans engage in. In a dialogue, a large range of dynamic signals are exchanged between interlocutors including body posture, facial expressions, head and eye movements, gestures and a rich acoustic speech signal. Besides the acoustic speech signal, only lip movements contain enough information to allow trained observers to comprehend speech through visual signals. Dynamic lip movements support disambiguation of syllables and can provide temporal onset cues for upcoming auditory signals. However, it is largely unclear how signals of dynamic lip movements during continuous speech are represented in the brain and how these visual representations interact with auditory representations. Here we investigated for the first time directly how these rhythms interact with neuronal oscillations in the brain. We recorded magnetoencephalography (MEG) signals from 44 participants (25 females; mean age: 20.45 ± 2.55 yrs) while attending to movies of audiovisual speech. Auditory and visual stimuli were manipulated to be congruent or incongruent; All congruent, All incongruent, AV congruent, AV incongruent. In each condition, one video recording was presented and two (identical or different) auditory recordings were presented to the left and the right ear, respectively. We extracted time series characterizing lip movements from the video and looked for common rhythmic modulations in lip movements and recorded brain activity using coherence. In order to rule out functional coupling (coherence) explained by auditory signals, we additionally computed partial coherence - coherence partialling out sound speech signals. Further, we identified its attentional modulation and effects on the speech comprehension. To examine behavioral consequence of the entrainment induced by lip movements, we searched brain areas that can be predicted by behavioral performance by regression analysis using comprehension accuracy across subjects. First, we report that the rhythms of lip movements in natural speech entrain brain activity in speech processing areas, both sensory and higher-order regions. Second, attentional lip-reading showed left-lateralized visual and right-lateralized auditory entrainment. Third, considering the coherent nature of lip-sound speech signals, we partialled out the effect of sound speech signal in the observation of lip entrainment to examine the main effect of speaking lips. This revealed that left motor cortex is important for the tracking of lip movements suggesting the functional role of visual speech in top-down predictive timing. Finally, we revealed that tracking of speaking lips in motor cortex is critical for the high level of speech comprehension. This is the first evidence

of the rhythmic synchronization of lip movements in the brain during audiovisual speech and their impact on speech comprehension. Importantly, our results demonstrate that left-lateralized motor areas in observers become synchronized to speaker's lip movements. This represents a likely mechanism for the previously demonstrated involvement of motor areas in speech perception. Our results therefore have far reaching consequences for our understanding of human communication as well as provide insights into fundamental neural mechanisms of speech processing. In addition, our methodology can be used for clinical applications such as study of lip-reading in deaf patients.

F5 Sensorimotor differences between stuttering and non-stuttering adults in speech and tone discrimination tasks observed in EEG mu rhythms

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Stuttering is associated with a sensorimotor compromise in speech. However, measures of sensorimotor activity in production tasks can be influenced by highly variable stuttering behaviors that can in turn, impart large variability in neural data. To overcome this barrier, it is possible to examine sensorimotor activity in auditory discrimination tasks that are known to recruit the same dorsal stream sensorimotor circuitry that is critical to production. The goal of this study was to compare sensorimotor integration from anterior dorsal (i.e., Premotor / motor) regions in speech and tone discrimination tasks between adults who stutter (AWS) and non-stuttering populations. 26 AWS and a cohort of age, gender, and handedness matched non-stuttering controls performed syllable and tone discrimination tasks in quiet and noisy conditions while 64-channel EEG data were recorded. Independent component analysis (ICA) was performed on the raw data from accurate discrimination trials. 21 left and 22 right sensorimotor mu (μ) components were identified in the AWS and their matched controls. All μ components met the criteria of having distinct peaks in the alpha (8-13 Hz) and beta (15-25 Hz) range, localized to premotor (BA 6), primary motor (BA 4) or primary sensorimotor (BA 1,2,3) regions. The first important finding is that μ rhythms from the AWS had significantly (pFDR<.05) smaller (i.e., lower spectral power) beta peaks than the controls. Weaker beta peaks persisted in spectral data from all discrimination conditions and the control condition, in which participants simply listened to passive noise, suggesting a trait-based neural marker of stuttering. Beta μ activity is thought to represent motor activity and the generation of efference copies. Therefore, this finding is consistent with the notion that stuttering is related to weak internal modeling. All spectral μ data underwent time-frequency decomposition, which revealed group-level differences in stimuli processing over the time course of experimental trials. In the left hemisphere, the AWS displayed stronger event-related desynchronization (ERD) across the event in beta bands. This difference again may indicate trait-related sensorimotor processing differences. The AWS produced stronger ERD in both alpha and beta bands before and during stimulus presentation in the tone in noise condition and in the beta band prior to stimulus presentation in the speech in noise condition. These differences suggest that stuttering is associated with differences in predictive coding (i.e., generation of internal models and ability to suppress non-relevant information) for speech discrimination. In the right hemisphere, group differences were not observed in the speech in noise condition, but were present in the tone in noise condition. This finding suggests that right hemisphere sensorimotor processing may compensate for left hemisphere deficits in AWS. Of note, both groups achieved over 90% discrimination accuracy in the speech conditions. Interestingly, the AWS group performed significantly poorer in the tone conditions, with the group difference reaching statistical significance in the quiet discrimination condition. Together, these data demonstrate that sensorimotor differences associated with stuttering are evident during auditory perception, not just production, and can be measured with precise temporal accuracy using this EEG technique.

F6 The role of the premotor cortex in multisensory speech perception throughout adulthood: a rTMS study

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Although neurobiological models of language argue for a left lateralization of the audio-motor dorsal pathway during speech perception [1], the question of the role of the right and left premotor ventral (PMv) areas in multisensory speech integration processes remains largely unknown. What is the contribution of the hemispheric differentiation in the integration processing and what role do premotor areas play in these mechanisms? Further, given the known differences in speech perception accuracy for young and older adults and decreasing sensorial acuities with age, it is possible that the lateralization of multimodal integration processes evolves over time. In the present study, we explored the impact of inhibitory transcranial magnetic stimulation (rTMS) on the right and left PMv during auditory (A), visual (V) and tactile (T) unimodal conditions as well as during audio-visual (AV) and audio-tactile (AT) bimodal conditions across age. The experiment consisted of 2 rTMS sessions (related to the left and right PMv) conducted for each of the 24 healthy right-handed participants (16 females; mean 46±19 [19-78] years). Following completion of each session, participants performed a force-choice identification task. They were told that they would be presented with /pa/, /ta/ or /ka/ syllables in 5 different sensory modalities (A, V, AV, T, AT) and had to identify, as quickly as possible, the perceived syllable by pressing on one of three keys on a response pad. To increase task-difficulty, half the trials were presented in quiet, while the other half was presented in noise. Mixed-model ANOVAs were conducted on the mean accuracy and median reaction time (RT) data with the target region (left PMv/right PMv), the acoustic environment (noise/no noise), and the modality (A/AV/AT/V/T for the accuracy analysis and A/AV/AT for the RT analysis) as the within-subjects factors, the order of the stimulation (left PMv first, right PMv first) as a between-subjects factor, and age as a continuous quantitative

between-subjects co-variable. Our results demonstrate that multimodal integration is relatively preserved in aging, becoming slower but not less accurate. Importantly, we found a significant linear negative relationship between hemispheric difference and age in the auditory modality, i.e., with increasing age, hemispheric differences declined. Interestingly, no such difference occurred in the bimodal modalities. This suggests a larger recruitment of the right PMv to support auditory speech processes in elderly adults, possibly as a consequence of a reduced auditory acuity with age, or a de-differentiation of the phonemic categories. In contrast, the absence of an age effect in the bimodal conditions suggests that multisensory processing remains stable throughout adulthood. Together, these results demonstrate that multisensory integration mechanisms are, at least in part, maintained with age despite a decline in auditory acuity, and demonstrate the feasibility of using rTMS in healthy elderly adults to study speech and language processes. Key words: motor system, rTMS, multisensory integration, aging Reference: [1] Murakami, T. et al (2015). Left dorsal speech stream components and their contribution to phonological processing. Journal of Neuroscience, 35(4):1411–1422

F7 Distributed Networks of Speech Production Regions Play a Context Determined Role in Speech Perception

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Does "the motor system" play a role in speech perception and, if so, where, when and why? To address this long-standing question, we conducted a quantitative review of 106 speech and language-related neuroimaging studies using region and network based meta-analyses and a novel text mining procedure. The analyses tested three hypotheses derived from a more traditional qualitative review of the literature. Specifically, we hypothesized that: 1) widely distributed sets of brain regions involved in speech production overlap with regions associated with passive speech perception; 2) regions of production-perception overlap are organized into distributed networks; and 3) the topology of these networks dynamically change as a function of listening context. To test these hypotheses, we queried the BrainMap database (www.brainmap.org) for experiments meeting a set of common criteria (e.g. "right-handed", "healthy") and sets of criteria specific to each hypothesis. These queries returned peaks of functional brain activity reported in neuroimaging papers. Activation Likelihood Estimation (ALE) meta-analyses were then performed by modelling each peak as a three-dimensional probability distribution and quantitatively assessing the convergence of peaks across experiments. To test the first hypothesis, the common criteria were combined with criteria associated with speech production and speech perception (e.g. "articulator movement", "passive listening"). Common locations of activation were then found. To test the second hypothesis, ALE co-activation meta-analyses was conducted to find which networks were associated with the previously identified production-perception regions. The variability and connectivity of the identified networks as well as their overlap was also assessed. To test the third hypothesis, automated text mining was used to create a corpus of common terms from the titles, abstracts and methods of the reviewed studies. The corpus was then used to relate changes in network topology to the stimuli and tasks used in the experiments (i.e. context). A functional correspondence between regions involved in non-linguistic movement of the articulators, covert and overt speech production, and the perception of both nonspeech and speech sounds was observed. Cortical and subcortical regions that are more distributed than typical definitions of the "motor system" formed multiple perception-related networks. Strikingly, the topology of these networks organized around listening context. The results are inconsistent with classic motor or acoustic only models of speech perception and they challenge dual-stream models of the organization of language and the brain. The results are more consistent with a sensorimotor model of speech perception that contains multiple self-organizing speech production related networks. We argue that these networks dynamically form to constrain interpretations of indeterminant acoustic patterns as listening context requires.

F8 Speech rhythm measure of non-native speech using a statistical phonemic duration model

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We normally understand speech in our native language without effort. Recent brain imaging studies revealed a common cortical activation in left-lateralized motor area for speech production and perception. Moreover, the activity was increased by listening to speech sounds with less natural frequency information such as sinewave speech and noise-vocoded speech. Rhythm is a natural part of speech. There is a difference between a mora-timed rhythm like Japanese and a stress-timed rhythm like English. A native Japanese speaker tends to apply mora-timed rhythm to English. However, few studied have investigated the neural mechanisms of the processing of speech rhythm during speech perception. We developed a method for decomposing speech signals into speech rhythm and frequency information. English speech sounds spoken by a native Japanese speaker were manipulated such that their rhythm was stress-timed like English and more-timed like Japanese. Stress-timed rhythm was obtained from a native British English speakers' speech. Noise-vocoding was used to minimize contributions of F0 and to control intelligibility across conditions. Twenty-one healthy right-handed native English speakers were participated. FMRI was used to image the brains of participants while they listened to the sentences. Result showed that left-lateralized supplementary motor area (SMA), a region involved in speech production, was more activated for mora-timed rhythm (non-native rhythm) than stress-timed rhythm. This suggests that integrating non-native speech rhythm with native language speech may rely on increased auditory-motor processing. In behavioral testing, native English speakers judged the naturalness of speaking rhythm of the sentences. Results confirmed participants judged English rhythm as being most natural. However, it is important that a difference between non-native rhythm and stress-timed rhythm in English speech should be quantified for further analysis. A pairwise variability index (PVI) of vocalic intervals was proposed as a speech rhythm measure. Native Japanese speakers tend to speak unnecessary vowels in English because a mora basically ends in a vowel. However, these unnecessary vowels affects PVI values: it is

not appropriate to the quantification for non-native speech. In this study, we developed a statistical model of phonemic duration in English to be independent of a type of interval. Speech stimuli of English sentences (TIMIT) spoken by both English and Japanese native speakers were used. Phonemic duration for each phoneme were determined by experts. The expectation-maximization algorithm created a two-state transition model of the phonemic duration for each native language. Mean durations in each state were short and long, respectively. Results showed that a variability among states of self-transition probability for the native Japanese speaker was significantly larger than for the native English speaker ($p < 0.01$). This indicated that longer phonemic duration was continuously repeated for native English speakers more than for native Japanese speakers. This suggests that these structures of phonemic duration affected activity in the speech perception network.

Multilingualism

F9 Bilingualism impacts white-matter connectivity: evidence from DTI

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Introduction: In the past two decades, many fMRI studies have highlighted how second language (L2) learners engage linguistic and non-linguistic brain networks differentially[1]. Fewer studies have investigated how speaking two languages promotes structural changes. Recent research has demonstrated that bilingualism affects white-matter density with bilinguals showing higher mean fractional anisotropy (FA). Positive effects of bilingualism on white-matter connectivity have been reported in children[2], young adults[3], and older adults with a life-long experience of speaking two languages[4]. Importantly, L2's proficiency, and age of acquisition have been show to modulate the effect. The goal of this study was to provide novel evidence for the effect of bilingualism on white matter connectivity in late yet proficient L2 learners, while controlling for the language background of the bilingual speakers. Method: 21 monolingual speakers (15 females), and 22 (20 females) bilinguals (age range:18-27) participated. English monolingual speakers had no or minimal knowledge of a second language. Bilingual speakers were native speakers of English who learned Spanish later in life (average: 12 years). They had intermediate-high proficiency in Spanish calculated through a language proficiency composite measure. DTI data were collected on a Siemen's TRIO. The following parameters were used: TR/TE = 6500/93 ms, FOV = 240 mm, matrix = 128x128, 48 slices, slice thickness = 3 mm with 20% gap, average = 2. iPAT factor = 2, phase partial Fourier = 6/8, 20 diffusion directions, b = 1000 s/mm2. Data were analyzed with FSL to examine the FA differences between monolinguals and English-Spanish bilinguals. In addition, regression analyses were performed to examine the impact of Spanish proficiency as well as the age of L2 acquisition. Analysis and results: The TBSS analysis shows a significant difference in FA between bilingual and monolingual subjects ($p<0.05$). The bilinguals showed increased FA primarily within the left hemisphere within the internal capsule. The posterior limb of the internal capsule contains sensory fibers that connect auditory and visual cortices to the temporal lobes via the thalamus. When examining the bilingual group only, the FA of the internal capsule showed a trending correlation with age of acquisition (n=15 due to missing data) but no correlation with proficiency. Conclusions: Our results show an overall effect of bilingualism on white-matter connectivity. FA differences were restricted to the left hemisphere for tracks that contain fibers related to sensory-motor processing. Our results also show a correlation between white-matter connectivity and age of acquisition. References: [1]Crinion, J., Turner, R., Grogan, a, Hanakawa, T., Noppeney, U., Devlin, J. T., … Price, C. J. (2006). Language control in the bilingual brain. Science, 312(5779), 1537–1540. [2]Mohades, S., et al. (2012). DTI reveals structural differences in white matter tracts between bilingual and monolingual children. Brain Research, 1435, 72–80. [3]Pliatsikas, C., et al. (2015). The effects of bilingualism on grey and white matter structure. Proceedings of the National Academy of Sciences, (11), 1–4. [4]Grady, C. L., Luk, G., Craik, F. I. M., & Bialystok, E. (2015). Brain network activity in monolingual and bilingual older adults. Neuropsychologia, 66(June), 170–181.

F10 Neural underpinnings of grammatical processing for less proficient L2 learners

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Research shows that the successful processing of complex morpho-syntactic constructions in adult second language (L2) learners is influenced by several factors, one of which is proficiency [1]. Recent neuroimaging studies show that a subset of highly proficient L2 speakers show native-like processing of L2 grammatical structures [2]. However, less is known about less proficient L2 learners and what factors might predict native-like processing. Event Related Potentials (ERPs) and Time-Frequency Representations analyses were used to show changes of oscillatory neuronal activity over time during morpho-syntactic processing [2]. We analyzed the neural response for subject-verb agreement violations in native Spanish speakers and late L2 learners of Spanish. Native Spanish speakers (n=23, mean age= 22) were tested in Granada, Spain and English-Spanish bilinguals (n=21, mean age= 21) were tested at Penn State University. The bilinguals rated aspects of their Spanish skills on a 1-10 scale (average score= 7) and completed a DELE grammar test (average score= 47%). There were 68 experimental items which included a preamble (always correct) followed by a target sentence (half correct, half with a subject-verb agreement violation) (1). (1) La familia compró un pastel grande para preparar una comida para una fiesta de cumpleaños. Antes de la gran fiesta, el pastel estaba/*estaban en el refrigerador de la familia. The family bought a big cake to prepare a meal for a birthday party. Before the big party, the cake was/*were in the family refrigerator. The time-domain results show that native Spanish speakers are sensitive to subject-verb violations shown in a positive deflection around 600ms after the violation (P600) occurred (μCorr.Cond -0.446; μIncorr.Cond 0.155; $F=4.930$; $p<.05$). The time-frequency analysis corroborated the time-domain results showing a significant ($p<.05$) decrease in alpha and beta power in the 8-18 Hz, 18-21 Hz and 26-29 Hz frequency ranges in the violation condition. The time-domain results for

L2 learners showed that L2 learners are also sensitive to the grammatical violation, as revealed by a more positive P600 for the violation condition (F=5.80, p<.05). Moreover, there was a significant positive effect of reading abilities on the P600 magnitude (F=7.19, p<.05), so L2 speakers with better reading abilities showed a larger P600 magnitude effect. Interestingly, there was a significant correlation between reading abilities and power in alpha (8-12 Hz) frequency band (r=0.45; p<.05). This study showed changes of oscillatory neuronal activity for morpho-syntactic processing in native speakers and L2 learners. Our results show that native speakers are sensitive to grammatical subject-verb agreement violations. Our data also show that L2 learners have an emergent neural sensitivity to subject-verb agreement violations. We demonstrated that sensitivity to grammatical violations is mediated by proficiency in L2 reading abilities. References: [1] Steinhauer, K. (2014). Event-related Potentials (ERPs) in Second Language Research: A Brief Introduction to the Technique, a Selected Review, and an Invitation to Reconsider Critical Periods in L2. Applied Linguistics, 1–26. [2] Rossi, E., Kroll, J. F., & Dussias, P. E. (2014). Clitic pronouns reveal the time course of processing gender and number in a second language. Neuropsychologia, 62(1), 11–25.

F11 While language-switching in the lab localizes in anterior cingulate cortex, comprehending code-switches in the wild begins in auditory cortex

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Introduction. Fluent code-switching is a remarkable feat of the bilingual brain and a central part of many bilinguals' everyday experience. However, the neurobiology of this ability has primarily been explored with experimental designs that make code-switching quite hard, involving artificial cues for switching (e.g., color-cues associated with a language). This contrasts starkly with the intuitive ease of naturally occurring switching. In this experiment, we conducted the first ever investigation of the spatio-temporal profile of language switching in natural conversation and linked this profile to effects in artificial switching paradigms. To cover the spectrum of potential dissimilarities between these two extremes, we included two more natural lab-switching tasks, modeled according to two different natural code-switching situations: dense code-switching (bilingual interlocutors interleaving languages freely) and dual-language switching (both languages are used but with different speakers). In sum, we aimed to elucidate whether switching costs reported in prior literature generalize to more natural contexts and to reveal the profile of switching effects in natural conversation, which could by hypothesis dissociate from even the most naturalistic laboratory tasks. Methods. Laboratory tasks: 19 Arabic-English bilinguals performed six switching-tasks varying in context (dense-code-switching/dual-language/artificial-color) and use (production/comprehension) during an MEG recording. In production, participants saw a language cue before naming a picture. In comprehension, subjects saw a cue, listened to Arabic/English words and then indicated whether the word matched a subsequent picture. In dense-code-switching and dual-language contexts, language cues were pictures of previously introduced speakers. In the artificial context, target language was indicated by a color cue. Natural conversation: Participants listened to five one minute-long real conversations between two Arabic-English bilinguals containing frequent code-switches. Non-switch controls were selected from fragments that mirrored the linguistic context of the switches but did not include switching. Triggers at these time-points were added post-hoc. Analyses focused on prefrontal and cingulate cortices (PFC/ACC) previously implicated for language switching (Abutalebi & Green, 2007), and in auditory cortices, hypothesized to underlie the comprehension of auditory switches (Blanco-Elorrieta & Pylkkänen, 2016). Results. Within the laboratory tasks, activity increased for switches in the ACC in both production and comprehension across all contexts. This effect was not, however, observed in the natural conversation. Instead, switch-effects in the conversation localized in auditory cortices at 50-150ms post switch-onset. Finally, within the laboratory tasks, we observed a reliable increase in bilateral ACC at 100-300ms for the dual and dense-code-switching situations as compared to the artificial color-cued context. Conclusion. While the detection of code-switches in natural speech appears to start in auditory cortex at 50ms, neural effects of language-switching in laboratory tasks onset later and localize in anterior cingulate cortex. Additionally, although the ACC switch-costs reported in prior literature did generalize to our more natural laboratory tasks, we also found that the traditional color-cuing design does not engage the ACC to the same degree as the more natural dense-code-switching and dual-language contexts, suggesting that within the laboratory tasks, the introduction of a social context may in fact engage the conflict resolution mechanisms of the ACC more than a completely artificial context.

F12 Perception and production interactions in non-native speech category learning

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Reaching a native-like level in a second language includes mastering phoneme contrasts that are not distinguished in one's mother tongue – both in perception and production. This study explores how those two domains interact in the course of learning and how behavioural changes in both listening and speaking ability are related to traceable changes in the brain. Unravelling the processes underlying speech category learning could guide the design of more efficient training methods. Production and perception processes could support each other during learning, or they could interfere with each other. Baese-Berk et al. (2010), for instance, observed delayed learning when perceptual training was combined with production practice compared to perception-only training. These results could indicate perception-production interference but could also be explained by differences in cognitive load between the two conditions. In order to disentangle the added value of production training in perceptual category learning, we systematically contrasted the combination of perceptual training with either related or unrelated production. Thirty-one native speakers of Dutch distributed between two groups participated in a 4-day high-variability training protocol on the British-English /æ/-/ɛ/ vowel contrast (multiple words spoken by multiple talkers). In the related production group

(n=15) feedback on a perceptual categorisation task was combined with pronouncing the respective correct word on every trial, whereas it was combined with pronouncing a matched but phonologically unrelated set of words in the unrelated production group (n=16). Cognitive load was matched between groups. Pre- and post-training measurements were taken of both perceptual abilities (in an identification task, an identification task assessing category boundaries on a morphed continuum, and a discrimination task on the same continuum) and production ability (a reading-aloud task with a list of isolated words). All auditory stimulus words during the training were presented according to a classical oddball paradigm, while the electrophysiological activity was recorded continuously. This enabled us to track neural changes in auditory discrimination ability using the mismatch negativity response (MMN). Results indicate that participants' perceptual ability significantly improved over the course of training. No significant difference in perceptual learning arose between the two groups. Measurements of the distribution of formants F1 and F2 in the words in the production task before and after training (quantified in terms of Mahalanobis distance) showed that participants in both groups significantly improved after training: the two English target vowels became acoustically more distinct. Analyses of the electrophysiological data and of the other behavioural tasks are ongoing and will be presented. The fact that participants' perceptual ability improved similarly regardless of whether they also practiced the respective productions could be seen as evidence that the perception and production systems for non-native vowels are separate. A more likely explanation, however, is that the added value of practicing the pronunciation of the vowels might have been counteracted – especially early in training - by exposure to sub-optimal utterances as the participants listened to their own voices. In order for production practice to be beneficial for the learner, immediate and informative feedback on production outcomes might be necessary.

F13 Unconscious translation from Japanese kanji to Chinese hanzi by Chinese-Japanese bilinguals: An ERP investigation

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Evidence from individuals who master two distant languages (e.g., Chinese and English) demonstrates unconscious "translation" retrieving word forms of their native language when they were reading or listening to the second language (Wu and Thierry, 2010). However, it is unclear whether such access exists for bilinguals whose languages are logographic and share grapheme-meaning conversion system, since this L1-inherited system may help them access the concept of L2 word relying on graphemes, and consequently enables them to bypass the translation to an L1 word. To test this hypothesis, 16 native Japanese and 14 Chinese advanced learners of Japanese were recruited to read Japanese two-kanji compounds while their EEG was recorded. Japanese Kanji and Chinese characters are morpho-graphic in nature and of identical origin, but not all compounds consisting of multiple kanji are shared by two languages. Participants were asked to judge whether pairs of sequentially presented words were related in meaning: while the preceding primes were lexical only in Japanese but not in Chinese, the subsequent targets were cognates existing in both languages. Relevant to the task, the prime could be semantically related/unrelated to the target (S+/S-); but its hidden Chinese translation could also have one/no character identical to the target cognate's (C+/C-). Accordingly, three critical types of prime-target pairs were formed: S+C-, S-C+, and S+C+, to be compared with their lexically matching baseline (S-C-), respectively. Japanese participants were expected to respond to only semantic, but not character priming since Chinese translations were unknown to them. Chinese participants should show semantic priming effect, too. Critically, the presence or absence of character priming effect may suggest whether or not access to concept for L2 word requires word-level translation with L1 forms activated when lexicon of these two language systems are close. We focused on the ERP responses in two time windows, i.e., the positivity component at 100-300 ms (P200) and the negativity component at 300-500 ms (N400) from the onset of the target; whereas the former is considered to indicate the pre-lexical processing of orthographic/phonological information, the latter reflects meaning access during word recognition. As predicted, Japanese participants responded with decreased N400 to both S+C- (2.42 μV) and S+C+ (2.51μV) relative to their corresponding S-C- ($ps < .01$), replicating the typical semantic priming effect reported in prior works. Repeated translation character did not contribute to Japanese participants' L1 word recognition, since the semantic priming effect size for S+C- and S+C+ were comparable without significant difference, and no other significant results were yielded ($ps > .1$). For Chinese participants reading L2 words, primes of S+C- and S+C+ also led to N400 attenuation on target reading, 2.12 μV, and 1.55 μV, respectively ($ps < .05$). Critically, evidence supports unconscious L2-to-L1 translation with the invisible L1 character information activated. P200 was 1.1 μV enlarged for S-C+ compared with its S-C- baseline ($p < .01$), suggesting an interference of L2 word recognition caused by reading an orthographically identical but phonologically differing character.

F14 The effects of cross-linguistic phonologic and semantic overlap in masked priming paradigm: behavioral and ERP evidence

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Introduction An unresolved question in neuroscience is how several languages are handled by the bilingual brain. A particularly controversial issue is whether bilingual lexicon is maintained as a single integrated store or separated into two independent ones. One way to approach this experimentally is to use interlingual homophones thus creating ambiguity in perception in case of integrated lexicon. Here, we used English-Russian prime-target word pairs with varied phonological and semantic similarity, taking advantage of the two languages using orthographically distinct writing systems. Thus, we investigated cross-linguistic phonological and semantic similarity effects on the activation of bilingual lexicon in the human brain in Russian-English bilinguals.

Methods Russian-English late unbalanced bilinguals (N=17) were tested in a masked priming paradigm with L1 (Russian) words as masked primes and L2 (English) words as targets. The subjects' proficiency in English was evaluated with LEAP-questionnaire and custom-made vocabulary test. The experimental task was to maintain the targets in memory until the next trial and match them against occasionally presented catch stimuli. In different randomly presented pairs, the primes and the targets either overlapped (1) phonetically, (2) semantically, (3) both phonetically and semantically, or (4) did not overlap. There were 73 unique one-syllable word pairs in each condition, balanced for frequency. In parallel, we continuously recorded 128-channel electroencephalogram (EEG) and measured the event-related potentials amplitude at N170 and N400 latencies (in 32-ms windows centered at 170 and 400 ms after target onset), where the most prominent peaks arose. The electrodes were pooled in 16 local clusters. The N170 activity was examined in lateral occipital clusters and N400 was investigated in the central clusters. In addition, LORETA source analysis was performed and source power was extracted from 4 regions-of-interest within the left temporal lobe. Results Our behavioral data analysis established that targets in phonologically overlapping cross-linguistic pairs were better identified than other targets, which was manifested as significant differences in the number of hits. In ERP analysis, semantically congruent pairs produced a marginal increase of the N170 component over right occipital electrode cluster. Critically, phonology and semantic interacted in the N400 window, where the amplitude was reduced by phonological overlap specifically in the semantically unrelated condition. The source analysis demonstrated a reduction of activity specifically in the situation of simultaneous phonetic and semantic overlap in comparison to either pure phonetic or pure semantic overlap. This effect was the strongest in the left inferior temporal gyrus (BA20). Conclusions Our data reveal cross-linguistic interaction in languages with distinct orthography in both behavioral and electrophysiological measures. The ERP data indicate that both phonological and semantic cross-linguistic similarities are detected by the brain, especially in the left inferior temporal gyrus. On retrival of the written form, the phonologically similarity between the words of the two languages caused ambiguity and, as a consequence, reduced behavioral performance in the task. The data thus support the notion of an integrated bilingual lexicon.

F15 Improving foreign language pronunciation with VocalXplorer: an interactive phone application providing immediate and customized auditory feedback.

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Developing novel motor sequences that are necessary for accurately pronouncing foreign speech is a challenge, and our work suggests that late learners of a foreign language may end the learning phase too early. Instead they overly rely on their original native motor patterns for producing speech, which results in speaking with a foreign accent. This has support from vocal learning studies on songbirds. Essential for song learning is a pathway, the homologue of mammalian cortical-basal ganglia 'loops', which includes the avian striatum. Jarvis (2004) put forward the hypothesis that as in songbirds there exist two pathways in humans: one for learning speech (the vocal learning pathway), and one for production of previously learnt speech (the motor pathway). Our previous findings also suggest that variability in behavioural performance may maintain activity within the vocal learning pathway and supports accurate pronunciation. The current study translates our neural work to behavior, exploring behavioural techniques that modify variability in pronunciation during second language learning, in order to identify strategies that keep speakers in the learning phase for longer. The aim was to develop and test novel strategies for increasing stochastic variability during learning associated with the striatum, as demonstrated by our earlier neuroimaging work. We have developed an interactive phone application – the vocalXplorer – that provides immediate customized auditory feedback with the goal of improving native-like foreign language pronunciation. VocalXplorer presents auditory stimuli, records the learner's attempt to repeat it, provides online auditory feedback of various types, and assesses acoustic variability. The online auditory feedback aims to optimize the user's variability in pronunciation in order to engage the vocal learning pathway for longer, with the hope of resulting in closer to native-like pronunciation. 16 subjects participated in the current study, for which the stimuli were bisyllabic novel foreign words from German, Mandarin and Spanish. The altered auditory feedback conditions included were: 'delayed', 'echo' and 'none' (removal of auditory feedback), with normal feedback as a baseline. Compared with the baseline of normal feedback, 'echo' and 'none' increased variability of vocal performance; 'delayed' resulted in less variability. When comparing over three timepoints, the most striking result was that removal of auditory feedback greatly increased variability. This suggests that without being able to monitor their speech by listening, participants stopped relying on their motor vocal pathway and engaged the vocal learning pathway for longer. Future steps will incorporate a machine-learning aspect into vocalXplorer using Bayesian optimization methods to effectively learn the auditory feedback type that results in the optimal amount of variability in pronunciation for each user individually.

Meaning: Lexical Semantics

F16 Electrophysiological registration of body and mental action processing within the thalamus, subthalamic and pedunculopontine nucleus

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Introduction Electrophysiological registration of semantic processing generally implies paradigms eliciting semantic violations on recognition memory or semantic judgement tasks. The N400, left anterior negativity and P600 may be sensitive to semantic judgement alterations on cortical level (Kuperberg et al., 2003, Olichney et al., 2008). Although semantic effects of subcortical modulation have been well described, it is unclear if semantic related local field potentials can be elicited in the main subcortical nuclei. Direct registration of language elicited EEG in the deep brain nuclei is only possible in patients recruited

for deep brain stimulation as a treatment for their illness and in the short period after the operation that the electrode leads are still externalized. The current research project focusses on the electrophysiological registration of semantics (body versus mental action verbs) within the thalamus, subthalamic nucleus (STN) and the pedunculopontine nucleus (PPN) 1 week after DBS-implantation. Methodology The current study implied 18 patients with deep brain electrodes within the STN (8 male/10 female), 2 patients with electrodes in the thalamus (mean lft/geslacht) and 1 patient with PPN stiumulation (mean lft/geslacht). All patients were non-medicated and right-handed at the moment of testing. The ERP-paradigms consisted of thirty hand action verbs (e.g. to sew, to point) and 30 mental action verbs (e.g. to leave, to develop). Data was collected using a 32 channel SynAmp (Neuroscan) amplifier. EEG analysis (ERP-waveform and source localizing) was performed in all nuclei using BrainVision Analyzer 2 (Brain Products, Munich, Germany). Results The results of the study demonstrates a grand average between 200 and 470 ms for body action verbs within the left STN (L0-L1/L1-L2). No grand average EP can be observed for the mental action verbs or for the difference between body action and mental action verbs. Within the left thalamus a clear grand average can be seen between 500 and 800 msec (L1-L2/L2-L3) in the action verbs and in the difference between action and non-action verbs (L1-L2/L2-L3). For the mental action verbs in the left thalamus a grand average can bee showed between 300 and 680 ms at the same electrode contacts (L1-L2/L2-L3). Within the PPN no grand average can be observed. Conclusion In contrast to the PPN, the left STN and thalamus seem to be involved in semantic processing, but on a different time window. The caudal part of the left STN demonstrates semantic activity in the same time window and cerebral side as on cortical level (300-400 ms in Zhang et al, 2004). References Kuperberg GR, Sitnikova T, Caplan D, Holcomb PJ (2003) Electrophysiological distinctions in processing conceptual relationships within simple sentences. Brain Res Cogn Brain Res 17: 117–129 doi:10.1016/S0926-6410(03)00086-7. Olichney, J.M., Taylor, J.R., Gatherwright, J., Salmon, D.P., Bressler, A.J., Kutas, M., Iragui-Madoz, V.J. (2008). Patients with MCI and N400 or P600 abnormalities are at very high risk for conversion to dementia. Neurology, 6, 1763-1770. Zhang, Q., Guo, C., Ding, J., & Wang, Z. (2004). ERP Differences Between Processing of Body Action and Mental Action Verbs. Acta Psychologica Sinica, 36, 690-696.

F17 Lexical specificity, imageability and emotional arousal modulate the N400 and the N700

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Introduction: The event-related potential (ERP) component N400 as well as a later effect, often labeled 'N700' have repeatedly been shown to increase for concrete as compared to abstract words (Barber, Otten, Kousta, & Vigliocco, 2013; Gullick, Mitra, & Coch, 2013; Kounios & Holcomb, 1994; Nittono, Suehiro, & Hori, 2002; West & Holcomb, 2000). In addition, pseudowords elicit greater N400s than real words (Lau, Phillips, & Poeppel, 2008). Previous interpretations of the N400 as indexing contextual integration or alternatively, activation of semantic features in long-term memory, do not fully explain the combination of these differences. The present study compared ERPs in the N400 and N700 time-windows for PSEUDOWORDS (e.g. 'danalod') and four noun categories differing in specificity and imageability: (SPECIFIC, e.g. 'squirrel', GENERAL, e.g. 'animal', EMOTIONAL, e.g. 'happiness' and ABSTRACT, e.g. 'tendency'). Methods: EEG was recorded from 32 scalp electrodes and response times were measured while 35 healthy, right-handed native Swedish speakers (age 20-37) performed an imageability rating (IR) task and a lexical decision (LD) task. The stimuli were 160 written nouns, 40 each of the above-mentioned semantic categories, and 160 phonologically legal pseudowords. Statistical comparisons of ERPs in the N400 (300-500 ms post-stimulus onset) and N700 (500-800 ms post-stimulus onset) time-windows were carried out using within-subjects ANOVAs. Results: In the LD task, N400 amplitudes increased in the order EMOTIONAL < ABSTRACT < GENERAL < SPECIFIC < PSEUDOWORD. A largely similar pattern was found in the IR task as well as in the N700 time-window of both tasks. N400 and N700 effects were found for SPECIFIC-GENERAL test words also when they were matched for imageability, indicating that something other than imageability per se was driving the effects. Conclusion: The pattern of ERP amplitudes seen in the present study could be explained by a model which assumes that words with larger numbers of associated words in the mental lexicon yield smaller N400s, for example abstract as compared to concrete words and real words as compared to pseudowords. The fact that N400 and N700 effects were found for SPECIFIC-GENERAL test words even when they were matched for imageability indicates that other factors, possibly related to hierarchical semantic relations between concrete noun categories, drive the effect. In line with the suggested model, this might be explained by superordinate GENERAL nouns having a larger number of lexical associates than SPECIFIC nouns. References: Barber, H. A., Otten, L. J., Kousta, S.-T., & Vigliocco, G. (2013). Brain and Language, 125(1), 47–53. Gullick, M. M., Mitra, P., & Coch, D. (2013). Psychophysiology, 50(5), 431–440. Kounios, J., & Holcomb, P. J. (1994). Journal of Experimental Psychology: Learning, Memory, and Cognition, 20(4), 804–823. Lau, E. F., Phillips, C., & Poeppel, D. (2008). Nature Reviews Neuroscience, 9(12), 920–933. Nittono, H., Suehiro, M., & Hori, T. (2002). International Journal of Psychophysiology, 1–11. West, W. C., & Holcomb, P. J. (2000). Journal of Cognitive Neuroscience, 12(6), 1024–1037.

F18 EEG correlates of word frequency and contextual predictability during reading

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Two main factors that influence the speed of word recognition are how often a word occurs in a language and the degree of bias associated with its preceding context. Word frequency and contextual predictability effects have been reliably demonstrated across a variety of measures – lexical decision RTs, eye fixation durations, and event-related potentials (ERPs). Previous research has been inconsistent as to whether these factors, when examined simultaneously, are additive or

interactive. Behavioural RT studies have typically demonstrated interactive effects (e.g., Stanovich & West, 1983), with a greater predictability difference for low frequency (LF) than for high frequency (HF) words. Sereno, Brewer, and O'Donnell (2003) obtained a similar pattern of effects in their ERP voltage amplitude data. In partial contrast, eye movement reading studies have been somewhat equivocal, showing both additive and interactive effects of frequency and predictability (see, e.g., Hand, Miellet, O'Donnell, and Sereno, 2010). Whether frequency-predictability effects are additive or interactive has implications for neurally plausible models of word recognition in reading. Although Sereno et al. (2003) examined such effects using EEG methods, the main focus was on lexical ambiguity resolution, preceding contexts were relatively short, and target words were sentence-final. The current experiment manipulated word frequency (HF, LF) and contextual predictability (Neutral, Biasing) across two-sentence passages. The second sentence containing the target word was identical across context conditions. One set of participants read half the targets in Neutral contexts and half in Biasing contexts, and this mapping was reversed for the other set of participants. There were a total of 62 items in each of the four conditions. Context sentences were initially presented in their entirety, and participants initiated the word-by-word presentation of the target sentence (SOA 300 ms; ISI 33 ms). In the N1 (150-190 ms) window, the ANOVA including 50 electrodes produced significant Context x Electrode and Context x Frequency x Electrode interactions. The ROI-based analysis did yield significant Context x ROI and Context x Frequency x ROI interactions. Further analyses indicated reliable context effects over the posterior midline ROI and the posterior right-hemispheric ROI, whereas there were significant Context x Frequency interactions only over the posterior left-hemispheric ROI and over the central right-hemispheric ROI. Specifically, the reliable predictability effect over the posterior left ROI for LF but not for HF words suggests an early chronometric locus of contextual predictability in reading.

F19 Unitary vs. modality-specific semantic knowledge in object perception: On the neural correlates of perceiving pictures, spoken and written words

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Some of the core questions in cognitive science evolve around the nature of conceptual knowledge, which is assumed to augment a wide variety of mental processes, ranging from language comprehension and production to visual perception and action planning. Previous research is divided as to whether there are distinct semantic representational systems for different sensory input modalities in the brain, or a convergence of semantic processing within a common conceptual representational space (Patterson et al., 2007). However, most studies have focused on comparing visually presented words and pictures (Devereux et al. 2013), even though this does not constitute an orthogonal comparison of sensory input modalities, but rather a comparison of different stimulus formats. Far fewer studies have compared the processing of spoken words with visually presented pictures (Costanzo et al. 2013). However, to the best of our knowledge, no studies have yet undertaken a direct, within-participants comparison of visually presented pictorial material with linguistic material of different input modalities. In addition, many studies relied on explicit semantic tasks such as category judgments or matching tasks, which added a layer of processing beyond "pure" perception that could potentially inflate the activation of amodal neural networks by requiring participants to generate an abstract stimulus judgment unrelated to perceptual processing of the stimuli. The present fMRI experiment addressed the question of whether the conceptual system is a unitary system comprising amodal representations that are used for multiple perceptual processes. To this end, eleven participants (preliminary data; 4 women, mean age: 24 years) were presented with the same objects in different modalities/formats in order to disentangle crossmodal and modality-specific activations in response to pictures, visually presented words and auditorily presented words. The experiment comprised two scanning sessions on two separate days. Each session consisted of six runs, in which 42 objects from six semantic categories (humans, mammals, insects, plants, tools, furniture) were presented once in each of three stimulus conditions: visual-picture, visual-word and auditory-word. Participants monitored the stimuli for the occurrence of either a rotation of the visually presented stimuli or a sinusoidal tone interrupting the auditory stimuli and reported this by pressing a button. Using conjunction analyses, we found robust semantic activation common to all three input conditions in the bilateral posterior superior temporal gyrus. In addition, there were modality-specific activations for the two visual conditions in the right fusiform gyrus and format-specific activations for the two linguistic conditions in the left and right posterior middle temporal gyrus. Activations in Heschl's gyrus and the inferior occipital gyrus most likely reflect intermediate, pre-semantic stages of visual and auditory processing respectively. Our data are consistent with a hierarchically structured, unitary system of semantic representations not only for visually perceived pictures and words, but also for the auditory perception of spoken words referring to the same objects. In addition, further analyses will explore the geometry of this semantic space with respect to animacy , thus testing the hypothesis of a common animacy hierarchy within crossmodal semantic space.

F20 Age-related changes in brain activity underlying word and gesture production

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Language production decreases with age and older adults produce simpler speech with more pauses, are slower and less accurate when naming pictures, and produce more tip-of-the-tongue states (Shafto & Tyler, 2014). However, older adults often show larger vocabulary size than young adults suggesting that older adults might be less efficient in retrieving words from intact memory because they have to search a larger lexicon as a result of life-long learning (Verhaeghen, 2003; Ramscar et al., 2013). Since word retrieval demands correlate with the number of possible alternatives, lexico-semantic search should be comparable across age groups for tool-gesture associations

because of the lower number of possible alternatives in the common use of tools. To test the hypothesis that semantic processing demands increase with age in the verbal but not the manual domain, we scanned young and older adults during a verb and gesture production task. Our hypothesis was that older adults would show more BOLD activity in frontal-temporal networks associated with lexico-semantic search (Birn et al., 2010) than young adults when producing words but not when producing gestures. 20 young and 20 older right-handed, native English speakers matched for amount of formal education were tested on a tool-action association and production task in a 2 x 2 design with independent variables modality (verb / gesture response) and semantics (meaningful / stereotyped response). Participants were presented with a stimulus followed by a green circle cueing their response. In the semantic conditions, stimuli consisted of tool nouns (e.g., scissors) and participants produced an action verb or a hand gesture semantically related to the stimulus (e.g., cut). In the stereotyped control conditions, the stimulus consisted of a meaningless symbol string and participants produced one of two pre-trained responses, a nonsense word (/gaga/) or a pinching gesture. Task-related brain activity was measured following the onset of the stimulus using a Siemens 3T Trio MRI. Data were preprocessed with SPM8 and analyzed with PLS. Neuropsychological testing revealed comparable mean scores for the reverse digit span (Y = 6.25, O = 5.6, p = 0.08), but significantly slower mean response times by older adults on trail making tests A (Y = 20.4s, O = 30.3s, p < 0.001) and B (Y = 39.7s, O = 59.3s, p < 0.001). Older adults showed a significantly larger vocabulary size on two multiple-choice tests (Y = 47.2 / 30.2, O = 52.1 / 37.9 out of 55 / 44, both p < 0.001). Group-analysis results revealed that older adults show increased activity in medial frontal gyrus, caudate nucleus, anterior temporal lobe, and hippocampus during word production. In contrast, during gesture production, younger adults showed more activity in anterior temporal lobe, middle temporal gyrus, and parahippocampus. Individual differences analysis across both groups revealed that hippocampal activity during word but not gesture production was positively correlated with working memory capacity. Together, our results provide evidence for an age-related increase in lexico-semantic processing demands in the medial temporal lobe for words but not for gestures.

Language Development

F21 Segmentation of words from song in 10-month-old infants

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Infant-directed songs are rhythmic with exaggerated intonation. These properties promote word segmentation from speech (Jusczyk et al 1999, Johnson & Jusczyk 2001, Mannel & Friederici 2013). Does that mean that infants are particularly good in segmenting words from songs? We measured EEG while we exposed forty 10-month-old Dutch infants to songs and stories, in each of which a word was repeated across phrases. Segmentation of the repeated word was inferred from the ERP familiarity effect (Kooijman et al 2005, Junge et al 2014), comparing the last two presentations to the first two presentations of the repeated word. Contrary to earlier work investigating speech only (Junge et al 2014), in our data there was no significant ERP familiarity effect within the speech condition, suggesting our infants did not segment the words from speech. However, in the song condition we identified a positive shift in the ERP, 300-900 ms after onset of the repeated word, over left frontal electrodes (p<.05 corrected for multiple comparisons). This suggests that the infants are able to segment words from song. Our failure to identify segmentation from speech might be due to the fact that our speech material was less child-directed than in the study of Junge and colleagues (see Floccia et al 2016). Our results suggest that the brain of 10-month-old infants uses the rhythmic and melodic properties of song to detect salient events and to segment words from the continuous auditory input.

F22 Phonological awareness and number-system knowledge in healthy school children: an fMRI study

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Approximately one in six primary school-aged children experience difficulties acquiring language, literacy and numeracy skills. Some studies have suggested that individual differences in phonological awareness – a critical skill for learning to read - might be linked to, or predict development of, numeracy skills. However, few studies have examined the neural mechanisms that might support this proposed relationship in children who have just commenced formal schooling. In the present study, healthy children (N = 17, age 6-7 years, 8 female) enrolled in Grade 1 at primary school completed a battery of behavioural measures including the Comprehensive Test of Phonological Processing (CTOPP-2), Wide-Range Achievement Test (WRAT4) and Wechsler Abbreviated Scale of Intelligence (WASI-2), followed by two fMRI experiments performed in the same scanning session. In the phoneme similarity judgment task (e.g., Byrne & Fielding-Barnsley, 1993), a target picture was presented concurrently with auditory presentation of its name (e.g., boot) followed by items with the same (match: bean) or different (foil: cup) initial phoneme, in random order. After a brief delay, the child was asked to select the item with the matching initial phoneme. The number system knowledge task (e.g., Holloway & Ansari, 2010) entailed a symbolic comparison (view two Arabic numerals between 1-9 and select the larger number), and a control judgment (view two abstract lines and select the line resembling a diagonal). The composite scores for phonological awareness and math computation from the CTOPP-2 and the WRAT-4, respectively, showed a significant positive correlation (r = .57, p = .017, two-tailed), which remained when WASI-2 IQ was partialled out (r = 51, p = .04, two-tailed). Analysis of the phonological awareness task fMRI data revealed significant neural repetition suppression (target > match) in an extensive bilateral network including inferior frontal and temporoparietal cortices (p < .001, cluster corrected p < .05). The number system knowledge fMRI contrast (number

> diagonal) revealed significant activity in the right parietal lobe. Inclusively masking the latter contrast with the former revealed a large cluster of overlapping activity encompassing the right supramarginal gyrus and intraparietal sulcus. Overall, these findings support a proposed link between phonological awareness and number system knowledge skills during the initial phase of formal schooling, and show that it involves the engagement of shared neural mechanisms.

F23 Language ability in children born preterm is predicted by arcuate fasciculi microstructure at term equivalent

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In adulthood a well-characterized direct dorsal-pathway, the arcuate fasciculus, connects the superior temporal cortex to the Broca's area. In humans this pathway is known to mediate word learning, reading abilities and sub-lexical speech repetition. It is unknown, however, if the arcuate fasciculus supports early language learning. In this work we aimed to evaluate the role of the direct segments of the arcuate fasciculi in the early acquisition of neurolinguistic architecture. We hypothesized that in premature infants a brain-behavior mode of co-variation related term equivalent microstructure of the direct segments of the arcuate fasciculi to inter-subject differences in linguistic behavior at 2 years of age. We imaged a cohort of 43 preterm born infants at term equivalent age (18 females; median age at birth of 30 gestational weeks; median age at scan of 42 postmenstrual weeks) using high b value high-angular resolution diffusion-weighted neuroimaging and, at 2 years of age, we assessed their linguistic developmental performance. Using constrained spherical deconvolution tractography we virtually dissected the arcuate fasciculus and extracted fractional anisotropy values of the tracts. As a negative control, we also delineated the cortico-spinal tracts. Using leave-one-out cross-validation and partial-least-square regression, we identified one single mode of brain-behavior co-variation: term equivalent fractional anisotropy of the left and right arcuate fascuculi was related to individual differences in receptive and expressive linguistic skills in early childhood. Of key importance, this brain-language behavior co-variation mode generalized to previously unseen infants (Pearson's r = 0.36, corrected pvalue = 0.02); and was still present even when adjusting for early environmental exposure linked to premature delivery. Further, this mode of co-variation was not predicted when using cortico-spinal tracts fractional anisotropy. These findings suggest that the link between language behavior and brain structure is already present around the time of normal birth and relatively unaffected by early environmental influences. These results also demonstrate that, in infancy, the arcuate fasciculus is a neurolinguistic precursor and may mediate early phonologic learning of language.

F24 Electrophysiological Evidence of Sublexical Phonological Access During Character Naming by Chinese-Speaking Children.

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The significance of phonological processing skills in learning to read an alphabetic orthography have long been recognized, and deficits in phonological skills have been identified as a core underlying reason for poor decoding in English and other alphabetic scripts. Yet in the case of Chinese, a less transparent script where grapheme-phoneme correspondence rules are not applicable, whether sublexical decoding skills are crucial still remains a controversial issue. Using event-related potential (ERP) technique, this study examined whether typically developing children are sensitive to sublexical phonological access during character naming. Primary grade four children were administered a standardized reading sub-test from the Hong Kong Test of Specific Learning Difficulties of Reading and Writing (Ho, Chan, Tsang & Lee, 2000), and asked to name a character presented on the screen after a cue was shown in a delayed naming task. Characters varied in regularity (regular vs. irregular) and phonological token consistency (consistent vs. inconsistent) factorially. Significant regularity effects were found showing that children named regular characters more accurately than irregular characters. ERP findings showed that regular characters elicited a smaller P200 amplitude in the frontal-central regions, but a larger N400 in the central left hemisphere compared to irregular characters. Significant correlations between reading ability with regularity effect at the N400 were also found, indicating that larger differences in regularity were associated with higher reading ability. Main effects of consistency were only found at the N400 with characters with inconsistent phonetic radicals eliciting a greater negativity than consistent ones. Overall, the findings suggest that the P200 and N400 components are sensitive to sublexical phonological access in Chinese, as more effortful phonological access was required for irregular characters at the P200, and greater lexical semantic competition was needed for retrieving characters with radicals that map onto multiple pronunciations or regular characters whose phonetic radical shared a similar pronunciation with the character. Critically, the findings suggest that sensitivity to sublexical phonological regularity is associated with reading skill.

F25 Top-down Predictions in Statistical Learning Carried by Alpha Oscillations

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Statistical regularities enable the learning of structure in the environment. For example, regularities in speech can support word segmentation. Although most research on such statistical learning has focused on the learning process itself, here we investigate the consequences of learning. In particular, we hypothesize that a key function of statistical learning is to enable predictions about the environment based on past experience. We used electroencephalography (EEG) to record brain activity while participants viewed a continuous sequence of images containing embedded pairs. Based on

transition probabilities, participants could learn to predict the second image in a pair from the first. In human and monkey visual cortex, top-down perceptual predictions are carried by oscillations in the alpha (8-12 Hz) and beta bands (14-30 Hz). We thus expected that, if statistical learning generates top-down predictions of future events, induced alpha/beta oscillatory activity should increase for the first (predictive) image vs. the second (non-predictive) image. We recorded EEG from human subjects (N=11). Participants were familiarized with a continuous stream of images. The order of images was generated with pair structure, with the first image in each of 4 pairs always appearing immediately before the second image. Participants were not informed of these patterns, and were asked to perform an unrelated vigilance task to maintain their attention. In a post-test, participants saw two sets of two images, one pair and one foil, and were instructed to choose the more familiar set. We compared time-frequency responses (TFR) to the predictive and non-predictive images, and contrasted this difference with an initial baseline block in which the order of images was randomly shuffled. TFRs were computed for frequencies from 5-30 Hz using wavelets. Significance was computed with cluster-based statistics over all frequency bands and all scalp electrodes, from 0-700 ms after the onset of the stimulus. The post-test revealed behavioral learning of the pairs ($p = .01$). In the baseline (shuffled) block, there were no significant differences in TFRs between the two items in a pair ($p > .43$. However, during blocks with regularities, we observed stronger alpha/beta oscillations (10-16 Hz) at occipital, temporal, and parietal channels 0.48-0.65 s after predictive images, compared with non-predictive images ($p < .05$); this difference was reliably larger than in the shuffled block ($p < .001$). Language benefits from prediction at multiple levels. Here we show that alpha/beta oscillations increase in strength after participants see an image that is strongly predictive of the next image in a sequence, relative to when they see images that do not allow for strong perceptual predictions. This suggests that regularities are learned not only for the sake of acquiring knowledge, but also to be deployed to facilitate online processing. Moreover, such predictions in statistical learning may rely on the same neural mechanisms as top-down signals in other domains.

F26 Children born profoundly deaf show typical hemispheric asymmetries in cerebral blood flow during language production

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Most adults show left lateralisation for speech production (Price, 2012). Developmental research suggests that functional asymmetries in early auditory areas, linked to the low-level acoustic properties of speech, may be a precursor to left-lateralised language processes later in development (Minagawa-Kawai et al.,2011). Children born deaf, regardless of amplification, will inevitably experience a drastically different spoken language input to hearing children. Assessing hemispheric dominance in deaf children allows us to test the relevance of auditory experience on language lateralisation. Measuring neural activity in deaf children has been difficult to date due to incompatibility between imaging techniques and cochlear implants, which have a high prevalence among eligible school-aged deaf children in the UK (Raine et al., 2013). Here we use functional transcranial Doppler sonography (fTCD) which is an implant-safe and cost-effective way of assessing gross differences in hemispheric activity during cognitive tasks (Deppe et al.,2004). Its tolerance to movement means it can also be reliably used in studies of sign production (Gutierrez-Sigut et al., 2015). In the current study we measured changes in cerebral blood flow velocity in the middle cerebral arteries in 21 school-aged deaf children (mean age 7 years 9 months) while they described an animated story in their preferred language (Bishop et al., 2009). Speech, sign, and gestural responses were recorded for transcription. We also included a battery of handedness, reading, and signed and spoken language measures. At the group level, significant left lateralisation during expressive language was observed (mean lateralisation index = 2.2 , sd = 3.3; $t(20)= 3.06$, $p = .006$, $d = 1.0$). A comparable proportion of children were left (78%), right (16%), and low (6%) lateralised as has been reported in studies of hearing children of a similar age (Groen et al., 2012; Payne et al., in prep). We will discuss the relationship between strength of lateralisation, and offline and online behavioural performance. This study is a first step in attempting to measure neurobiological processes involved in language production in this understudied paediatric population.

Grammar: Syntax

F27 Neuro-computational modelling of lexico-syntactic representation and integration during speech comprehension

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Speech comprehension engages complex cognitive processes, including the rapid analysis of lexical properties of words and their on-line integration which require accurate lexical representations and evaluation of prior expectations. Previous neuro-linguistic studies have shown some success in modelling neural responses with models capturing processes related to integration (Frank et al., 2015; Willems et al., 2015). Here, we examine the relationship between the detailed lexico-syntactic information about words and processes of integration by investigating how strongly the lexical constraints of verbs influence the expectation of the upcoming complement structure. Addressing this question illuminates the process of activating the lexical properties of previous word(s) to rapidly integrate the subsequent input onto the sentence-level representation. To investigate the patterns of neural activity associated with more expected or less expected complement structure, we manipulated the complement structure probabilities based on relative frequency given the previous verb calculated from the VALEX lexicon (Korhonen et al., 2006). To determine the spatio-temporal properties of these processes, we recorded neural activity using electroencephalography and magnetoencephalography (EMEG) while participants were listening to sentences with high- or low-likelihood complement structures. We used representational similarity analysis (RSA; Kriegskorte et al., 2008) to reveal the strength of association between multivariate activity pattern of a brain signal and the psycho-linguistic variables captured by our models. In order to model the process of lexico-syntactic

analysis, we constructed a subcategorisation frame (SCF) model reflecting the relative frequency distribution about the upcoming complement structure given the preceding verb. For syntactic integration, we built a model based on entropy measure (Shannon, 1948) describing the degree of uncertainty (or, equivalently, predictability) about the upcoming structure before it is heard and surprisal/prediction error measures (Hale, 2001; Gagnepain et al., 2012) capturing how consistent the actual continuation is with the prior expectation. Consistent with claims about activation of lexical representations in the brain (Tyler & Marslen-Wilson, 2008; Hagoort, 2013), we found a significant SCF effect, reflecting the lexico-syntactic representation of verbs in the left-lateralised fronto-temporal language network including posterior middle temporal gyrus (pMTG) and LIFG. This effect started from 200ms after the verb onset in left pMTG and gradually moved onto the LIFG around 350-400ms after the onset. We found a prediction error effect centred on BA45 in LIFG from 570ms to 660ms after the verb onset. Since the average verb and complement word duration were 420ms and 89ms respectively, we suggest that the lexico-syntactic information about verb SCF is rapidly retrieved from the moment the verb is recognised and represented in left-lateralised fronto-temporal language network which is maintained throughout and enables effective incremental computations. Moreover, LIFG additionally evaluates the prior expectation soon after the actual complement structure is recognised in order to integrate the syntactic structure as accurately as possible. Our study corroborates the role of the left fronto-temporal network in syntactic processing and distinguishes between activation of lexical knowledge and the evaluation of the prior expectancy derived from such knowledge, demonstrating a specific role for LIFG in such early process of integration.

F28 The interaction of syntactic structure and lexical constraints during sentence processing

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Understanding a spoken sentence involves a complex set of processes that integrate the stream of words into a coherent representation of the utterance's structure and meaning. A number of factors have been proposed to influence the ease with which a word can be integrated into the unfolding representation, including the overall syntactic complexity of the sentence (Friederici, 2002; Gibson 1998) and probabilistic lexical knowledge about the kinds of structures a word tends to be used in (Hagoort, 2005; MacDonald, Pearlmutter, & Seidenberg, 1994; Marslen-Wilson, 1973; Vosse & Kempen, 2000; Tyler et al. 2013). Reflecting these separate accounts, neuroimaging studies investigating integrative processes in sentence comprehension have often either manipulated syntactic complexity whilst strictly controlling or eliminating lexical influences (e.g. Bahlmann et al, 2008; Makuuchi et al., 2009), or have manipulated lexical properties in the context of a relatively minimal grammatical structure (e.g. Obleser & Kotz, 2009; Shetreet, Friedmann & Hadar, 2010). In the current MEG study, we investigate how both lexically-driven expectations and syntactic complexity interact during the incremental interpretation of spoken sentences by manipulating both syntactic structure and lexical information. Seventeen participants listened to sentences where an intervening clause could separate the subject and main verb of the sentence, creating a long-distance dependency between them. We included three conditions featuring a long-distance dependency: (a) sentences containing a central phrase that was unambiguously a relative clause (e.g. "The van that was clamped on the driveway had run out of petrol"); (b) sentences containing a reduced relative clause with a highly transitive verb (e.g. "The van clamped on the driveway had run out of petrol") and (c) sentences containing a reduced relative clause where the verb could be used intransitively ("The van stalled on the driveway had run out of petrol"). Conditions (b) and (c) differ only because of the different lexico-syntactic expectations associated with the two verbs ("clamped" vs "stalled") – the prepositional phrase in (b) unambiguously indicates a passive construction with "clamped on the driveway" functioning as a relative clause, whilst the prepositional phrase in (c) can be interpreted as an adjunct to the intransitive verb. This creates a classic garden path in (c), where the main verb ("was") is surprising and difficult to integrate with the preceding context. We also included matched sentences without long-distance dependencies ("The guard clamped the accused to the bars of the witness box") as filler items. In the source-space MEG analysis, we found significantly greater evoked power for the surprising reduced-relative condition (c), compared with the unsurprising reduced relative condition (b) and the fully unambiguous condition (a), in posterior temporal, parietal and frontal regions from the onset of the main verb (i.e. "was"). However, there were no differences between the fully unambiguous condition (a) and the reduced relative clause condition (b) at the main verb. These results are important in demonstrating how lexical knowledge about verbs interacts with complex syntactic processing during spoken language comprehension, yielding a detailed picture of processes of integration in sentence processing.

F29 An investigation of the relationship between the cognitive resources engaged by syntactic and acoustic complexity

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The cognitive resources required for sentence comprehension are debated, however, it is well established that sentences with non-canonical (e.g. subject-object-verb) are more difficult to understand than canonical (e.g. subject-verb-object) syntactic structures. It is also well known that understanding speech in noisy, degraded situations often requires increased effort and/or may lead to an increase in comprehension errors. Successful comprehension of both syntactically complex sentences and of speech in noise may recruit additional resources such as working memory, selective attention and/or cognitive control. However, it is unclear how the cognitive resources engaged by noisy environments and difficult syntactic information are related. In this study, we sought to observe the relationship between the effects of syntactic structure and type of noise on sentence comprehension. Twenty-two cognitively typical, right-handed, native-English speaking adults completed a sentence-picture matching task adapted from Wilson et al. 2010. Sentences varied in terms of sentence structure: canonical

sentences contained subject-verb-object word order with a color modifier (e.g. 'The boy who is green is chasing the girl'); non-canonical sentences were of subject-object-verb word order in conjunction with a passive clause (e.g. 'The boy who the girl is kissed by is green'). Sentences also differed in the type of noise masker presented simultaneously with each sentence: 4-talker babble, broadband noise shaped to the long-term average spectrum of the 4-talker babble masker, or no masker (i.e. silence). The noise began 500ms prior to the onset of the target sentence and continued for an additional 500ms following the target sentence. The signal-to-noise (SNR) ratio of the target sentence to the noise masker also varied (-4dB, -2dB, 0dB and +2dB), but our results here will focus on the findings for the +2dB SNR, as previous research indicates that at this SNR, performance is near ceiling for simple canonical phrases presented in both babble and broadband noise, suggesting that the words presented are clearly audible. Following the presentation of each sentence, participants were asked to select one of two line drawings that matched the content of the sentence presented. Accuracy and reaction times were recorded and analyzed with repeated-measures ANOVAs. The accuracy results were as follows: There was a significant main effect of syntactic structure, with lower accuracy for non-canonical than canonical sentences; canonical sentence comprehension was at ceiling. This syntactic structure effect coincides with previous work presenting sentences in silence. There also was a significant main effect of noise type, with lower accuracy in the babble noise condition compared to both silence and broadband noise. Lastly, the interaction of noise type x syntactic structure was significant. This interaction was driven by the babble noise significantly lowering performance for non-canonical, but not canonical sentences compared to both broadband noise and silence. Results for the reaction time data followed a similar trend. These preliminary results suggest that non-canonical sentence structures and multi-speaker environments engage overlapping cognitive resources.

F30 Dynamics of supramodal unification processes during sentence comprehension

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It is generally assumed that structure building processes in the spoken and written modalities are subserved by modality-independent lexical, morphological, grammatical, and conceptual processes. We present a large-scale neuroimaging study (N=204) on whether the unification of sentence structure is supramodal in this sense, testing if observations replicate across written and spoken sentence materials. The activity in the unification network should increase when it is presented with a challenging sentence structure, irrespective of the input modality. We build on the well-established findings that multiple non-local dependencies, overlapping in time, are challenging and that language users disprefer left- over right-branching sentence structures in written and spoken language, at least in the context of mainly right-branching languages such as English and Dutch. We thus focused our study with Dutch participants on a left-branching processing complexity measure. Supramodal effects of left-branching complexity were observed in a left-lateralized perisylvian network. The left inferior frontal gyrus (LIFG) and the left posterior middle temporal gyrus (LpMTG) were most clearly associated with left-branching processing complexity. The left anterior middle temporal gyrus (LaMTG) and left inferior parietal lobe (LIPL) were also significant, although less specifically. The LaMTG was increasingly active also for sentences with increasing right-branching processing complexity. A direct comparison between left- and right-branching processing complexity yielded activity in an LIFG ROI for left > right-branching complexity, while the right > left contrast showed no activation. Using a linear contrast testing for increases in the left-branching complexity effect over the sentence, we found significant activity in LIFG and LpMTG. In other words, the activity in these regions increased from sentence onset to end, in parallel with the increase of the left-branching complexity measure. No similar increase was observed in LIPL. Thus, the observed functional segregation during sentence processing of LaMTG and LIPL vs. LIFG and LpMTG is consistent with our observation of differential activation changes in sensitivity to left- vs. right-branching structure. While LIFG, LpMTG, LaMTG and LIPL all contribute to the supramodal unification processes, the results suggest that these regions differ in their respective contributions to the subprocesses of unification. Our results speak to the high processing costs of (1) simultaneous unification and (2) maintenance of constituents that are not yet attached to the already unified part of the sentence. Sentences with high left- (compared to right-) branching complexity impose an added load on unification. We show that this added load leads to an increased BOLD response in left perisylvian regions. The results are relevant for understanding the neural underpinnings of the processing difficulty linked to multiple, overlapping non-local dependencies. In conclusion, we used the left- and right branching complexity measures to index this processing difficulty and showed that the unification network operates with similar spatiotemporal dynamics over the course of the sentence, during unification of both written and spoken sentences.

F31 The relationship between language abilities and brain activity

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The question of how individual differences in cognitive ability are reflected in brain activity remains to be a matter of debate in the neuroscientific literature. In the domain of language, higher levels of verbal ability have been associated with both, increases and decreases of neural activity in language relevant areas, depending on the particular language process being studied and the ability measure used (e.g. Prat & Just, 2010; Van-Ettinger-Veenstra et al., 2016). We investigated the relationship between verbal abilities and brain activations during semantic, syntactic and phonological processing in an fMRI study. In a passive listening task twenty-two healthy right-handed adults were presented with sentences and an auditory control (reversed pseudospeech). In a production task participants repeated pseudowords and words. Participants' verbal abilities were assessed with the verbal subscale of the Wechsler Abbreviated Scale of Intelligence (WASI) and a verbal fluency task (semantic and phonological fluency). As

expected, auditory sentence comprehension (contrasted with reversed pseudospeech) activated brain regions known to be involved in semantic and syntactic processing in the left anterior and posterior superior and middle temporal gyrus and temporal pole. The repetition of pseudowords (contrasted with the repetition of words) engaged areas associated with phonological processing in the left inferior frontal gyrus, pars triangularis and pars opercularis, and precentral gyrus. Covariate analyses revealed significant correlations of these activations with the two measures of verbal ability: a higher verbal IQ and higher verbal fluency were both associated with greater signal change in the left temporal lobe in the comprehension task. For the repetition task a higher verbal IQ and higher verbal fluency were both associated with greater signal change in the left frontal lobe. These areas of correlation greatly overlapped with the areas activated by the respective contrasts in the group analysis. This indicates an increased involvement of process-specific regions during semantic and syntactic as well as phonological processing in participants with higher verbal performance levels, suggesting a general link between high levels of cognitive ability and enhanced activity in brain regions relevant to these abilities.

Language Disorders

F32 Language impairment profile across distinct clinical variants of amyloid positive early onset Alzheimer's disease

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Introduction: It is well known that early and predominant language impairment is the hallmark of one form of early onset Alzheimer's disease (AD), the logopenic variant of primary progressive aphasia (lvPPA). However, the characteristics and extent of language impairment in other clinical variants of early-onset AD have been less studied. Furthermore, the neuroanatomical bases of specific language deficits in early onset AD (including lvPPA) are not fully understood. Our objective was to characterize the language impairment profiles across different clinical variants of early onset AD and investigate their neural correlates. A better understanding of the clinical and neuroanatomical overlap/heterogeneity between these syndromes may yield important insights into Alzheimer's disease mechanisms and have direct implications for diagnosis and management. Methods: We recruited patients who presented prospectively between 2005 and 2016 and received a clinical diagnosis of logopenic variant primary progressive aphasia [lvPPA, n=27], executive/amnestic predominant early onset Alzheimer's disease [EOAD, n=25], or posterior cortical atrophy [PCA, n=10]; have a positive amyloid brain scan; underwent a comprehensive language evaluation and MRI or PET FDG imaging within 6 months. Cognitive data was compared between groups and to age-matched controls to calculate z-scores. Voxel-based morphometry (VBM) was used to investigate the neural correlates of performance on specific language tests. Results: All three AD variants showed a similar profile of language impairment. Verbal repetition, phonologic manipulation, and naming were the most impaired while semantics and verbal agility were relatively preserved. No subject presented with apraxia of speech. Furthermore, EOAD, lvPPA, and PCA showed a similar slope of decline in verbal repetition across different stages of disease severity. Only EOAD and lvPPA showed similar slopes of decline in picture naming. VBM analysis showed verbal repetition, sentence comprehension, and picture naming performance were associated to atrophy in different networks that overlapped in the left mid-posterior middle temporal gyrus. Verbal repetition was associated to atrophy in the left middle and superior temporal gyri, posterior insula, putamen, caudate, and inferior frontal gyrus pars opercularis and triangularis. Sentence comprehension was associated to atrophy in the left inferior, middle, and superior temporal gyri, the supramarginal gyrus, precuneus, the inferior frontal gyrus pars triangularis and bilateral cerebellar cortex. Picture naming was associated to atrophy in the left middle temporal gyrus, supramarginal gyrus, caudate, and the inferior frontal gyrus pars triangularis. Conclusion: Distinct clinical syndromes of AD present similar language impairment profiles associated to lesion of distinct networks anchored by the middle temporal gyrus. Future studies are needed to determine the factors that determine vulnerability of this region and networks to AD pathologic mechanisms.

F33 Classification of language impairments in acute aphasic patients

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Most cognitive-linguistic functions are multicomponential and are processed within interacting networks (the dual loop model). In the past, attempts to classify these multidimensional impairments yielded in syndrome classification. However this classification underestimates the highly variable and heterogeneous language impairments of aphasic patients. The aim of this study was to capture the multidimensionality of language impairments by using principal component analysis (PCA) in acute stroke patients with aphasia (n=100) and to investigate the underlying neuroanatomical basis, in relation to the dual loop model, applying voxel-wise lesion behaviour mapping (VLSM). Patients were assessed with the Aachen Aphasia Bedside Test and the Aachen Aphasia Test. Structural imaging from high-resolution MRI was acquired in order to apply VLSM to the data. The PCA revealed four factors contributing to the patients' performances: phonology, complexity/executive functions, fluency and semantics. Phonology was related to temporo-parietal regions including superior temporal gyrus, middle temporal gyrus, supramarginal gyrus, angular gyrus, inferior parietal cortex, posterior insula, heschl gyrus and the rolandic operculum and affected the dorsal stream. The complexity/executive functions factor was not related to any specific region in the brain (not displayed). This might be due to the widely-distributed and multi-functional nature of the regions that support executive functions. Fluency related mainly to the precentral gyrus, but also the postcentral gyrus, insula, inferior frontal gyrus, putamen and rolandic operculum. Semantics related to the middle and superior temporal gyri, the temporal pole, insula, putamen and inferior

frontal gyrus and affected the ventral stream. These results of acute aphasic patients provide insights in the lesion patterns of different cognitive-linguistic components in the context of the dual pathway model and are consistent with those obtained using other methodologies such as functional neuroimaging.

F34 Behavioural predictors of functional communication in post-stroke aphasia

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In some cases of post-stroke aphasia, inner speech has been shown to be relatively intact in relation to overt speech (Geva et al, 2011). The goal of this work is to ascertain whether inner speech is contributing, over and above other cognitive and language capacities, to functional communication. 38 patients with aphasia following left hemisphere Middle Cerebral Artery-territory stroke, age 21-87 years, 8-111 months post-stroke participated in the study. Functional communication measurements included the spoken and written picture description scores and the word fluency score from the Comprehensive Aphasia Test (CAT). Independent variables included non-language semantic memory, sentence repetition (measure of verbal working memory) and non-word repetition (proxy measure of apraxia) from the CAT, alongside measurements of rhyme and homophone judgements using inner speech and overt speech, taken from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA). Patient performance on the Spoken Picture Description (n=32) was significant (R2=0.71, S=0.64, p=0.02); inner speech rhyme judgment was the best predictor (p=0.07) and semi-partial correlation showed that inner speech rhyme judgment contributed significantly (r=0.8, p<0.001). The model for Written Picture Description (n=30) was not significant (R2=0.66, S=0.67, p=0.09). The model for Word Fluency (n=35) was significant (R2=0.76, S=0.52, p=0.002), where non-word repetition was the most significant predictor (p=0.07) and semi-partial correlations showed that non-word repetition contributed significantly (r=0.59, p<0.001). Rhyme judgement using inner speech was the best predictor of spoken picture description score; notably, performance on the inner speech task predicted performance on a measurement of overt speech, over and above variables measuring overt speech production. Rhyme judgement using inner speech arguably utilizes working memory alongside language capabilities, therefore either can be the factor mostly influencing patients' ability to overtly describe a picture. Written picture description was not explained by the independent variables chosen here. This might be because most independent variables measured components of spoken language and working memory. This suggests that the modality (spoken vs written production) is a major determinant in predicting the level of functional ability. Moreover, it is perhaps the case that, in written picture description as compared to spoken picture description, participants have a greater chance for revising and correcting their errors, resulting in a score which is less reflective of their functional impairment. Finally, word fluency score was best predicted by non-word repetition, a component associated with apraxia of speech. While word fluency scores represent an array of linguistic and meta-linguistic abilities, apraxia of speech is often a major determinant for fluency and coherence of spoken output. In conclusion, inner speech was shown to be the best predictor of spoken picture description score in this cohort, beyond cognitive and overt speech measures. This result suggests that measurements of inner speech could contribute to reliable prognosis, and that targeting inner speech during therapy may facilitate recovery of some functional speech post-stroke.

F35 The effect of the lesion in Broca's area in naming: an MEG study

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Introduction It is well acknowledged that the lesion in Broca's area perturbs language function, crucially when naming an object. However, it has yet to be fully addressed why naming is more difficult or delayed in the patients with lesion in Broca's area than with the lesion elsewhere. Naming involves various but hierarchically organised processing stages until the perceived concept of an object is articulated. We aimed to tease apart the naming processing into stages and associate them with Broca's lesion. Methods Patients with lesion in Broca's (Br) area were compared with the patients with lesion elsewhere (NBr). A total of 210 simple drawings were shown to name while the brain signal was collected using a 306 whole-brain channel magnetoencephalography (VectorView, Elekta Neuromag, Oy, Helsinki, Finland). An artifact-free averaged epoch of -200~800 ms was fed into analyses. Peak latencies in the four brain areas were compared in terms of four time windows; conceptual preparation (0~175 ms), Lemma retrieval and lexical selection (150~350 ms), phonological code retrieval (250~330 ms) and syllabification (350~450 ms) stages. Results While no difference of peak latency was observed in the temporal and parietal areas between the groups, group Br recorded a longer mean latency (417.6 ms) than group NBr (290 ms) in the inferior frontal gyrus. The occipital and the parietal areas were seen peaked at the similar time points in both the groups (BR 278.4 ms and NBr 266.8 ms in the occipital area, BR 116 ms and NBr 116 ms in the parietal region). Conclusion Either in conceptual preparation or Lemma selection, both groups were found to have normal processing. Syllabification stage, however, marked the distinct delay in the BR group. Our finding first addresses the effect of Broca's lesion in a specific stage of naming lending support for the idea that naming involves levels of production planning.

F36 Lower network efficiency in the speech production network in dyslexia: a resting-state fMRI graph-analysis

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Dyslexia is a brain-based difficulty in acquiring fluent reading skills and is characterized by a phonological deficit. More specifically, phonological representations are reported to be poorly specified or less accessible in individuals with dyslexia. Models of speech production suggest that the quality of phonological representations is dependent on speech feedforward and feedback mechanisms, and indeed, data in our

lab indicates that individuals with dyslexia show impairments in these mechanisms on a behavioural level. In this study, we tested whether this finding could be further corroborated by examining the functional connectivity between the estimates of brain areas involved in the formation and modulation of phonological representations using graph analyses. Group differences between measures of network segregation, integration and centrality were examined. Network segregation reflects the ability of the brain for specialized processing within densely interconnected brain areas. Integration indicates the ability to combine and integrate information from distributed brain areas. The centrality measures specify whether individual nodes are crucially important for the functioning of the network. Twenty adult dyslexic readers and 20 controls participated in this fMRI study. All scans were performed using a Siemens 3T Magnetom PrismaFit scanner. An MP-RAGE sequence was used to obtain anatomical data. A gradient-echo EPI sequence (TR = .735 ms TE = 33; FA = 52°) was used to collect resting-state fMRI data. All functional images were pre-processed using AFNI. Fifty-four Regions-of-Interest (ROIs) were selected based on the MNI coordinates of all components of the DIVA speech production model, as specified in Guenther et al. (2006) and Tourville et al. (2011). A correlation matrix of the time course of these ROIs per participant was entered in the Graph-Theoretical Analysis Toolbox for analysis. Binary connection matrices were derived by thresholding the correlation matrices at a range of densities (0.01:0.4). Group differences for network segregation, integration and centrality were subsequently calculated. Two measures of segregation (modularity and transitivity) yielded mixed results. Between group differences were found for the modularity across densities ($p = .011$), indicating that the degree of non-overlapping and clearly delineated modules was lower in the dyslexia group. However, no differences were found for the number of clusters in the network, the transitivity. The characteristic path length ($p = .019$) and the global efficiency measure ($p = .006$) both indicate stronger integration in the speech network for the control group. With respect to group differences at a regional level, the centrality measures node and edge betweenness, indicators of the centrality of the nodes and edges in the network, showed significant differences between groups ($p < .01$). No differences were found for local efficiency. The current study shows that the functional connectivity in the network involved in the formation and modulation of phonological representation is, on average, less efficient in individuals with dyslexia. This finding provides a neurobiological account of deficiencies in speech feedforward and feedback mechanisms in dyslexia.

Language Genetics

F37 Effects of FOXP2 mutation: abnormal structure of the cerebellum associated with verbal and orofacial dyspraxia

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Introduction Bilateral caudate volume reduction has been established as a characteristic brain abnormality associated with a point mutation in the gene FOXP2 in affected members of the 'KE family'. Half the members of this multi-generational family have a severe form of verbal and orofacial dyspraxia in conjunction with pervasive language deficits. Despite the early and prominent expression of FOXP2 in the cerebellum across species, very little is known about the cerebellar abnormalities in affected members of the KE family and how these abnormalities might be related to the phenotype of their disorder. We hypothesized that the neocerebellar VIIa Crus I would show the most pronounced structural and functional abnormalities in affected KE members, because it is embedded within the same functional network as the caudate nucleus, and is also involved in complex motor programming. Methods We employed cerebellum-specific voxel-based morphometry and automated volumetry (Spatially Unbiased Infra-Tentorial Template toolbox implemented in SPM12) on separate T1-weighted MRI datasets in subsets of affected, unaffected KE members and unrelated controls at three different time-points over a period of 12 years (time-point 1: affected: n = 10; unaffected: n = 5; unrelated controls: n = 9; time-point 2: affected: n = 6; age-/sex-matched unrelated controls for affected: n = 6; unaffected: n = 6; age-/sex-matched unrelated controls for unaffected: n = 6; time-point 3: affected: n = 4; age-/sex-matched unrelated controls: n = 4; 4 affected members participated in all 3 time-points; 2 participated in time-points 1 and 2). We also assessed the correlation of affected members' cerebellar lobular volumes with accuracy of non-word repetition available in two time-points. Finally, we analysed the cerebellar haemodynamic activity in affected KE members compared to matched controls during non-word repetition, available from one fMRI dataset, in a whole-cerebellum fixed-effects analysis, using SPM12. Results As predicted, we report a selective grey matter reduction in neocerebellar lobule VIIa Crus I in affected KE members compared to unaffected members and unrelated controls in datasets acquired at three separate time-points. The volume reduction in this lobule was inversely correlated with accuracy of non-word repetition (time-points 1,3). The same lobule also showed the largest hypoactivation in the cerebella of affected members relative to controls during non-word repetition (time-point 3). Conclusion The association of Crus I with the production of speech sound sequences is highly consistent with recent evidence confirming its involvement in sequencing aspects of verbal praxis and programming of complex limb movements. The grey matter reduction that affected KE members show in both the caudate nucleus and lobule VIIa Crus I dovetails with recent findings on their participation in common resting-state functional networks, the parallel, segregated reciprocal connectivity between the cerebellum and the basal ganglia, and the complex interplay of these two structures in motor learning. Overall, our results highlight the significance of neocerebellar-basal ganglionic connections in the development of articulate speech.

Language Therapy

F38 Changes in dynamic resting state network connectivity following aphasia therapy

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Introduction: Resting state functional magnetic resonance imaging (rsfMRI) permits observation of intrinsic neural networks produced by task-independent correlations in low frequency brain activity. Various resting state networks have been described, with each thought to reflect common engagement in some shared function (Damoiseaux et al., 2006). There has been limited investigation of the plasticity in these networks in relation to disease or therapeutic intervention, including stroke and stroke rehabilitation. An important manifestation of stroke is a communication disorder (aphasia), and in this work, we investigate resting state network plasticity during aphasia treatment. Methods: Twelve subjects with chronic aphasia were imaged at multiple time points before (baseline) and after imitation-based aphasia therapy. Language assessment with a narrative production task was performed at the same time points (Duncan & Small, under review). Group independent component analysis (ICA) was performed on the rsfMRI data to identify resting state networks. A sliding window approach was then applied to assess the dynamic nature of the correlations among these networks. Network correlations during each 30-second window were used to cluster the data into ten states representing each window at each time point for each subject, with the number of states selected based on the amount of variance accounted for by each added state in order to control for overfitting. Correlation was then performed between changes in time spent in each state and therapeutic gains on the narrative task. Results: The amount of time spent in a single one of the (ten overall) dynamic states was positively associated with behavioral improvement on the narrative task at the 6-week post-therapy maintenance interval when compared with either baseline or assessment immediately following therapy. This particular state was characterized by minimal correlation among the task-independent resting state networks. Conclusion: Increased functional independence and segregation of resting state networks underlies improvement on a narrative production task following imitation-based aphasia treatment. These results are similar to those found with memory and healthy aging (Chan et al., 2014) as well as in the sensorimotor networks of people with Parkinson's disease (Tinaz et al., 2016). This result has clinical implications for helping to target noninvasive brain stimulation as an adjunct to aphasia therapy. References: 1. Damoiseaux JS, Rombouts SA, Barkhof F, et al. Consistent resting-state networks across healthy subjects. Proc Natl Acad Sci U S A. 2006;103(37):13848-13853. 2. Duncan ES, Small SL. Imitation-based aphasia therapy and the superior longitudinal fasciculus. Under review. 3. Chan MY, Park DC, Savalia NK, Petersen SE, Wig GS. Decreased segregation of brain systems across the healthy adult lifespan. Proc Natl Acad Sci U S A. 2014;111(46):E4997-5006. 4. Tinaz S, Lauro P, Hallett M, Horovitz SG. Deficits in task-set maintenance and execution networks in Parkinson's disease. Brain Struct Funct. 2016;221(3):1413-1425.

F39 Investigating microstructural changes of the ipsilateral SLF and ILF underlying speech therapy using advanced diffusion MRI techniques

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Introduction: Not all subjects with chronic aphasia respond well to treatment and to date little is known about what drives rehabilitation success. A popular hypothesis suggests that recovery-related neuroplasticity is associated with the strengthening or the re-establishment of structural connections between key related brain regions. In this study, we aimed to test this hypothesis by assessing the relationship between therapy-related improvements in naming errors and microstructural white matter fiber properties, using innovative assessments of mean kurtosis (MK), which is a novel and sensitive metric of microstructural complexity (Jensen, 2010), measured longitudinally along white matter pathways associated with the dorsal and ventral stream for language processing. Methods: Eight subjects (age = 52.0±7.2y; 62% male; MRI Time post-stroke = 50.25±29.8m) with chronic post-stroke aphasia received Intensive Language Action Therapy for a period of three weeks. All subjects underwent four MRI sessions, two before and two after therapy. Structural images (T1 & T2) and diffusional kurtosis images (DKI) (30 directions, b= [1000, 2000 s/mm2]) were acquired. The following image processing pipeline was implemented. First a probabilistic white matter (WM) mask was estimated from T1 images using the clinical toolbox in SPM8. Then conventional DKI tractography was performed using the fiber tracking toolbox in Diffusion Kurtosis Estimator (Glenn, 2015; Tabesh, 2011) using the WM mask as a seeding region. Lastly, we optimized the automated fiber quantification (AFQ) software to acquire along tract MK measurements (Yeatman, 2012; Glenn, 2016) resulting in 100 nodal mean kurtosis measurements along major tracts. Simple correlations were performed to assess the relationship between error improvements and MK in the center (nodes 41-60) of the left Superior Longitudinal Fasciculus (SLF) and of the left Inferior Longitudinal Fasciculus (ILF). Statistical analyses were adjusted for multiple comparisons using Bonferroni correction. Results: A therapy-related reduction in semantic errors was associated with an increase in MK in the ILF ($R^2=0.67$). A therapy-related increase in the number of phonological errors was associated with an increase in MK in the SLF ($R^2=0.96$). A therapy-related increase in the number of phonological errors, but not semantic errors, was associated with an increase in speech production. Conclusion: Our results suggest that with therapy the center of the ILF becomes increasingly complex if less semantic errors are made. Contrarily, the SLF displays a more complex microstructure if more phonetic errors are made, possibly a reflection of a therapy related increase in speech production. These results likely fit the dual stream model for language, as changes in the dorsal pathway (SLF) correlated with changes in articulation and changes in semantics reflected as microstructural changes in the ventral stream (ILF).

F40 Dementia Patients Demonstrate Reduced Anomia after Parietal tDCS Anodal Stimulation with Language Training

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Objective: Examine whether transcranial direct current stimulation (tDCS) could help improve picture naming abilities in people living with dementia (Alzheimer's and frontotemporal). Methods: We studied 12 participants with FTD or AD as suspected clinical diagnosis. These included svPPA, n=5, lvPPA, n=3, nfPPA, n=3, and atypical AD with prominent verbal impairment, n=1. All demonstrated left perisylvian hypo metabolism on FDG PET. Utilizing a double-blind cross-over design, these twelve participants were trained on picture naming over a series of 10 sessions of 30 minutes of anodal (2 mA) tDCS stimulation to either the parietal lobe (P3), frontal lobe (F3) or sham stimulation. They received training in naming a particular series of images during the tDCS or sham application. Evaluation was carried out before stimulation, on the final stimulation session, and two weeks post-stimulation. We evaluated performance on the trained picture naming set, on an equivalent untrained set, and on a set of additional neuropsychological tasks. Results: Participants improved significantly more on the training set after receiving real anodal parietal tDCS stimulation compared to improvement noted when they received sham or frontal tDCS. Furthermore, these participants showed a small increase for untrained picture naming items when they received real stimulation, but a notable decrease in picture naming when sham stimulation was received. This resulted in significant benefit for naming both trained and untrained pictures at the final stimulation session and two weeks post-stimulation. Finally, a significant benefit was also noted for digit span following parietal stimulation, but other neuropsychological parameters did not improve. Conclusions: tDCS stimulation has promise as a treatment for people with dementia who suffer from anomia, and the beneficial effect appears to generalize to unstudied items as well as other cognitive abilities.

F41 Design and Validation of a Novel Test to Measure Single Word Reading Speed and Accuracy for an Online Reading Therapy

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Introduction: This experiment aimed to validate a novel word-to-picture matching test measuring single-word reading speed and accuracy. The purpose was to assess the construct validity and efficacy of this test by comparing it with a 'gold-standard' oral reading test. The future goal is the test's inclusion in the online therapy application 'iReadMore' http://www.ucl.ac.uk/aphasialab/apps/ireadmore.html, designed for stroke patients with reading impairments. An important property of the final version of the test is that it can be self-administered online. Methods: The picture-matching test was compared with a 'gold-standard' word-reading test where subjects had to read aloud written words, providing both accuracy and reaction time (RT) with the same spoken response. The picture-matching test also measured both speed and accuracy; however, because it does not measure vocal responses, the two measures were assessed separately. A written word appeared on screen and participants indicated when they had read the word by pressing a button, which made the word disappear (this gave the reaction time). Four pictures appeared on screen and participants selected the picture that matched the written word they had just read (this assessed reading accuracy). We tested 20 native English speakers (mean age = 48 years) with no history of neurological or developmental language disorders. The word list comprised of 109 words 3 to 6 letters in length, with a preference for high frequency words. The stimuli included nouns, verbs, adjectives, function words and other parts of speech, but excluded regular suffixed words. The images used for the picture-matching task were all selected, edited or created by the experimenter. The images were presented in the same dimensions: 500× 400 pixels. Stimuli were split into 6 blocks, and block order was counterbalanced across participants. Word order within each block was randomised. Subjects performed the picture-matching test first, then the oral-reading test. Results: The participants exhibited high levels of accuracy in both the picture-matching (novel) and word-reading (standard) tests: accuracy was 95% for the picture-matching test and 100% for the word-reading test. Mean reaction time (RT) was 749ms in the picture-matching test, while RTs were almost 100ms faster in the word-reading test (mean RT = 656ms). A multivariate regression analysis was conducted to examine whether RT on the picture-matching test could be explained by word-reading RT and the age of subjects. This model was statistically significant ($F(2,17) = 6.35$, $p<.01$). There was a significant positive relationship between reading times on the (novel) picture-matching test and the (standard) word-reading test ($b2 =1.35$, $p<.005$). The intraclass correlation coefficient (ICC) was calculated to test agreement between both tests. Using a two-way mixed consistency model (ICC (3,k)) a significant effect was found ($F(19,19)= 2.69$, $p<.05$) with an ICC of 0.63, indicating moderate agreement. Conclusions:The results show that the picture-matching test has construct validity and could be a useful tool to measure single word reading performance for online reading therapy.

F42 The development of an Auditory Comprehension of Speech Test that will be used in a clinical trial to establish the effectiveness of an auditory comprehension therapy application for patients with impaired speech comprehension caused by a stroke.

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Introduction. 'Listen-In' is a therapy application developed to alleviate auditory comprehension deficits in patients with impaired speech comprehension caused by stroke. The effectiveness of the application will be subjected to a cross-over design clinical trial with the use of behavioural and structural imaging markers to investigate the effect of therapy on people with aphasia. The objective of this study is to choose an appropriate format to design the main outcome measure that will be used to assess the efficacy of Listen-In. The instrument will also investigate any generalisation to untreated items. Methods. Two tests to assess auditory comprehension of speech in post-stroke aphasia were created using two formats: spoken word/sentence to picture matching (WPM) and picture verification (PV). Each test consists of

20 items, which are matched between tests for concreteness, frequency, word syllable and type of construction. For the WPM format, each item consists of a target, two semantic foils, two phonological foils and one unrelated foil. For the PV format, each item consists of a target, a semantic foil and a phonological foil, which are presented in a randomized order. The format consists of visual presentation of one picture (target or foils) and simultaneous presentation of a spoken word or sentence; the subject must decide if the picture matches the spoken stimulus. To score the item correctly, the subject must correctly identify the target and the foils. The number of foils was decided based on probability of correctly answering by guessing (WPM=0.167, PV= 0.125). Two versions of each test were created so that all items were assessed on each format. Nine people with post-stroke aphasia were evaluated with these assessments to investigate the their sensitivity to auditory comprehension problems and the additional time required to conduct the PV test. The participants were randomly assigned to two groups; each group took the two formats of the tests and were evaluated on all 40 items. Results. The mean administration time for WPM format was 342.22 s (range: 210-557; SD = 139.02) and for PV, 561.56 s (range: 441-703; SD = 105.03). The mean accuracy score for WPM format was 13.67/20 (range: 8-18) items correct and for PV, 8.78/20 (range: 3-19) items correct. All patients reported that they felt comfortable with both versions, but six said they preferred WPM. Implications. One of the formats will be chosen for the design of the final test that will assess the efficacy of Listen-In. The PV appears to be most sensitive to a range of auditory comprehension deficits and does not take three times as long as the WPM, which was considered to be a significant reason not to use this assessment. The final test is being developed based on these findings and will be used in the main clinical trial to investigate improvement in auditory comprehension as a response to completing 100 hours of therapy, and will also be used in the analysis of structural imaging data to investigate neural changes as a response to therapy.

F43 The role of dopamine in the comprehension of a simulated cochlear implant speech signal

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Cochlear implantation has proven beneficial in restoring hearing in profoundly deaf individuals. However, success is variable, and there is a need for a simple post-implantation therapy that could significantly increase implantation success rate. Dopamine has a general role in assigning value to environmental stimuli, and it has been shown to modulate learning in several contexts. The aim of this study was to test the effect of acute increases in the level of the neuromodulator dopamine in the comprehension of spectrally-shifted noise-vocoded speech (SSNV speech), which simulates in hearing individuals the signal delivered by a cochlear implant in deaf individuals. The effect of dopamine was tested by administering single doses of L-DOPA (Madopar: 3,4-dihydroxy-L-phenylalanine, 100 mg), a metabolic precursor of dopamine which enhances dopaminergic function. We tested the comprehension of SSNV speech in 35 participants over two experimental sessions separated by 35 days. 12 participants received L-DOPA in session 1 (Group 1), 11 participants received L-DOPA on session 2 (Group 2), and 12 other participants received only a placebo in both sessions (Group 3). Each session consisted of 3 training and 4 testing blocks (one testing block before any training, and one after each training run). Each training block lasted 10 min, and consisted of trials beginning with the acoustic presentation of a target SSNV sentence, followed by six orthographically presented words that appeared in random positions on a computer screen. Subjects were instructed to select the three words that were present in the target sentence, and were provided with visual feedback. The testing block consisted of the acoustic presentation of 30 phonetically-balanced sentences with no feedback. After each sentence, participants reported the sentence verbally, while the experimenter recorded the number of correctly reported key words (5 in each sentence). The SSNV speech signal consisted of 8 frequency channels, where the output filters had cut-off frequencies shifted upwards from the analysis filters by 5mm on the basilar membrane according to Greenwood's map. The learning rate was calculated separately for each session. All groups of participants showed successful learning, and there were no significant differences between groups. The effect of dopamine was evaluated in Groups 1 and 2 by comparing learning rate in the dopamine session vs learning rate in the placebo session. Participants performed significantly better in the dopamine session ($p < .05$, 1-tailed) than in the placebo session. These findings are a promising first step in exploring the use of dopamine to enhance speech understanding in patients with cochlear implants. However, further studies are necessary to determine whether these results can be replicated in patients, and translate into a benefit in terms of everyday language comprehension.

F44 Donepezil improves speech output but not speech comprehension abilities in patients with Wernicke's aphasia.

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INTRODUCTION: The incidence of auditory speech comprehension impairments in person with aphasia (PWA) at one-year post-stroke has been reported to be approximately 15% (Pederson et al., 2004). There has been increasing interest in the potential role of drug therapies as adjuncts to behavioural therapies in this population. One drug which has shown preliminary evidence for improving aphasia severity is the acetylcholinesterase inhibitor donepezil, hypothesised to promote experience-dependent neuroplasticity. Two clinical trials have found beneficial effects of donepezil on standardised language measures when combined with

traditional speech and language therapy (Berthier et al., 2003; Berthier et al. 2006). In this study we investigated the effects of donepezil as an adjunct to a specific phonological behavioural therapy (Earobics®) in patients with global and Wernicke's type aphasia. METHOD: Twenty four patients with chronic auditory perceptual deficits as a result of left hemisphere stroke participated (age range=43-90 years). Participants had moderate to severe aphasia according to the Comprehensive Aphasia Test battery (CAT) (Swinburn et al., 2004), and all were aphasic on the compound score of speech comprehension, the main inclusion criteria. The effect of donepezil as an adjunct to phonological therapy was tested in a double blind, placebo controlled crossover design, with block randomisation. Two therapies were tested: a computer-based phonological training therapy (Earobics®) (10 hours/week over 5 weeks), and donepezil therapy in conjunction with phonological therapy. Behavioural and functional magnetic resonance imaging (fMRI) data were collected at a range of time points. The speech comprehension score on the CAT was the primary outcome measure. RESULTS: Exploratory data analysis using a Two-Step Cluster Analysis revealed patients could be split into moderate (n=9) and severe (n=15) subgroups based on scores on the CAT. Results of a repeated measures ANOVA revealed that phonological training significantly improved Speech Comprehensions scores, indicated by a main effect of phonological therapy ($F(1, 22)=5.66$, $p=.03$). There was a significant main effect of donepezil on patient's Speech Comprehension scores ($F(1, 22)=6.72$, $p=.02$); however, patients were worse with donepezil versus placebo. Analysis of further CAT measures revealed a significant main effect of donepezil on Naming (CAT) ($F(1, 22)=5.98$, $p=.02$). This was driven by improvement in the moderate but not the severe subgroup of patients. DISCUSSION: Results showed that phonological therapy significantly improved patients' speech comprehension skills. Our hypothesis that donepezil would enhance the effect of phonological therapy was not supported. However, donepezil did significantly improve spoken output (Naming) scores in these patients. To further elucidate the neural underpinnings of this behavioural effect, we will report on analysis of fMRI data. REFERENCES: Berthier ML, Green C, Higueras C, Fernández I, Hinojosa F, Martín MC. A randomized, placebo-controlled study of donepezil in poststroke aphasia. Neurology 2006; 67:1687-1689. Berthier ML, Hinojasa J, Martín M del C, Fernández I. Open-label study of donepezil in chronic poststroke aphasia. Neurology 2003; 60:1218-1219. Swinburn K, Porter G, Howard D. The Comprehensive Aphasia Test. Hove: Psychology Press; 2005. Pederson, P, Vinter, K and Olsen, T (2004). Aphasia after Stroke: Type, Severity and Prognosis. Cerebrovascular Disease 17:35–43.

Meaning: Combinatorial Semantics

F45 Concurrent emotional generation and language combination: An event related potential study

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Previous studies on emotional words processing suggest that emotional saliency could override lexical-semantic analysis. Using event-related potentials (ERPs), this study examines the time course of deriving implied emotion from language descriptions. In the same sentential context, an emotionally neutral word rendered the whole sentence emotionally neutral or emotional, or semantically incongruent. Compared to the words in the neutral condition, the words in the incongruent condition elicited a larger N400 than those in the neutral condition, indicating of the combinatory processing; whereas the words in the emotional condition elicited a long-lasting positivity between 300 and 1000 ms, indicating of the emotional response. The overlapping time window between the combinatory processing and the emotional response suggests that the emotional generation is concomitant to the language combination. The results indicate that implied emotional processing could be a result of combinatory operation but not necessarily requires the simulation of the mental representation of the sentences.

F46 Shared neural circuits subserve processing of reference frames in spatial navigation and language comprehension

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A theme which has defined much of research into the neural architecture of language is how the linguistic network interacts with other neurocognitive domains. Recent findings in psychology and neuroscience have stimulated the development of neural reuse theories according to which, rather than depend on completely separate and evolutionarily novel systems, the task of language processing is simplified through the use of already existing brain mechanisms. Indeed, a wealth of evidence shows that at least the processing of single words depends, in part, on non-linguistic functions including motor, perceptual, and affective brain systems. Much less is known, however, about higher-level contextual and pragmatic language comprehension in real-life situations. For example, understanding the meaning of even a simple phrase, such as "I am eating an apple", can involve construction of very different representations - a person can mentally simulate performing the action themselves and thus adopt an egocentric/internal reference frame, or they can assume an allocentric perspective, as an external observer of the action. How this perspective-taking is achieved, in what way it influences comprehension, and which neural networks support such computations, remains poorly understood. In extension of the neural reuse framework, we hypothesised that such reference-frame processing in language might actually make use of mechanisms used in navigation, since spatial thinking routinely involves construction of frame-based representations of the actor and their environment. To test this suggestion experimentally, we recorded high-density EEG in 27 subjects and used independent component analysis to identify spatiotemporal dynamics underlying reference frame computation. In two separate conditions, participants performed (1) a navigation task to evaluate the brain activity underlying perspective-taking in non-linguistic conditions, and (2) a language comprehension/picture matching task. The former involved traversing virtual corridors which turned at varying angles, and estimating the navigator's starting location. The latter task consisted of listening to sentences and verifying

their congruence to subsequently presented allo/egocentric pictures. By decomposing the EEG signal into a set of maximally independent activity patterns, and localising these in neuroanatomical source space, we were able to identify a subset of ICA components which characterised distinct strategies in spatial navigation. We also found that neural correlates of linguistic perspective during sentence comprehension dissociates between individuals, based on their adoption of egocentric or allocentric reference frames. Remarkably, our results further show that activity in a set of six ICA component clusters accompanies computation of reference frames in both navigation and language. These were localised in or near left inferior-frontal and right precentral gyrus, cuneus, precuneus, and extrastiate and lingual areas. Most importantly, we found individual co-variability in the two tasks: individuals who navigated space using different reference frames also responded differently when understanding perspective in language, and cortical generators of such strategy-dependent activity respond both in language and navigation. Thus we report, for the first time, evidence for shared brain mechanisms across the domains of language and spatial navigation - advancing our understanding of language's neural architecture, its interaction with other cognitive systems, and the individual differences shaping language processing.

Meaning: Discourse and Pragmatics

F47 Predicting discourse topics: Evidence for the privileged role of the syntactic subject during the comprehension of naturalistic auditory stories using event-related potentials.

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The syntactic subject possesses a key function during discourse comprehension in serving as an attentional cue of upcoming discourse topics. Cross-linguistic text analyses (e.g. Givón, 1983) showed that syntactic subjects have a high cataphoric potential, i.e. they are more likely to be referred to in subsequent parts of a discourse compared to syntactic objects (subjects are persistent). Previous behavioral experiments suggested a connection between attentional focus and the syntactic subject: in an attentional cueing paradigm (Tomlin, 1995), participants described pictures of transitive events after either the actor or undergoer was visually cued. In support of the attention-related role of the syntactic subject, participants realised cued actors as subjects of an active sentence and cued undergoers as subjects of a passive sentence. Also, recent event-related potential (ERP) studies provide evidence for a relationship between syntactic role and the persistence of discourse referents in terms of prominence features (Schumacher, Backhaus & Dangl, 2016: word order and verb type; Schumacher, Dangl, Uzun, 2016: thematic role; Hung and Schumacher, 2014; animacy). However, these studies focused on the interpretation and resolution of different pronoun types as a factor of prominence features (e.g. 'does pronoun A preferably refer to the subject or the object of the last sentence') rather than on the cataphoric function of the grammatical subject. The present ERP study tested how prominence features influence predictive processes connected to the reoccurrence of the subject in upcoming discourse. We embedded sentence pairs in short stories, presented auditorily in German (mean length: 106.3 s). Within the stories we introduced the referent in a full NP sentence, in which we manipulated actor prototypicality by using different verbs (high/ low causality, e.g. schlagen, 'to hit' vs. sehen, 'to see', cf. Proto-role properties by Dowty, 1991), grammatical voice (active/passive) and word order (subject-verb [SV]/verb-subject [VS]). The upcoming discourse referred back to the differentially introduced subject with the same NP as subject of a new sentence (anaphor). After presentation of each story, participants (N = 60) answered 2 general comprehension questions. Mixed-effects modelling of the ERP response to anaphors on a single-trial basis revealed effects of prominence features on the N400/P3 (300-500 ms). In the high-causality condition, we found a broadly distributed positive deflection with a parietal maximum for the non-initial order for both passive and active sentences, which we interpret as an instance of the P3 indexing attentional orientation towards the prominent (actor-subject) and thus expected discourse referent. This effect was reversed to a small negative effect in the low-causality condition which we interpret as an index of computational cost following a less attended referent. The present study supports the cataphoric function of the grammatical subject during auditory story comprehension by influencing the predictability of its reoccurrence as a function of linguistic prominence features. These findings support Bornkessel-Schlesewsky and Schlesewsky (2014)'s view that the grammatical subject serves as an attentional 'attractor' in providing a reliable predictive cue for upcoming topics during incremental language processing and that topic formation and topic prediction are influenced by prominence features of discourse referents.

F48 Narrative reading comprehension versus Narrative scene comprehension: An fMRI study

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Comprehending a story from a series of pictures or from a narrative passage quite possibly accesses overlapping sets of cortical areas supporting semantic access, event segmentation, discourse structure building and so on. However, controlled comparative assessment of linguistic and non-linguistic comprehension is sparse in the literature. Here, we utilized two tasks -- narrative reading and narrative scene comprehension, controlled for low-level visual processing and eye movements, to assess the degree to which serial assembly processes in linguistic and non-linguistic comprehension intersect and diverge. Additionally, the identified regions were characterised relative to topological visual, auditory and somatomotor maps found across the entire cortex in the same set of subjects. In the reading comprehension task, subjects made naturalistic but controlled saccades (by occluding all but one word at a time with a gray rectangle) to read interesting and coherent 64 word passages. Contrast conditions were meaningless (to the subjects) Hindi character strings, or a large dot, and a central

fixation screen OFF. In the scene comprehension task, the same subjects viewed a series of pictures that told a coherent story (no text captions of any kind). Participant's saccades across each single- or multi- frame picture within a story page were controlled by 'saccading' a transparent Gaussian 'bubble'-style mask (at 1 Hz) to relevant points in each image, chosen by offline comprehension testing. Contrast conditions were a jigsawed version and a shuffled version of the story, and a fixation screen OFF. In both scene and reading experiments, comprehension was measured with a questionnaire afterward. The same subjects also took part in cortical mapping experiments (retinotopic, auditory and somatomotor). The reading comprehension and cortical mapping experiments were detailed previously in Sood & Sereno (2016). The scene comprehension data was acquired on a 1.5T Tim Avanto System with a 30 channel head coil (standard 32 channel with eye-coils removed) using a multi-band sequence (40 slices, 3.2x3.2x3.2mm, flip=75°, TE=54.8ms, TR=1sec, accel=4). Single subject scene data (as well as reading) was analysed in FSL (univariate analysis), with group analysis carried out on the fsaverage surface using Freesurfer tools and corrected for multiple comparisons with a surface cluster filter (Hagler et al., 2006). The analysis of mapping data used Fourier based methods (Sood & Sereno, 2016). Reading and scene comprehension activations, though different in their spread, were centred around occipito-parietal, temporal, and frontal cortex. The scene activation in left temporal and frontal cortex was also largely contained within the more expansive reading activation in these regions, while the reverse was true in the right hemisphere. The shared activations between reading and scene also largely overlapped topological cortical maps (mainly visual and auditory maps). Additionally, there were regions overlapping topological maps that were distinct to either reading or scene processing. References: Hagler, D.J. Jr., Saygin A.P., and Sereno, M.I. (2006) Smoothing and cluster thresholding for cortical surface-based group analysis of fMRI data. Neuroimage 33:1093-1103. Sood, M.R. and Sereno, M.I. (2016) Areas activated during naturalistic reading comprehension overlap topological visual, auditory, and somatotomotor maps. Hum. Brain Mapp. doi: 10.1002/hbm.23208

Perception: Orthographic and Other Visual Processes

F49 Effect of word lengths' morphological family size (type frequency) when reading Arabic words in adults

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Background: Reading research is dominated by the use of Latinate languages. In English, increasing word length increases reading aloud response times in healthy adult subjects. However, little is known about word length's impact on reading speed in the Semitic languages. This study investigated the impact of increasing word length on Arabic adult reader's single word reading aloud speed. Method: 28 native Arabic readers took part in the study, aged between 42 and 77 years (M = 63.00, SD = 1.56). We measured oral reading response times and accuracy of single Arabic words of three, five, and seven letters. 105 target words, divided equally into three-, five-, and seven-letter words, were presented using E-prime. Participants were instructed to read words aloud as quickly and accurately as possible. A voice-key was used to detect the latency of the vocal response. The words remained onscreen until a response was detected. The mean response times for three-, five-, and seven-letter Arabic words were calculated. Responses more than two standard deviations away from the mean were excluded from further analyses. To calculate accuracy, trials read correctly scored 1, and errors or omitted words were scored 0. Word length effects were calculated by taking the average morphological neighbourhood size for each word length. The significance threshold was set at p=0.05. Results: There was a significant effect of word length on reading aloud speed. Specifically, response times were significantly longer for three-letter words than for five- and seven-letter words. A one-way repeated measures ANOVA showed that three-letter words had a larger morphological neighbourhood size (M = 50.65, SD = 11.83) than five-letter words (M = 26.67, SD = 14.27) and seven-letter words (M = 16.47, SD = 7.62). Post-hoc analyses found that shorter words had a significantly larger morphological neighbourhood size than longer words ($F(2, 93) = 71.90$, $p = .000$). A Tukey post-hoc test revealed that three-letter words had a large morphological neighbourhood size when compared to (M = 50.65, SD = 11.83) five-letter Arabic words (M = 26.67, SD = 14.27) and seven-letter Arabic words (M = 16.47, SD = 7.62). There was also a significant positive correlation between reading response times and morphological neighbourhood size, $r(96) = .34$, $p < .001$. Conclusion: Compared to the data from Latinate Languages our data from adult Arabic readers found there is a "reversed" effect of word length on response time. That is, Arabic readers on average take longer to read aloud 3-letter words than 7-letter words. This is consistent with a previous study on typical adult readers of Hebrew (Yael, Tami & Tali, 2015). Furthermore, we found a significant correlation between oral reading speed and the density of morphological neighbourhood size for Arabic single words. Our results provide the first evidence that, in Arabic, word length's morphological family size (type frequency) influences how long adult readers take to read aloud single words Reference: Yael, W. (2015). The effects of orthographic transparency…..on reading Hebrew words in adults. Ann. Of Dyslexia, 66, 84-102.

Phonology and Phonological Working Memory

F50 Place and height mismatch in vowels: evidence from an MMN study

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The mismatch negativity (MMN) has been shown to be sensitive to differences in vowel contrasts (Näätänen et al., 2007). Research into the processing of vowels has shown a number of these differences to be asymmetric (e.g. Eulitz & Lahiri, 2004; Scharinger et al., 2012). The present study investigates the representation of both place and height features in English vowels using MMN. Four stimulus pairs were chosen: the ablaut verbs get/got and sit/sat and the corresponding pseudo-words *gef/*gof and *sif/*saf. The vowels in get/got differ in place (/e/ = [CORONAL]; /ɔ/ =

[DORSAL]) but not in height while those in sit/sat differ in height (/ɪ/ = [HIGH]; /æ/ = ([LOW]) but not place. This allows for two sets of predictions – one acoustic and one phonological: (1) Taking only acoustics into account, the contrasts between /æ/ & /ɪ/ and between /e/ & /ɔ/ should both result in symmetrical MMNs of the same magnitude regardless of which vowel is the deviant as the acoustic distance between the vowels remains constant. (2) Our phonological predictions are based on the Featurally Underspecified Lexicon (FUL) which proposes that certain features are not specified in the mental representation of a sound (Lahiri & Reetz, 2010). For example, the feature [CORONAL], while it is extracted from the speech signal, is not represented in the lexicon (Eulitz & Lahiri, 2004). We would thus predict a processing asymmetry for get/got and *gef/*gof with a reduced MMN for a [DORSAL] deviant in the context of a [CORONAL] standard. Vowel height, however, is fully specified for both [æ] ([LOW]) and [ɪ] ([HIGH]) which should result in symmetrical mismatches of equal amplitude. We conducted two MMN experiments with eight blocks in a standard oddball paradigm (700 trials per block, 15% deviants; ISI 600ms) with 18 native English speakers. Four tokens of each word were presented which included natural variation in the vowel. All other sounds were kept constant and one version of each consonant cross-spliced onto the four vowels. Stimuli were presented in their pairs once as a deviant and once as a standard in separate blocks. The difference waveforms show MMN responses of symmetrical magnitude for sit-sat and *sif-*saf while the difference waveforms for get and *gef show a significantly reduced MMN response compared to the response to got and *gof. This asymmetry is evident in both words and pseudo-words. These results support the phonological predictions made by the FUL model based on the underspecification of [CORONAL]. References Eulitz, C. & A. Lahiri, (2004). Neurobiological evidence for abstract phonological representations in the mental lexicon during speech recognition. J Cogn Neurosci 16(4), 577-83. Lahiri, A. & H. Reetz (2010). Distinctive Features: Phonological underspecification in representation and processing. J Phon 38, 44-59. Näätänen R., P. Paavilainen, T. Rinne & K. Alho (2007). The mismatch negativity (MMN) in basic research of central auditory processing: A review. Clin Neurophysiol 118, 2544-90. Scharinger, M., P. J. Monahan & W. J. Idsardi (2012). Asymmetries in the processing of vowel height. J Speech Lang Hear 55, 903-18.

F51 MMN magnitude reveals asymmetries in phonological encoding: phoneme-specific representations for vowel length in Dutch

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Languages differ in how they employ individual acoustic dimensions to differentiate speech sounds. For example, some languages use duration to distinguish their vowels, while others do not. This difference is often projected in the languages' phonologies: in some languages phonetically short and long sounds are encoded in the lexicon as phonological length contrasts. Interestingly, in some cases there seems to be a discrepancy between phonological descriptions and the phonetics. An example is Dutch, which has been formally described as having phonological length contrasts in vowels (Moulton, 1962). However, Dutch speakers do not produce most of their phonologically long vowels with long duration (van Leussen et al., 2011). For instance, the Dutch /iː/-/ɪ/ contrast is formally described as a length contrast but the two vowels are both realized with short duration. In order to resolve the apparent phonology-production discrepancy, here we examine Dutch speakers' pre-attentive processing of the /iː/-/ɪ/ distinction. We ask whether Dutch listeners perceptually associate /iː/ and /ɪ/ with long and short durations respectively (which would provide support for phonological encoding in terms of length categories), or whether they rely more robustly on spectrum (which would favor an alternative phonological encoding), or whether there is asymmetry in cue-reliance within this contrast (as was suggested for Dutch /aː/-/ɑ/, Chládková et al., 2015). In order to compare the perceptual reliance on duration and spectrum within the /iː/-/ɪ/ contrast, we designed two oddball blocks: block 1 with [iː] as standard and with [i] and [ɪː] as the duration and spectrum deviants, respectively; block 2 with [ɪ] as standard and this time with [ɪː] and [i] as the duration and spectrum deviants, respectively. If the /iː/-/ɪ/ contrast is, to some extent, perceptually cued by duration, there will be a relatively large MMN to the duration deviants in both blocks. Alternatively, if there is asymmetry in length encoding, the duration deviant from only one block will yield a large MMN. Eight Dutch native speakers were tested in an unattended oddball paradigm; one participant was excluded due to many artifacts. Difference waves were computed by subtracting responses to physically identical stimuli (deviant minus control). MMN was quantified in the difference wave as area under curve between 100ms and 300ms after stimulus onset. Given the low number of participants, statistical tests were done with alpha = .1 (Royall, 1986). We found a significant main effect of deviant vowel (p=.096): [ɪː] yielded a larger MMN than [i] in both blocks, i.e. irrespective of whether it was a duration or a spectrum deviant. No other main of interaction effects were found. The detected perceptual asymmetry in cue reliance within the /iː/-/ɪ/ contrast indicates an asymmetry in phonological encoding. Durational changes are perceptually more salient for an [ɪ]-quality than they are for an [i]-quality. This implies that both short [i] and long [iː] are acceptable as /iː/, while only short [ɪ] (but not long [ɪː]) is acceptable as /ɪ/. We thus conclude that /ɪ/ is phonologically encoded as a short vowel, while /iː/ has no phonological specification for length.

Signed Language and Gesture

F52 Cortical encoding of sensorimotor and linguistic features in American Sign Language

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Fluent production of sign language requires the tight coordination of motor and sensory representations of the hands and body, and higher-order linguistic representations. Previous studies have identified pre- and post- central gyri, supplementary motor areas, and both inferior and superior parietal regions as being involved in sensorimotor, phonological, and lexical processing of sign. However, the fine-scale coordinated dynamics of these regions have not been explored. Here, we present a rare case study of a

profoundly deaf signer who was implanted with high-density electrocorticography (ECoG) arrays during surgical resection of a tumor. The patient viewed videos of single ASL signs and pseudosigns, and produced a variety of responses, including repetitions, fingerspellings, and non-linguistic gestures. The patient's manual behaviors were recorded and annotated frame-by-frame to provide nearly 8000 events that could be time-locked to the neural data. We examined two aspects of sign language production: 1) How are sensorimotor and phonological (e.g., location and handshape) features encoded? 2) How do higher-order linguistic (e.g., lexical) representations modulate neural responses in real-time? We identified single electrodes throughout sensorimotor and parietal cortex that responded selectively to signs produced at specific locations (e.g., 'face' vs. 'hand') and with specific handshapes (e.g., 'O' vs. 'S'). Population neural activity was examined using unsupervised hierarchical clustering, which revealed highly structured neural representations of sensorimotor-based phonological features. Supervised classification analyses demonstrated that location, handshape, and movement features could be decoded from neural activity with significantly above-chance accuracy for several hundred milliseconds around the onset of each sign. Neural activity differentiated linguistic and non-linguistic movements with clear spatiotemporal patterns. Generally, there was greater activity on ventral and dorsal pre-central gyrus and supramarginal gyrus for linguistic movements. These patterns overlapped with greater responses to real signs compared to pseudosigns. Finally, dorsolateral prefrontal cortex was significantly modulated by the lexical factors of frequency and age of acquisition throughout the timecourse of sign production. Together, these results provide unprecedented detail of the cortical basis of sign language production. In addition to demonstrating striking similarity with the dynamics of speech production, this study indicates that population neural activity in supra-Sylvian cortex is sufficiently discrete to allow behavioral decoding.

Speech Motor Control and Sensorimotor Integration

F53 Speech error analysis in isolated Apraxia of Speech may reveal subtypes: evidence from two stroke case studies

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Apraxia of Speech (AOS) is a motor speech disorder characterised by incoordination of the speech musculature (Wertz et al., 1984). AOS typically arises following stroke, often co-occurring with aphasia and dysarthria, making differential diagnosis challenging (Darley et al., 1975). Diadochokinetic (DDK) rate is a principal assessment used to detect AOS by examining incoordination of tongue movements (Wertz et al.,1984). However, incoordination of other elements of speech production, such as phonatory sequencing for voiced/voiceless contrasts, have not been assessed with DDK. In this study, speech errors of two acute stroke patients with isolated AOS were analysed to explore quality of errors, sensitivity of DDK in its current form and consequently, to infer potential functional specificity of lesion sites based on error types. METHOD: CW (age 60, right-handed female) and BF (age 25, left-handed male) were recruited during the acute stage of stroke. Routinely-acquired clinical scans (CT, MRI) were collected for both patients to determine lesion site. AOS was assessed using the Motor Speech Evaluation (MSE): Oro-motor exam and DDK (Wertz et al., 1984), Rainbow passage (connected speech sample generated through reading; Fairbanks, 1960) and the Cinderella Story (spontaneous speech sample). Aphasia (Western Aphasia Battery-Revised; Kertesz, 2007) and dysarthria (MSE) were ruled out and a Speech and Language Therapist conducted all assessments. Speech errors were phonetically transcribed and categorised by type (e.g. articulatory substitution, phonatory substitution, addition etc.). RESULTS: Lesion sites: CW, left posterior inferior frontal gyrus focal haematoma. BF, left frontal operculum infarct extending superiorly towards the pre-central gyrus. MSE: Both patients had impaired DDK sequencing, where production of isolated phonemes was preserved. Oro-motor exams were unremarkable and thus both patients were classified as having isolated AOS. Speech error analysis: CW produced errors consisting mainly of articulatory substitutions (50%) and was more likely to produce omission errors in spontaneous speech (25% as compared to 13.6% in connected speech) and addition errors in connected speech (27.3% as compared to 8.3% in spontaneous speech). BF produced errors consisting mainly of vowel distortions (28% in spontaneous speech; 35% in connected speech) and was more likely to produce phonatory substitutions in connected speech (21.4%) than in spontaneous speech (3.9%). Unlike CW, BF displayed syllable segmentation behaviours throughout both speech samples. CONCLUSION: Our preliminary findings show that speech error analysis reveals different presentations of AOS that were not detected by DDK, supporting the notion of AOS sub-types (Josephs et al., 2013). DDK assessments that analyse articulation and phonation incoordination may be more useful in interpreting AOS presentation. Moreover, our findings suggest that reading could influence the type of errors produced as compared to spontaneous speech. Analysis into type of substitution errors may also reveal a functional specificity for lesion site in relation to tract pathways and could explain why past research has identified numerous regions in the left hemisphere associated with AOS (Hillis et al., 2004; Dronkers, 1996; Duffy, 1995; Rueckert et al., 1994; Josephs et al., 2014). Future studies with greater participant numbers are needed to establish the validity and sensitivity of these findings.

F54 Exogenous and Endogenous Auditory Prediction in Speech

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Auditory sensory prediction plays a central role in speech motor planning and control. One approach to investigating this predictive process is through the comparison of auditory

cortical responses to auditory feedback during active speech vs. passive (offline) listening to the same acoustic speech signals. Neural responses during active speech production are typically suppressed, which is presumed to reflect a subtraction of the motor-sensory prediction from auditory feedback. In the present EEG study, we further explored the link between online (feedback) and offline (passive listening) speech processing by measuring auditory evoked responses in combination with two different manipulations that alter a talker's ability to accurately predict the sensory consequences of speech actions. One manipulation involved a real-time change in auditory feedback (F1) during vowel production, creating a mismatch between sensory prediction and auditory feedback (reducing accuracy). The second manipulation involved presenting a stable auditory vowel target corresponding to the subject's own typical speech output before each production (predicted to enhance prediction accuracy). Method: 20 adult participants carried out two pairs of tasks, each consisting of matched speech production and passive listening phases. In each task pair, subjects first produced 240 vowel-consonant syllables while listening to their auditory feedback through earphones. Following 80 initial trials with normal feedback (baseline), vowel F1 frequency was altered in real-time (35% increase) for 80 trials, with 80 final trials under normal feedback. Following the production task, subjects passively listened to the entire recorded speech sequence in a manner that was identical in timing and amplitude to the auditory feedback provided during the preceding speech production phase. Two separate pairs of production/listening tasks were carried out (order counterbalanced), one involving a visual cue to speak and the other involving an auditory presentation of the speech target (previously recorded from the subject). During all tasks, EEG signals were recorded from 64 scalp electrodes. Using individual syllable onsets as acoustic triggers, averaged auditory-evoked potentials (N1/P2) at fronto-central electrodes were computed for each task (perception vs. production), feedback condition (normal vs. altered) and target cueing condition (visual vs. auditory). Results: Behaviourally, subjects showed a significant compensatory decrease in vowel F1 output relative to baseline in response to the auditory feedback manipulation under both visual and auditory cueing conditions. EEG analyses showed a significant speech-induced suppression (SIS) of the auditory evoked N1/P2, with a difference in amplitude between the auditory and visually cued productions. Interestingly, this difference in SIS magnitude resulted from a differential effect of cueing modality on the evoked responses during the listening task, with a reduction in auditory evoked N1/P2 between the auditory target and the subject's speech production (i.e., the classic auditory habituation effect) occurring during offline listening, but not during online speech production. These results support a key role for auditory prediction in speech motor control. However, by demonstrating distinct exogenous and endogenous predictive processes during speaking and listening, they also provide new evidence that the online auditory processing of speech feedback is functionally decoupled from the offline processing of speech originating from outside the speaker.

F55 Speech comprehension and associated lip motor activity are modulated by suppression of premotor cortex

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It has become increasingly evident that primary motor (M1) areas for speech production activate during speech perception. Furthermore, the extent of activation in M1 increases when listening to speech that is difficult to perceive, possibly to assist perception. M1 activity when listening to speech appears dependent upon modulatory inputs from the premotor cortex (PMC), which do not affect M1 activity to non-speech. Suppression of PMC has also been found to impair identification of speech-in-noise but not clear speech. How PMC differentially modulates M1 activity during perception of speech that is easy or challenging to understand, however, is unclear. This study aimed to address the link between PMC and M1 activity during challenging speech perception by concurrently recording M1 activity and behavioural data during identification of clear and distorted speech. We hypothesized that increased M1 activation during challenging speech perception may be governed by increased signaling from PMC to M1. We predicted that suppression of PMC would lead to greater impairment when perceiving speech that is difficult to understand, relative to clear speech. We tested this hypothesis by using transcranial magnetic stimulation (TMS). Continuous theta burst stimulation (cTBS) was applied to ventral PMC to create a temporary virtual lesion. Post-cTBS, stimulation of the lip representation in the left M1 elicited motor evoked potentials (MEPs) that indexed excitability of the underlying motor representation. At the same time as MEPs were elicited, participants performed a sentence verification task on distorted (imprecisely articulated), or non-distorted (clear) speech. Collection of baseline data was counter-balanced pre- and post-cTBS. Fifteen normally-hearing adult subjects (aged 18-30; 4 males) participated in the study. Results indicated that there was a significant interaction between the effect of cTBS and speech type on reaction time ($F(1,14) = 9.26$, $p = 0.009$). Planned contrasts confirmed that there was a trend towards a reduction in reaction time to motor-distorted speech post-cTBS ($p = 0.1$), but not for clear speech ($p = 0.3$). There was no significant effect of cTBS on accuracy ($F(1,14) = 1.73$, $p = 0.2$), indicating that this result did not indicate a speed-accuracy trade-off. This behavioural effect was reflected in the interaction between the effect of cTBS and speech type on lip MEPs, which showed a trend towards significance ($p = 0.1$). MEPs during distorted speech perception were not suppressed after cTBS, but data indicated that cTBS reduced MEPs to clear speech. These surprising findings were counter to our hypothesis. It is unlikely that these results reflect learning of motor-distorted stimuli, as cTBS occurred both pre and post collection of baseline data. One possible interpretation is that the role of the motor system in speech perception is dependent upon the speech task. Here, participants were asked to focus on semantics and not phonology. Therefore, suppression of PMC may have changed the balance between other recruited brain regions due to compensation, which resulted in facilitation of task performance.

F56 Age-related differences in language production: The neural correlates of semantic inference, phonological facilitation, and target picture frequency

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Introduction: Language production requires multiple stages of processing (e.g., semantic retrieval, lexical selection), each of which may involve distinct brain regions. Distractor words can be combined with picture naming to examine factors that influence language production. Phonologically-related distractors have been found to speed picture naming (facilitation), while slower response times and decreased accuracy (interference) generally occur when a distractor is categorically related to the target image. Moreover, effects of frequency have been consistently demonstrated, where lower frequency items are produced more slowly. At the same time, older adults often show declines in language production as reflected in slower naming times, increased pauses in speech, increased word finding failures, and increased tip of the tongue experiences. Methods: Here we used fMRI and behavioral measures to investigate age differences (N=20 younger, 20 older adults) during the picture-word interference task. We examined age-differences as a function of distractor type (categorical, phonological, unrelated, nonword) and target picture frequency. Results: Behaviorally, all adults showed the typical frequency effects with a negative correlation between RT and frequency. All participants were also slower to name pictures presented with a categorical distractor, and showed no statistically significant differences in RT across the other distractor categories. Neurally, older adults showed increased activation compared to younger adults, during production with a categorical distractor, in early perceptual processing (lingual gyrus), semantic organization (left middle frontal gyrus), and elaboration regions (bilateral precuneus). Age differences also emerged when comparing phonological to categorical distractors, as younger adults showed greater activation than older adults in bilateral supramarginal gyri, bilateral pre and post-central gyri, and right insula. With respect to the effect of target frequency, older but not younger adults elicited greater activation to low frequency targets presented with phonological distractors in regions associated with articulation (bilateral pre and post-central gyri) and early visual processing (bilateral occipital cortex and lingual gyri). Conclusions: These results suggest that older adults' semantic networks are activated to a greater extent than younger adults when categorical distractors are presented. Moreover, even when provided with partial access to the phonology, older adults show less engagement of regions that support production. The frequency effects illustrate that the presence of a phonological distractor may increase activation in regions that support motor planning, potentially aiding articulation for words that are most difficult to produce. These results are partially consistent with the Transmission Deficit Theory.

F57 Disrupting the speech motor mechanism: exploring left hemisphere specialisation for verbal and manual sequencing using a dual task approach

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It is well established that speech production and fine motor praxis are linked neurologically, with evidence indicating that shared left hemisphere networks underpin both functions. One suggestion for the crucial component of this left lateralised specialisation is that both speech and praxis rely on effective sequencing of information for their successful execution (Flowers & Hudson, 2013). Whilst the concept of speech and motor sequencing and their neural correlates is well accepted, few studies explore the behavioural characteristics of language and praxis when performed simultaneously. This study was designed to probe the mechanism behind this interaction by overloading the left hemisphere sequencing network via a dual task paradigm. Participants (n=22) performed an experimental set of motor and speech tasks, (namely a verbal fluency paradigm and an electronic peg moving task), as well as a control set of similar tasks, (namely digit recall and a box crossing tracking test), both under single and dual task conditions. The two sets of tasks differed on the extent to which they relied on motor and speech sequencing, and it was hypothesised that tasks more reliant on this type of processing (i.e. the experimental condition) would suffer a greater performance decrement under dual task conditions, thus reflecting the greater load placed on left hemisphere speech and praxis centres. Each task was performed for 2 mins for both conditions, and scores were calculated based upon number of correct responses/movements made. Ordering of single and dual presentation was counterbalanced between participants. Participants subsequently underwent functional Transcranial Doppler ultrasound (fTCD) whilst performing a word generation task, to provide a direct measure of their hemispheric language dominance. Results showed that tasks forming the experimental arm were more impaired under dual task conditions than the control tasks, suggesting they both relied on a common processing system. Most interestingly speech production scores in the experimental arm were consistently impaired under dual task conditions, whereas the control arm speech task performance remained consistent with single task conditions. Motor performance suffered less in dual task conditions over both experimental and control arms, but there was a significant effect of hand dominance on performance in dual task conditions, whereby non-preferred hand usage didn't suffer under dual task conditions, but preferred hand did. This data indicates the common processing capacity for speech and fine motor tasks of the right hand are controlled by left hemisphere networks which can be disrupted through a dual task paradigm. This data supports theories suggesting a motor based, gestural origin for language (e.g. Corballis, 2003), and indicates that speech production is more sensitive to the effects of increased processing requirements than are motor tasks.

F58 Shared Neural Correlates of Spoken and Written Communication

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While oral communication is a product of biological evolution, reading and writing are cultural inventions from the last few thousand years. Since a naturally evolved brain mechanism for written communication is unlikely to exist, one recent hypothesis postulates that evolutionary adapted brain systems for spoken communication might provide a neural foundation for reading and writing abilities. In order to determine whether reading and writing might also partly rely on brain areas common with those for speech perception and production, we asked twenty-six participants to passively listen to and produce phonemes, and to read and write corresponding graphemes while measuring neural activity with sparse sampling fMRI. Functional and structural MRI images were acquired with a 3T MR scanner in two separate sessions, counterbalanced across participants. One session consisted on a listening task followed by a speaking task; the other session consisted on a reading task followed by a writing task. The same experimental and acquisition parameters were used in the two sessions (functional images: 53 axial slices, 3mm3; TR of 8s, delay in TR of 5s; structural images: 256 x 224 x 176mm3 with a 1mm isotropic resolution). Phoneme presentation and acoustic recordings were performed through MRI compatible headphones and microphone, while grapheme presentation and kinematic parameters were performed through a computer screen and an MRI compatible graphic tablet. Following standard preprocessing of individual data using DARTEL and a 8mm full-width at half maximum spatial smoothing, BOLD responses were analyzed in both sessions using a general linear model, including eight regressors of interest (2 modalities x 4 stimuli) and six realignment parameters, with the silent trials forming an implicit baseline. A second-level random effect group analysis was carried-out, with the communication mode (spoken, written), the modality (perception, production) and the stimuli (/p/, /b/, /t/, /d/) as within-subject factors and the subjects treated as a random factor. All reported effects were calculated with a significance level set at $p < .05$ FWE corrected at the voxel level. Apart from sensory-specific activity of the primary, secondary and associative auditory or visual cortices, activations common to phoneme perception and production, and activations common to grapheme perception and production were observed in several frontal and parietal motor areas including the opercular and triangular parts of the inferior frontal gyrus, the ventral and dorsal premotor cortices, the supplementary motor area, the inferior and superior parietal lobules and the cerebellum. A global conjunction analysis between the four tasks further revealed common activation in the postero-dorsal part of the left inferior frontal gyrus, extending to the ventral part of the premotor cortex, and in the supplementary motor area. These results demonstrate that processing of letters and speech sounds during listening, speaking, reading and writing rely on sensory-specific auditory and visual brain areas as well as common premotor regions. They provide strong experimental evidence for a functional coupling between action and perception systems in both spoken and written communication. This research was partly funded by Agence Nationale de la Recherche ANR-11-BSH2-010 (Multimex).

History of the Neurobiology of Language

F59 Evolutionary origins of non-adjacent rule processing in primate brain potentials

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There is considerable interest in understanding the ontogeny and phylogeny of the human language system, yet, empirical work at the interface of both fields is rarely conducted. Syntactic processes in language build on both sophisticated sensory processing and sequencing capabilities on the side of the receiver. While insights on the development of auditory perception and non-adjacent sequencing operations in the human brain have expanded, we lack knowledge on whether and how these processes are implemented in the brains of our primate relatives. In the present nonhuman primate study we used a paradigm initially developed to evaluate human infant and adult brain potentials associated with the processing of non-adjacent dependencies in auditory sequences. We measured scalp-recorded event-related potentials (ERPs) from two macaque monkeys listening to syllable triplets. Frequent standard triplet sequences were interspersed with infrequent voice pitch or non-adjacent rule deviants. Monkey ERPs revealed early pitch and rule deviant mismatch responses that are strikingly similar to those previously reported in human infants in response to the same stimuli material, suggesting similar automaticity in processes. This stands in contrast to adults' later ERP responses for rule deviants, indicating less automaticity in sequencing functions. The results reveal the evolutionary origins of non-adjacent sequencing operations in the primate brain and they provide evidence for evolutionarily conserved neurophysiological effects, some of which are remarkably like those seen at an early human developmental stage.

F60 Heinrich Sachs on the neurobiology of language

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The work of the German neuropsychiatrist and anatomist, Heinrich Sachs (1863–1928), has been recently reappraised in neuroimaging research. He was a pioneer in the golden era of atlasing white matter pathways of the human brain and his contribution is directly relevant to contemporary tractography. What is less know is the contribution of Sachs to the field of language. Here we present the first translation of his book Brain and Language (1905) that represents an extraordinary example of the advanced ideas that were developed by the Wernicke's school in Breslau, of which Sachs was a proud representative. We translated two of Sachs' most prominent monographs on language. In addition, information about his life and work was compiled from libraries, historic city archives, and Universities across Poland, Germany, and the UK. We found that Sachs has made the most important contribution to the field of reading.

In particular, he gave the first detailed account of the vertical occipital fasciculus, an intralobar tract connecting dorsal and ventral visual areas. Sachs provided stained coronal sections of this tract and credited his discovery to Karl Wernicke (Forkel et al., 2015). Despite this tract being one of the largest intraoccipital connections, its function still remains unknown. More recent studies in patients with lesions to this white matter tract or its cortical projections suggest that it may have a role in reading (Yeatman et al., 2013). Other tracts described by Sachs are still waiting to be ascribed a specific functional correlate. In his 1905 monograph "Brain and Language" Sachs considered reading as a multisensory function facilitated by the association fibres between relevant cortical areas, such as the visual centre and the language network. He further postulates that different proficiency levels of reading (bearing in mind this was written when reading and writing was only available to some people) will be expressed through different anatomical routes. He further believed, that given this large associative anatomical network similar behavioural presentations might be caused by lesions affecting different underlying white matter structures as for example an angular lesion will affect at least three different pathways (callosal fibres, temporo-occipital fibres and visual pathway) and might disconnect occipital visual and central motor regions. Heinrich Sachs was a pioneer of neuroanatomy and the clinico-anatomical correlation method and his ideas on reading were exceptionally modern. His work strongly deserves attention and credit in contemporary neuroscience.

Animal Communication

F61 Hyperscaling of frontal white matter in the human brain may be linked to the emergence of language

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Introduction: The frontal cortex is involved in many linguistic functions including semantic and syntactic processes, higher-level linguistic reasoning and other related functions such as working memory, social information processing and motor planning[1]. Humans and other primates have a large frontal cortex compared to other mammals[2] but more striking is the disproportionately large frontal white matter volume in humans compared to closely related primates[3-6]. This suggests that the expansion of frontal networks played a key role in human evolution. In this study we use a novel approach to investigate white matter networks beyond the boundaries of the frontal lobes and study the relative volume of frontal connections in humans and monkey specimens. Methods: Diffusion MRI data from 10 healthy male subjects were acquired in vivo at 3T with 2.4 mm isotropic resolution, 60 directions and b-value of 3000 s/mm2. Diffusion data from 5 rhesus monkeys, 4 vervets and 6 marmosets were acquired ex vivo at 4.7T and 7T with resolution between 0.35 and 0.5mm, at least 60 directions and b-values of 7500, 8000 and 3000 s/mm2, respectively. Spherical deconvolution[7] and tractography parameters were optimised for each monkey specimen to maximize angular resolution and minimise noise. Whole brain tractography reconstructions were dissected manually to reveal the volume of connections passing through the frontal lobe, and the volume of the frontal association, commissural and projection networks. Frontal over total white matter volume ratios were compared for each network, across species. Results: The proportion of frontal over total white matter volume was largest in humans at 66%, while 49% in vervets, 52% in rhesus monkeys and 32% in marmosets. The proportion of frontal connections in the association, commissural and projection networks were similarly large in humans at 37%, 30% and 15% respectively, while 26%, 18% and 6% in vervets; 23%, 18% and 5% in rhesus monkeys and 15%, 10% and 3% in marmosets. Conclusion: We have used tractography to reveal a progressive expansion of frontal lobe networks from old world to new world monkeys to humans. This hyperscaling of frontal white matter connections in humans is driven by a global change affecting the association, commissural and projection pathways. These results support the hypothesis that the emergence of human language depended on an increased complexity of cortico-cortical and cortico-subcortical networks[1,8]. References: [1] P.T. Schoenemann, Language Learning 59 (2009) 162–186. [2] J.M. Fuster, in:, Comparative Neuroscience and Neurobiology, Birkhäuser Boston, Boston, MA, 1988, pp. 107–109. [3] K. Semendeferi, A. Lu, N. Schenker, H. Damásio, Nature Neuroscience 5 (2002) 272–276. [4] K. Zhang, T.J. Sejnowski, Proc Natl Acad Sci USA 97 (2000) 5621–5626. [5] P.T. Schoenemann, M.J. Sheehan, L.D. Glotzer, Nature Neuroscience 8 (2005) 242–252. [6] J.B. Smaers et al., PLoS ONE 5 (2010) e9123. [7] F. Dell'Acqua et al., Hum Brain Mapp 34 (2013) 2464–2483. [8] N. Geschwind, in:, Selected Papers on Language and the Brain, Springer Netherlands, Dordrecht, 1974, pp. 86–104.

Meaning: Prosody, Social and Emotional Processes

F62 Understanding Communicative Intentions via Prosody – Neural Bases and Networks

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Action-theoretic views of language posit that the recognition of others' intentions is key to successful interpersonal communication. Yet, speakers do not always code their intentions literally. In a recent study, we found that prosody—the tone of voice—is a successful channel for the transmission of different intentions. It remained unclear, however, via which cognitive mechanisms participants decode prosodic information to get to the speaker's intent. Of course, the acoustic features play an important role, but the acoustic profile of the speech sounds alone was not sufficient to fully explain listeners' intention recognition. Additionally, listeners may rely on the emotional connotation of the intentional prosody, and literature, further, suggests theory of mind (ToM) processes for the comprehension of a speaker's intention. Thus, we assumed a complex interplay of acoustic, emotional, and social mechanisms for the comprehension of intentional prosody and tested its neural bases in the current fMRI study. Single words (e.g., "beer"), intoned by 2 female speakers to express criticism, doubt, and suggestion, were acoustically morphed to create three 7-step prosodic continua, one for each intention pair. During fMRI scanning, participants categorized the intention of each stimulus in a 2-AFC manner, separately for each of the three continua. FMRI data analysis

contrasted the comprehension of clear prosodic intentions (morph steps 1, 2, 6, 7 similar to the original stimuli) to comprehension of acoustically matched control stimuli (morph steps 3, 4, 5) without a clear intention expression and included reaction times as a control for task difficulty. Clear intentional prosodies compared to ambiguous speech signals elicited stronger activations in several functional networks associated with acoustic template matching (superior temporal gyrus [STG] and Heschl's gyrus [HG] expanding to planum temporale), ToM (medial prefrontal cortex, angular gyrus, precuneus, middle temporal gyrus), as well as emotional prosody (amygdala, hippocampus, putamen). This shows that prosodic changes alone can activate large-scale brain networks beyond the typical perisylvian areas. The opposite contrast showed higher activations for ambiguous stimuli compared to clear intention expressions in the anterior cingulate cortex (ACC), anterior insula (AI), and inferior frontal gyrus (IFG). These regions belong to the salience network and have been associated with higher cognitive effort for decision making. Thus, it can be assumed that participants dissociate from social inference processing of clear stimuli towards more stimulus- and task-related mechanisms in case of ambiguous signals. Further investigations of functional connectivity with psychophysiological interactions showed correlations of the amygdala with the salience network (ACC, AI, IFG) and auditory regions (HG and STG) during the comprehension of clear stimuli compared to ambiguous prosodies. Such connections might reflect the detection of emotionally relevant sounds and emotional tagging of auditory processes. To conclude, we demonstrated that interacting auditory, social, and emotional networks are involved in the decoding of speakers' intentions from meaningful prosodic sounds, whereas ambiguous prosodies activated more stimulus-related, decision making processes. These multiple mechanisms and their flexible weighting depending on listening situation may provide the robust basis for successful communication beyond the literal meaning.

F63 Neural Correlates of Linguistic Prosody Discrimination in Children

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Neuroimaging and lesion-based studies of the processing of linguistic prosody suggest that it is supported by both right and left hemisphere mechanisms (Kreitewolf, Friederici, & von Kriegstein, 2014; Witteman, van Ijzendoorn, van de Velde, van Heuven, & Schiller, 2011). However, little is known about the neural correlates of prosody perception in children. 30 typically-developing, right-handed, native-English-speaking children (16F), age 5-13 years participated. BOLD fMRI data was collected on a Philips 3T Acheiva MRI scanner using a sparse acquisition approach (Schmithorst & Holland, 2004). Participants were presented with 6-second video clips, each of which included a single sentence spoken by the same native speaker. Alternating sets of instructions were presented every 5 sentences in a block design. In the prosody condition, participants were asked to determine if the sentences were statements or questions. In the contrasting semantic condition, participants were asked to determine whether the content of the sentence included a person; in both conditions, a two-option forced choice button press response was given. There were no interrogative words in the sentences, so the statement/question decision was made based solely on prosody. Fifteen sentences were presented in both statement and question versions. The same stimuli were used for semantic task; this resulted in 30 sentences per condition presented in counterbalanced order. Stimuli were presented during MRI scanner silence, followed by 6 seconds of fMRI data collection (TR=2000ms). After standard pre-processing steps, a generalized linear model approach was used to identify regions of significant group activation (initial $z>2.3$, cluster-based correction to $p<0.05$) for the prosody task relative to the semantic judgment task. For the prosody task, accuracy in task performance averaged 74% correct (SD 20.5, four participants performed below 50% accuracy). For the semantic task, accuracy in task performance averaged 84% correct (SD 17.9, only one participant performed below 50% accuracy). Performance on the prosody task was positively correlated with participant age ($r=0.42$, $p<0.01$), but this was not the case for the semantic task ($p>.10$). Regions of significant group activation (prosody>semantic) included right and left inferior frontal gyri, right and left temporal poles, right inferior and superior temporal regions, and right supramarginal gyrus. No effects of age or task performance on BOLD response were observed that survived correction for multiple comparisons. These results suggest that prosody discrimination skill continues to develop during children's school-age years. When compared to semantic processing, children's processing of prosody is supported by a bilateral, but right-lateralized network of frontal and temporal brain regions.

F64 Comprehension of Sentential Prosody in Brain Lesioned Cases: A Test of Two Hypotheses

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Introduction Lesion studies have reported results that were sometimes supportive of the overwhelming role of the right hemisphere and at other times emphasizing the role of left hemisphere (Paulmann, 2016). Subsequently, attempts were made to resolve such contradictory findings by the formulation of Cue or Feature Dependency Hypothesis (Van Lancker & Sidtis, 1992; Sidtis & Van Lancker Sidtis, 2003). According to this hypothesis the right hemisphere is adept in processing pitch and the left hemisphere in processing duration and intensity features of prosody. In contradistinction to the feature dependency hypothesis (FDH) several clinical studies found prosodic disorders in cases with lesions in basal ganglia structures that lead to the formulation of basal ganglia mediation hypothesis (BMH) of linguistic prosody (Paulmann, Pell, & Kotz, 2009). The present study, a retrospective one, reports on deficits in processing linguistic prosody in two aphasic patients. The FDH will predict that lesions anywhere in the extensive neural network sub-serving prosody that are distributed in both hemispheres can produce deficits in processing syntactic/linguistic prosody. From the BMH point of view, a lesion in basal ganglia is critical for the occurrence of processing deficits. The data obtained from these two cases are discussed in the context of FDH and BMH, as well as, more recent neuroimaging studies of processing of syntactic prosody. Method Subjects. Subject 1. SE, a 69-year-old right-handed female with symptoms of nonfluent aphasia and apraxia

of speech related to subcortical lesions in the caudate and putamen of the right hemisphere. Subject 2. LK, a 45-year-old male with a lesion in temporal region extending up to a portion of the frontal lobe and the basal ganglia of the LH, with the symptoms of nonfluent aphasia. Materials Clinical tests: Boston diagnostic aphasia examination, and Discourse comprehension test Experimental test: A set of 10 sentences with surface structure ambiguity, that is, sentences with identical words but differ in their prosodic patterns (pauses, stress, length and pitch) that conveyed distinct meanings. For example, the sentence 'The man speaks to the woman in tears' can be presented with two distinct prosodic patterns. For each such sentence four pictures were drawn: two related to the targeted meanings, one semantically related and the other not related in any way to the target meanings. The stimulus sentences were acoustically analyzed for their pitch patterns, pauses, length and stress. Procedure Each subject was tested using a sentence-picture matching task. Only correct sentence-picture matching response for a given prosodic pattern was given credit and the maximum possible score was 20. ¬Results and Discussion Both LK and SE have performed at 20% accuracy level in processing the syntactic prosody. The FDH can account for the results based on the fact that the stimulus sentences were characterized my multiple acoustic prosodic cues and LK and SE might have encountered problems in processing specific but different cues. On the other hand, the comparable deficits in both LK's and SE's performance might be related to the basal ganglia lesions shared by both, supporting BMH.

Methods

F65 Parallel Processing in a Language Task: Estimates from Intracerebral Single Trial Data

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Introduction Cognitive theories describing information processing stages are often concerned with their temporal organization. A primary distinction has been made between serial and parallel architectures, that is between stages that operate sequentially and stages that operate concurrently. This distinction has been extensively explored with behavioral and, more recently, neurophysiological evidence, notably in models of language processing. Word production is thought to involve multiple types of representations and levels of processing, whose organization in serial vs. parallel architectures has been extensively debated (e.g., [1-2]), also based on intra-cranial brain activity [3-5]). Yet, despite the available evidence, the issue remains unsettled. Here, we provide a critical examination of the cognitive distinction between serial and parallel processing, and discuss the methodological conditions that need to be met to asses such alternative. The importance of reasoning at the level of single trials, rather than averages, is highlighted. We then report the results of an experiment where the parallel processing hypothesis was tested at an unprecedented level of granularity with intracerebral data recorded during a picture naming task. ** Methods** Intracerebral EEG data recorded from 15 patients with intractable epilepsy performing a naming task were processed. We extracted averaged patterns of high gamma activity that were consistent across at least two patients. To assess the temporal overlap between cognitive functions, we associated neurophysiological activity in different regions to cognitive processing stages engaged in the task and computed activity overlap at the level of single trials between pairs of regions. For each pair of regions, at each time sample, the overlap was defined as the ratio between the number of trials that were significantly active (signals thresholded with local FDR) in both regions and the number of trials that were significantly active in one or the other region. This ratio can be though of as a variant of discrete mutual information, intended to implement a metric that was as close as possible to the original parallel processing cognitive hypothesis ** Results** Signals recorded within different brain regions, presumably indexing distinct cognitive processes, revealed a large degree of concurrent activity when they were averaged. In the single trial analysis 107 pairs of regions were included, from among which 81 had enough trials to be further analyzed. Eight pairs of regions survived a strict permutation test of the temporal overlap. Thus in comparison to the analysis of averages, the temporal overlap detected among significant activities at the level of single trials was unexpectedly low, with the exception of visual and motor cortices. ** Conclusion** These findings show the limitations of using on average measures to test temporal processing hypothesis. They reveal remarkable limits on how much parallel processing is detected during a multi-stage task such as picture naming. [1] Munding et al. (2015) Lang Cogn Neurosci. [2] Rapp and Goldrick (2000) Pschol. Rev. [3] Llorens et al. (2011) Front. Psychology [4] Edwards et al. (2010) Neuroimage. [5] Sahin et al. (2009) Science

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Notes

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