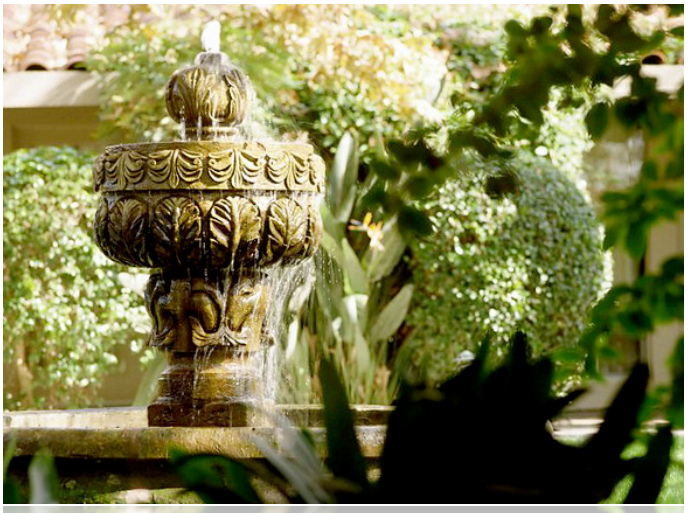
THE SECOND ANNUAL NEUROBIOLOGY OF LANGUAGE CONFERENCE

San Diego 2010



SCIENTIFIC PROGRAM

Rancho Bernardo Inn Golf Resort & Spa

17550 Bernardo Oaks Drive

San Diego, CA 92128

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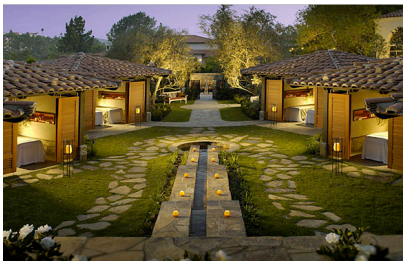
Foreword

The Neurobiology of Language Conference provides a unique forum for students and researchers to present work on the neural mechanisms underlying language performance in humans. This topic has a long and interesting scientific history, but recent technological advances have changed the very nature of investigation in this field.

Last year over 350 people from 22 different countries attended the first Neurobiology of Language Conference, which was held on October 15-16 2009 in Chicago, as a satellite of the Annual Meeting of the Society for Neuroscience, and over 220 posters were presented. As announced, the best papers at the Conference will appear in a special issue of the international journal *Brain and Language*, to be published later in 2010.


Building off of last year's success, the Neurobiology of Language Organizing Committee has been working on planning the second annual meeting which will be held at the Rancho Bernardo Inn Golf Resort & Spa, in San Diego, California, on November 11-12, 2010, as a satellite of the Annual Meeting of the Society for Neuroscience. It is with great pleasure that we introduce the preliminary program for this year's meeting! We look forward to meeting you in San Diego in November!

Pascale Tremblay and Steven L. Small

The Neurobiology of Language Conference Organizing Committee

Detailed schedule

Wednesday November 10		
Time	**Event**	**Room**
2:00 - 8:00 p.m.	Registration	Main building
6:00 - 8:00 p.m.	Welcome reception	Veranda Grill

Thursday November 11		
Time	**Event**	**Room**
7:00 - 8:45 a.m.	Breakfast Registration	Aragon Lawn Aragon Lawn
8:45 - 9:00 a.m.	Opening Remarks	Aragon Ballroom
9:00 - 10:00 a.m. 10:00 - 10:15 a.m.	Keynote Lecture: Karl Deisseroth Coffee Break	Aragon Ballroom Aragon Pre-function Space
10:00 a.m. - 12:30 p.m.	Poster session A: Comprehension and Semantics, Manual gestures and Sign Language, Syntax, Cognitive and Executive functions, Reading and Writing	Aragon Ballroom
12:30 - 1:45 p.m.	Lunch Break	Aragon Lawn
1:45 - 3:45 p.m.	Panel Discussion A: The neural architecture of semantic memory. Featuring Alex Martin and Karalyn Patterson	Aragon Ballroom
3:45 - 4:00 p.m.	Coffee break	Aragon Pre-function Space
4:00 - 6:00 p.m.	Slide session A	Aragon Ballroom
6:00 - 8:00 p.m.	Reception	Aragon Lawn

Friday November 12		
Time	**Event**	**Room**
7:00 - 8:45 a.m.	Breakfast Registration	Aragon Lawn Aragon Lawn
8:45 - 9:00 a.m.	Opening Remarks	Aragon Ballroom
9:00 - 10:00 a.m.	Keynote Lecture: Daniel Margoliash	Aragon Ballroom
10:00 - 11:00 p.m.	Special session: the future of NLC	Aragon Ballroom
11:00 - 11:15 p.m.	Coffee Break	Aragon Pre-function Space
11:15 a.m. - 1:15 p.m.	Panel Discussion B: The visual word form area: selective for words? Featuring Cathy Price and Stanislas Dehaene.	Aragon Ballroom
1:15 - 2:30 p.m.	Lunch Break	Aragon Lawn
2:30 - 4:30 p.m.	Slide session B	Aragon Ballroom
4:30 - 7 p.m.	Coffee break and poster session B: Speech perception, Multilingualism, Speech production, Prosody, Social and emotional processing, Acquisition, Anatomy, Brain plasticity and Brain diseases.	Aragon Ballroom

Keynote Lectures

Optogenetics: Development and application

Thursday, November 11th, 9:00 - 10:00 a.m. Aragon Ballroom.

Speaker: Karl Deisseroth, M.D., Ph.D. Departments of Bioengineering and Psychiatry, Stanford University, Howard Hughes Medical Institute

Session Chair: Michael Arbib (University of Southern California, USA)

We have been developing and applying optogenetics, a technology based on single component opsin-based regulators of transmembrane ion conductance and signaling; in this approach, opsin genes are delivered by genetically or topologically-targeted vectors, and light is delivered to the freely moving mammal by portable solid-state optical devices. In previous work (refs 1-9) we have developed a panel of optogenetic genes and related optical devices, with which cells can be turned on or off with millisecond precision and in different patterns within freely moving mammals, and we have applied this technology to probe the dynamics of cells and circuits relevant to schizophrenia, narcolepsy, Parkinson's disease, depression, and addiction. More recently (refs 10-12), we have shown that application of molecular engineering and trafficking principles can further expand the optogenetic repertoire along several long-sought dimensions. For example, we have shown that membrane trafficking strategies now permit 1) optical regulation at the far red/infrared border; 2) increased potency of optical inhibition without increased light power requirement (chloride-mediated photocurrents beyond the nanoampere level that maintain the light sensitivity and behaviorally-significant reversible, step-like stable kinetics of earlier tools); and 3) generalizable strategies for targeting cells based not on genetic identity, but on morphology and tissue topology, to allow versatile targeting when promoters are not available. Together these results illustrate use of molecular and cellular principles to enable versatile, fast optogenetic technologies suitable for the study of circuit dynamics, mammalian behavior, and neuropsychiatric disease.

References

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12. Lee et al., (2010), Nature in press.

Evaluating the strengths and limitations of birdsong as a model for speech and language

Friday, November 12th, 9:00 - 10:00 a.m. Aragon Ballroom.

Speaker: Daniel Margoliash, Ph.D. Departments of Organismal Biology and Anatomy & Psychology, University of Chicago.
Session Chair: Gregory Hickok (University of California, Irvine, USA)

From a biological perspective, human speech and language are notable as they are acquired over an extended developmental trajectory, with prominence in shaping behavior of individuals and social interactions, with achieved performance (perceptual and productive) indicating extreme specialization, and with a shrouded evolutionary history in the primate lineage. The last point in particular has prompted interest in birdsong learning as a model system, which shares similar attributes with speech and language but from a well-established comparative ethological perspective. The neurobiology of birdsong learning continues to be extensively investigated, and is complemented by continuing insights in behavior such as recent results investigating the development of vocal culture.

Several factors constrain both the human and birdsong systems, and work to make the latter a good model for the former. Unlike many other vocal communication systems, in both songbirds and humans, vocalizations are learned and are dominated by forebrain control. Song and speech unfold at sufficiently fast rates as to present difficult problems in feedback control, which is exacerbated by the challenges of articulating and recognizing complex arbitrary signals, especially in face of the longer delays communicating to forebrain. Behavioral evidence such as similar effects of delayed auditory feedback in speech and song production suggest that the two systems may share common control solutions. The underlying circuitry, hence mechanisms, may also be more common than is generally recognized. In recent years a long held fundamental misconception regarding the organization of the avian forebrain has been utterly displaced, overthrown by extensive histological, hodological, and molecular evidence emphasizing specific homologies between avian pallium and mammalian cortex. This modern perspective helps to emphasize the significance to speech and language mechanisms of a series of observations in the birdsong system. I will briefly review the extensive work on the role of basal ganglia in providing structured variation into the birdsong system, and how this facilitates developmental song learning and adult song maintenance. I will also review recent observations regarding the form of timing control in the forebrain, the potential role of analogous mirror neurons in the song system, and the role of sleep in vocal learning. Most of these observations have nascent corollaries in speech and language research, which should prompt additional efforts in human studies.

For all these points of convergence between the systems, there are also important limitations that need to be stressed. Song is sexually dimorphic, under seasonal control, and evolved strongly influenced by sexual selection. Speech and language probably evolved under natural selection. This does not appear to represent a serious threat to the value of the birdsong model in evaluating the neurobiology of speech and language, but it should not be ignored. Far more insidious is any tendency to underestimate the implication of the commonalities between humans and other animals. For example, in evaluating molecular deficits in human patients by examining experimentally-induced corresponding deficits in animals, it is essential to determine if

any observed similarity of effects in humans and animals arise from mechanisms directly controlling vocal learning or arise from corresponding non-specific manipulations of homologous regions of the forebrain.
Pushing birdsong learning further in the direction of language is increasingly difficult. Recent work in syntactic pattern processing has challenged the categorical distinctions between humans and animals made by Chomskian linguists, but this remains controversial. Perhaps the most fundamental issue facing psychologists is assessing qualitative and quantitative differences in human language behavior in face of the massive computational advantage humans enjoy. Animal studies alone cannot address such problems. These limitations imply that a research project that embraces a collaborative effort with human and animal work informing each other is both attractive and essential.

Discussion panels

Panel A: The neural architecture of semantic memory

Thursday, November 11th, 1:45 - 3:45 p.m. Aragon Ballroom.

Panelists: Featuring Alex Martin and Karalyn Patterson
Moderators: Marta Kutas (University of California, San Diego, USA) and David Poeppel (New York University, USA)

The panelists

Alex Martin is a NIH Senior Investigator and Chief of Section on Cognitive Neuropsychology NIMH, Bethesda MD.

Karalyn Patterson is a senior scientist at the Department of Clinical Neurosciences, University of Cambridge UK and Medical Research Council Cognition & Brain Sciences Unit, Cambridge UK

The abstracts

Martin

'Semantic memory' covers a vast terrain of cognition, ranging from information about historical and scientific facts, details of public events and mathematical equations to the information that allows us to identify objects and understand words. Functional neuroimaging and neuropsychological investigations have established a number of findings about this division of memory, especially with regard to the neural substrate underpinning perceiving and knowing about concrete objects.

Patterson

Essentially all current views about semantic memory share the idea that much of the content of our semantic memory relates to perception and action and is represented in brain regions that overlap with, or possibly even correspond to, the regions responsible for perceiving and acting. This view about semantic memory therefore entails commitment to the idea that semantic memory is a widely distributed neural network, with its individual components taking 'responsibility' for different

Martin *(continued)*

First, object information is not stored in a single place but rather is distributed throughout the brain. Second, the location of this information in the brain is not random. Information about specific properties of objects – such as what they look like, how they move, how they are manipulated, and our emotional response to them – is stored in our perceptual, action, and affective processing systems. Third, these property-based regions are organized into distinct circuits; some of which underpin knowing about broadly defined object categories such as animate entities (living things that move on their own) and manmade manipulable objects designed to perform specific functions ('tools'). Integration of object property-based information is a characteristic of the circuits themselves, accomplish via the dynamic interaction among the nodes. As a result of this co-dependence, damage to one node could potentially cause widespread disruption and even a catastrophic collapse of the circuit, resulting in a domain-specific category disorder. Generalization across concepts, as well individualization of specific concepts is a function of these circuits, perhaps in unison with frontal cortices. These circuits serve as a foundation or scaffolding upon which we can build our rich store of conceptual knowledge, much of which is dependent on, and stored in, the language system. The idea of a single hub in the anterior temporal lobe(s) for integration of information to support generalization and other conceptual functions is unnecessary. A single hub architecture for conceptual processing remains largely unsupported by a variety of measures, including a spate of recent studies on the large-scale functional connectivity of the human brain. More likely roles for the anterior temporal lobes in conceptual processing include representation of individuals or a more general role in social processing, and/or experience-dependent sharpening of representations stored elsewhere.

Patterson *(continued)*

modality-specific aspects of conceptual knowledge (visual, auditory, tactile, etc) and also perhaps for different categories of knowledge (e.g. living things vs. manmade objects). Theoretical positions differ, however, on the following question: are these distributed brain regions, plus connections between them, the entire neural basis of semantic memory? Many researchers offer a positive answer to this question (the 'distributed-only' view). My position (the distributed-plus-hub view) is that the sensory-, motor- and language-specific aspects of conceptual knowledge are necessary but not sufficient, and that the functions of semantic memory also require a central component or hub that supports the interactive activation of representations in all modalities, for all semantic categories. There are two principal reasons for this view, one empirical and one theoretical:

Empirical: From the distributed-only perspective, no form of focal brain damage would be expected to yield a semantic impairment that is independent of the modality of input (objects, pictures, words, sounds, tastes, etc.), of the modality of output (naming an object, drawing it, using it correctly, etc.) and of the category to which the concept belongs. Yet precisely such an impairment is observed in semantic dementia (SD), characterized primarily by atrophy of the bilateral anterior-inferior temporal lobes. Although critics of this position argue that the damage in SD extends beyond this circumscribed region, there is accruing evidence not only that this is the major site of abnormality but also that it is the only region to correlate significantly with the patients' semantic deficit. Furthermore, the proposal that the semantic deficit in SD might arise from damage to multiple brain regions offers no explanation for the identical nature of the deficit across all modalities/categories, with strong modulation by the factors of frequency and typicality.

Theoretical: A central function of semantic memory is to generalize across concepts that have similar semantic significance, but do not necessarily have similar specific attributes. If semantic memory consisted only of the modality-specific content of objects (and the links between them), it is not clear that we could ever achieve the higher-order generalizations on which so much of our semantic processing relies.

Panel B: The visual word form area: selective for words?

Friday, November 11th, 11:15 a.m. - 1:15 p.m. Aragon Ballroom.

Panelists: Cathy Price and Stanislas Dehaene
Moderators: Manuel Carreiras (Basque Center on Cognition, Brain and Language, Spain) and Sharon Thompson-Schill (University of Pennsylvania, USA)

The panelists

Cathy Price is a professor at the Wellcome Trust Department of Neuroimaging, University College London (UCL).

Stanislas Dehaene is a Professor at the Collège de France, chair of Experimental Cognitive Psychology, and Director of the INSERM-CEA Cognitive Neuroimaging Unit, Paris, France.

The abstracts

Price

Although we all agree that visual word form processing activates the left ventral occipito-temporal cortex (vOT), there is disagreement over the following:
1. Evidence for whether this region is selective for words. Stan and Lauren Cohen have argued for word selective responses relative to picture processing. Joe Devlin and I argue that it depends on the task and the processing computations, not the stimulus. Consequently, activation is higher for pictures in some tasks and higher for words in other tasks.During naming tasks, it is invariably higher for pictures than words. Likewise, damage to the left ventral occipito-temporal cortex impairs object naming more than reading

Dehaene

My argument is that we already have much evidence that the visual word form area hosts computations specialized for reading. Cathy and I agree the VWFA is a major site of change associated with literacy. Lesion to that site, its afferents or its efferents can create a specific reading deficit. We both also agree that reading activates only a small subset of the areas involved in object recognition. I argue that this finding suggests functional specialization at this cortical location.
The VWFA responds identically to objects and words only when the comparison is uncontrolled for visual features. With better controls, we now find a significantly greater response to words.

Price *(Continued)*

2. Terminology. Given that there is no evidence that the area is specialized for word stimuli, is it useful to refer to it as the visual word form area? There are pros and cons. The term VWFA is easy to remember. It also makes it easy to remember the wrong function of the area. We believe that an area should be named by anatomy not its function, particularly since nobody yet knows what the exact computations of the area are.

3. Structure-function mapping at the cognitive level. Is it ever possible to assign cognitive functions to a single region? We don't think so because the function of an area depends on the regions that it is interacting with. Cognitive functions therefore arise at the level of distributed rather than modular processing.

Dehaene *(Continued)*

The VWFA responds to words and pictures with distinct patterns of invariance (e.g. case invariance) and selectivity (e.g. greater response to frequent bigrams) that forcefully indicate specialization for reading in a specific script.

In particular, the VWFA hosts a mirror-invariant representation of objects, but distinguishes mirror images of words and even single letters of matched complexity (e.g. b and d), again indicating functional specialization of two different circuits within the same voxel.

The overall pattern of results is compatible with the "neuronal recycling" hypothesis, according to which we acquire novel cultural abilities through the pre-emption and minimal reconfiguration of evolutionarily older circuits. The VWFA is not a region "evolved for reading". Rather, it inherits from primate evolution a propensity for the detection of line junctions, which are non-accidental features useful for both scene and object recognition – and these features are then used in the shapes of our letters.

Neuronal recycling explains the partial similarities between word and picture recognition, while at the same time leaving room for increasing cortical specialization with increasingly expert reading, thus dissolving much of the debate between Cathy and I.

Slide sessions

Slide Session A

Thursday, November 11th 4:00 – 6:00 p.m. Aragon Ballroom.

Session chairs: Peter Hagoort (Max Planck Institute for Psycholinguistics, The Netherlands) and Kate Watkins (University of Oxford, UK)

1. 4:00 – 4:15 p.m.

Low-frequency phase modulations as a tool for attentional selection at a cocktail party: insights from intracranial EEG and MEG in humans

Zion Golumbic, E. (1,2), Bickel, S. (3), Cogen, G.B. (4), Mehta, A.D. (3), Schevon, C.A. (4), Emerson, R.G. (4), Poeppel, D. (4), and Schroeder, C.E. (1,2). 1. Columbia University, Departments of Psychiatry and Neurology, New York, NY, USA. 2. Nathan Kline Institute, The Cognitive Neuroscience and Schizophrenia Research Program, Orangeburg, NY, USA. 3. Long Island Jewish Medical Center, Department of Neurology, Long Island, NY, USA. 4. New York University, Department of Neuroscience, New York, NY, USA.

Our ability to attend to a particular conversation amidst competing input stream, epitomized by the "cocktail party" effect, is remarkable. Yet, the neural mechanisms involved in segregating, selecting and attending to one stream of conversation over other competing streams are not well understood. Studies show that speech comprehension and stream segregation rely heavily on the temporal structure of the input (Drullman et al. 1994), suggesting that temporal regularities within the speech structure serve as important cues for continuous attention to a particular stream. Previous findings have demonstrated that the temporal pattern theta-band phase, which corresponded to the syllabic rate of speech, discriminates between difference speech segments (Luo and Poeppel 2007) and is modulated by attention in a "cocktail party" situation (Kerlin et al. 2009). These findings suggest that theta phase serves to represent the timing of "events" within an attended stream, however, the relationship between theta phase and the temporal structure of an attended speech segment has not been directly addressed. To this end, here we simulated a "cocktail party" using 8 second segments of natural speech while recording intracranial EEG in epileptic patients undergoing electrode implantation for clinical purposes, as well as non-invasive MEG in normal adults. Two concurrent conversations were played (male and female speakers) and participants were instructed on each trial to attend to one speaker and ignore the other and perform a semantic congruency task. Overall, our results were qualitatively consistent across the two methods of recording used here (MEG and intracranial EEG). In the cocktail-party conditions, despite the identical physical stimulus, the temporal pattern of theta-band phase was modulated by attention. Importantly, theta activity was more highly correlated with the temporal envelope of the attended speech segment than with the envelope of the ignored segment. These effects were significant over auditory cortex, as well as in an array of additional regions, including frontal, prefrontal, motor cortex and parietal regions. These results support the hypothesis that theta-band activity is utilized for speech processing by adjusting its phase to match the timing of syllabic input and may be instrumental for parsing the stream for further processing. The wide-spread effect suggests that rather than merely reflecting a sensory response, this attention-based phase adjustment involves high cognitive regions involved in directing attention to task-relevant time intervals and processing the stimuli that occur during those intervals.

2. 4:15 – 4:30 p.m.

Native and non-native speech-evoked responses in high-risk infant siblings

Percaccio, C.R. (1), Padden, D. (2), Edwards E. (3), and Kuhl, P.K. 1. Institute for Learning and Brain Sciences, University of Washington. 2. Department of Computer Science & Engineering, University of Washington. 3. Department of Speech & Hearing Sciences, University of Washington.

Studies of infants who have an older sibling with autism indicate that 30-50% exhibit abnormal sensory behaviors, language and/or social delays as early as 12-mo of age (i.e., Zwaigenbaum et al., 2005). Although children with autism are a densely heterogeneous population, communication and/or language delays are part of the fundamental triad of impairments contributing to a diagnosis of autism. While young typically developing infants can discriminate phonemes used in all languages, between 10- and 12-mo of age, native-language phonetic perception ability increases, while the detection of unfamiliar patterns in non-native languages decreases (i.e., Kuhl et al., 2006). Our lab has also demonstrated a predictive relationship between discrimination of a native syllable contrast at 7-mo of age and the number of words produced at 18- and 24-mo of age (Kuhl et al., 2008). The goal of this research is to investigate if an abnormal pattern of speech perception is a risk marker that can be used to facilitate an earlier diagnosis of language delay or an

autism spectrum disorder. EEG data was recorded from high-risk sibs and from low-risk infants at 7-mo of age. After data collection, high-risk sibs were randomly assigned to either the UW-provided intervention group or the community-intervention group. All infants were re-assessed at 12- and 18-mo of age. At each age, English and Mandarin syllable contrasts were presented in an oddball paradigm to test discrimination. Preliminary results indicate that before 8-mo of age, high-risk sibs have different evoked responses to English speech syllables compared to low-risk infants. Analysis was also expanded to the spectral domain to provide insight into how induced responses facilitate speech perception in infants. Compared to low-risk infants, preliminary results indicate that decreased event-related synchronization in the theta band may contribute to reduced syllable discrimination in high-risk sibs. Compared to typically developing infants, high-risk sibs continue to process native-language stimuli differently at one year of age; however, both groups of infants continue to process non-native syllable contrasts similarly. By 18-mo of age, high-risk sibs have the same pattern of physiological responses observed in low-risk infants at 7-mo of age. Taken together, these results may indicate that some infants who will develop autism have an auditory processing disorder that hinders the acquisition of critical language skills.

3. 4:30 – 4:45 p.m.

The mirror neuron system associated with speech perception modulates the activity of the human motor cortex face area. A combined fMRI and TMS study

Murakami, T., Restle, J., and Ziemann, U. Goethe University, Department of Neurology, Frankfurt am Main, Germany.

The human mirror neuron system (MNS) related to speech perception is distributed over several brain regions and is thought to modulate neuronal excitability in the motor cortex (M1). However, this interaction between the MNS and M1 has not been clearly investigated in the human brain. Here, we combined transcranial magnetic stimulation (TMS) and functional magnetic resonance imaging (fMRI) to identify the MNS regions related to visual and auditory speech perception and their modulating effect on M1 excitability during speech perception. Methods: Eighteen healthy right handed subjects participated. TMS was applied to the left M1, and we recorded motor evoked potential (MEP) and short-interval intracortical inhibition (SICI) from the subjectsí right orbicularis oris (OO) and first dorsal interosseous (FDI) muscles during viewing speech, fixating a small point, listening to speech, listening to non-verbal sounds, and viewing and listening to noise control conditions. We also performed fMRI recordings during the same task conditions and analysed the blood-oxygen-level dependent (BOLD) increase relative to rest. To identify the common MNS regions related to both visual and auditory speech perception, conjunction analysis was performed. The BOLD signal intensities of the activated regions in each condition were compared by region of interest (ROI) analyses. Linear regression analyses between MEP or SICI changes and activities of the common MNS regions were examined. Finally, as a virtual lesion study, continuous theta burst stimulation (cTBS: 600 pulses, 80% active motor threshold of FDI) was applied to the MNS region, in which a significant correlation was obtained from above regression analyses, and in a control session over the left M1, using a fMRI-navigated TMS system. The MEP amplitudes during speech perception and control conditions were compared before and after cTBS. Results: MEPs of OO muscle increased during visual and auditory speech perception. SICI of OO muscle was facilitated only during visual speech perception. No significant task-dependent modulations were observed in the FDI muscle. Conjunction analysis revealed MNS regions activated during both visual and auditory speech perception in left inferior frontal gyrus, left premotor area, left inferior parietal lobule, and bilateral superior temporal sulcus (STS) (Figure). The activations of all these regions were seen only during speech perception by ROI analyses (Figure). The task-related BOLD increase in bilateral STS during auditory speech perception correlated directly with the task-related increase of MEP amplitude. There was no significant correlation between task-related BOLD and SICI changes. CTBS over the left STS resulted in disappearance of the task-related increase of MEP amplitude during auditory speech perception but not the control condition, whereas MEP amplitudes during both conditions decreased strongly after cTBS over the left M1. Conclusions: The MNS is activated during speech perception and modulates M1 excitability of the face representation specifically. Findings from the regression analyses and the virtual lesion study suggest that STS, which plays a role in phonological recognition, is a crucial region to modulate M1 excitability to translate the perceived auditory speech to the motor system."

4. 4:45 – 5:00 p.m.

Of mice, birds and men: the mouse ultrasonic song system has features in common with vocal learners

Jarvis, E.D., Arriaga, G., and Zhou, E. Department of Neurobiology, Howard Hughes Medical Institute, Duke University Medical Center, Durham, NC 27710.

Vocal learning is a rare and critical trait for song imitation in several groups of birds and speech learning in humans. Their critical features include vocal control by forebrain motor areas, a direct cortical projection to brainstem vocal motor neurons, and dependence on auditory feedback to acquire and maintain learned vocalizations, features not found in closely related avian and non-human primate species. Male mice produce courtship ultrasonic vocalizations (USVs) with acoustic features similar to songs of vocal learning birds. It is assumed that these USVs are innate, although

this has never been tested. Here we discovered the mouse song system, and found that it includes a motor cortex region active during singing that projects layer V neurons directly to brainstem vocal motor neurons and is critical for normal song production. We further discovered that male mice depend on auditory feedback to develop and maintain normal ultrasonic songs, and that different sub-strains have differences in songs, which when cross-housed can causes changes to the pitch of each otherís songs. We conclude that male mice have neuroanatomical and behavioral features thought to be exclusive to song learning birds and humans, suggesting that mice may be at least limited vocal learners.

5. 5:00 – 5:15 p.m.

Language processing in the left occipital cortices of congenitally blind adults

Bedny, M. (1,2), Dodell-Feder, D. (1), Fedorenko, E. (1), Pascual-Leone, A. (2), and Saxe, R. (1). 1. Massachusetts Institute of Technology. 2. Berenson-Allen Center for Noninvasive Brain Stimulation, Beth Israel Deaconess Medical Center, Harvard Medical School.

The neural architecture of language is grossly consistent across languages, cultures and individuals. Language processing is supported by left prefrontal, lateral temporal, and temporoparietal cortices. Studies with congenitally blind adults suggest that developmental experience may nevertheless profoundly alter the neural architecture of language: Congenitally blind adults activate left occipital cortices, including primary visual cortex, during verbal tasks (Amedi et al., 2003; Burton, 2003; Burton et al., 2003; Burton et al., 2002). TMS studies further suggest that this activation is functionally relevant to task performance (Amedi et al., 2004). However, it remains unclear whether occipital regions contribute to language processing per se, or instead to difficult tasks in general, or to mnemonic or executive components of verbal tasks. In two experiments we asked whether left occipital regions are involved in language processing. In Experiment 1 congenitally blind, late blind and sighted participants listened to stories and answered true/false questions about them. In a control task, participants made a match/non-match judgment with backwards speech stimuli. In congenitally blind, but not sighted or late blind adults the left occipital cortex responded more to stories than backwards speech. This effect was observed despite the greater difficulty of the backwards speech condition as measured by reaction time and accuracy. In Experiment 2 we asked whether the left occipital cortex is involved in compositional structure building, lexical processing or phonological perception. We compared the occipital response to sentences, word lists, Jabberwocky sentences, nonword lists, and backwards speech. Left occipital cortices responded both to lexical information (sentences + word lists > Jabberwocky + nonword lists) and compositional information (sentences + jabberwocky> words + nonwords). Some but not all occipital regions also showed an effect of phonological information (nonwords>backwards speech). The response profile of the left occipital cortices was similar to the response of left prefrontal and lateral temporal regions. To gain insight into how linguistic information reaches occipital areas, we performed a resting state functional connectivity analysis using occipital regions as seeds. In congenitally blind adults, occipital areas had increased functional connectivity with left prefrontal and left thalamic regions that were active during language processing. These data suggest that the left occipital areas of congenitally blind individuals are involved in language processing and that language information may access occipital cortices through feedback from left prefrontal regions. In summary, our data suggest that brain regions that did not evolve for language can participate in language processing, including combinatorial processes necessary for constructing more complex representations from smaller units. References: Amedi, A., Floel, A., Knecht, S., Zohary, E., and Cohen, L.G. (2004). Transcranial magnetic stimulation of the occipital pole interferes with verbal processing in blind subjects. Nat. Neurosci. 7, 1266-1270. Amedi, A., Raz, N., Pianka, P., Malach, R., and Zohary, E. (2003). Early 'visual' cortex activation correlates with superior verbal memory performance in the blind. Nat. Neurosci. 6, 758-766. Burton, H. (2003). Visual cortex activity in early and late blind people. J. Neurosci. 23, 4005-4011. Burton, H., Diamond, J.B., and McDermott, K.B. (2003). Dissociating cortical regions activated by semantic and phonological tasks: a FMRI study in blind and sighted people. J. Neurophysiol. 90, 1965-1982. Burton, H., Snyder, A.Z., Diamond, J.B., and Raichle, M.E. (2002). Adaptive changes in early and late blind: a FMRI study of verb generation to heard nouns. J. Neurophysiol. 88, 3359-3371.

6. 5:15 – 5:30 p.m.

Phase-locked magnetic brain activity during perception of ultra-fast and moderately fast speech in blind and in sighted listeners

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Using computers for text reception, blind individuals may learn to understand ultra-fast synthetic speech at a rate of up to about 25 syllables (syl/sec), an accomplishment by far exceeding the performance level of normal-sighted listeners (8-10 syl/sec). Preceding functional magnetic resonance imaging (fMRI) studies of our group revealed the ability to perceive speech at high rates (ca. 16 syl/sec) to be associated with hemodynamic activation of the central-visual system, particularly, right primary visual cortex (V1) and contralateral fusiform gyrus (FG) - in addition to the perisylvian ""language network"" of the dominant hemisphere (Hertrich et al., Neurocase 2009,15:163-170; Dietrich et al., submitted). The present study sought to further elucidate the neural processes underlying ultra-fast speech perception by means of magnetoencephalography (MEG). More specifically, we expected under these conditions enhanced phase-locking of

evoked magnetic fields to distinct components of the acoustic speech signal as an index of improved temporal resolution of auditory phonetic information. Since previous MEG and fMRI studies of audiovisual perception documented cross-modal interactions even at the level of primary sensory areas (Hertrich et al., J Cogn Neurosci 2009, 21:259-274; Hertrich et al., J Cogn Neurosci 2010 in press), we hypothesized, furthermore, that signal components phase-locked to the acoustic speech signal may extent to V1. MEG signals were recorded while the participants (14 blind, 12 sighted subjects) listened to 4-sec portions of ultra-fast (16 syl/sec) or moderately fast verbal utterances (8 syl/sec). The MEG channels were convolved with three derivates of the acoustic signal: (1) the speech envelope, predominantly synchronized to syllabic nuclei, (2) the positive part of the slope of the speech envelope, bound to syllable onsets, and (3) pitch (fundamental frequency, F0). For the analysis of pitch-related phase locking, the speech wave was rectified and band-pass filtered (50-180 Hz) in order to obtain a sinusoidal signal representing F0. Four bilateral dipole sources were defined, including auditory cortex (A1), posterior primary visual cortex (V1), fusiform gyrus (FG), and inferior frontal gyrus (IFG). At the level of A1, envelope- and syllable onset-related convolutes revealed MEG components comparable to the auditory M50 and M100 evoked responses while pitch-related phase-locking showed a transient resonance to F0, centered at a delay of ca. 40 ms. The V1, FG, and IFG source locations showed significant phase-locked components as well. Phase-locking within A1 was tighter in blind than in sighted subjects. Furthermore, V1 and FG showed 3-way interactions between subject group, speech rate, and hemisphere in the syllable onset derivate, indicating differential rate-dependent lateralization effects: Phase-locking to syllable onsets within the visual system was found to be lateralized toward the right hemisphere during ultra-fast speech perception in blind subjects as compared to their sighted controls. Pitch-related phase locking displayed the reverse lateralization effects within IFG. These results suggest that the ability of blind subjects to understand ultra-fast speech is facilitated by enhanced early signal-related encoding mechanisms both within an outside the central-auditory system.

7. 5:30 – 5:45 p.m.

Dopaminergic modulation of striatal circuits during speech production

Simonyan, K. (1), Herscovitch, P. (2), and Horwitz, B. (3). 1. Departments of Neurology and Otolaryngology, Mount Sinani School of Medicine, New York, NY, USA. 2. PET Department, Clinical Center, NIH, Bethesda, MD, USA. 3. Brain Imaging and Modeling Section, NIDCD/NIH, Bethesda, MD, USA.

The basal ganglia play a key role in voice and speech control, but little is known about their neurotransmission function in speech production. Using positron emission tomography (PET) and functional MRI (fMRI), we investigated endogenous dopamine release during speech production and its effects on the functional brain networks in healthy humans. PET data from 20 healthy subjects (mean 53.2 y.o., 12 F/8 M) were obtained following the bolus injection/constant infusion of [11C]raclopride (RAC) (50 min rest, 50 min speech production). RAC binding potential (BP) was determined as a ratio of concentrations in the regions with (putamen and caudate) and without (cerebellum) specific binding. Speech-induced effects on dopamine release were estimated as percent change from resting baseline (a decrease in RAC BP indicates an increase in dopamine release). RAC binding significance was assessed with paired t-test ($p \leq 0.05$, corrected). BOLD fMRI data were acquired with a sparse sampling design. Speech-related responses were analyzed using multiple linear regression; group activation maps were generated using a mixed-effect design ANOVA ($p \leq 0.05$, corrected). Putaminal functional connectivity was assessed using psychophysiological interactions (PPI) analysis. The relationship between the PPI values and ΔBPND was examined using voxel-wise Spearman's rank correlation coefficient. Speech production induced a significant reduction in RAC binding in both putamen and caudate nucleus with left lateralization in the dorsal putamen (DPU) ($p = 0.006$). PPI analysis conducted with the seeds placed in the bilateral DPU showed left-hemispheric lateralization of striatal networks. Positive connections of the left DPU were found with inferior frontal gyrus, Heschl's gyrus and cerebellum; negative connections were observed with the laryngeal motor cortex, supplementary motor area, caudate nucleus, cerebellum and midbrain. The right DPU network exhibited only negative connections with these regions. The PPI values of the left putaminal network were positively correlated with ΔBPND in the right caudate and left putamen, whereas the right putaminal network was negatively correlated with the ΔBPND in the bilateral putamen. We demonstrated that during speech production, endogenous release of dopamine in the dorsal putamen shows left lateralization, which is consistent with left hemispheric lateralization of the putaminal functional networks. These findings indicate behavior-specific integration of the dopamine system and modulation of functional networks for control of speech production in humans.

8. 5:45 – 6:00 p.m.

A comparison between visual half field experiments and fMRI as language laterality indicators

Van der Haegen, L., Cai, Q., and Brysbaert, M. Ghent University, Department of Experimental Psychology, Belgium.

The functional contribution of each hemisphere of the human brain depends on the task to be performed. The best established lateralized function is speech production, with the majority of the population having left hemisphere lan-

guage dominance (over 95% of right-handers and about 75% of the left-handers). An important question in laterality research is how to assess speech dominance. The two most valid techniques are the WADA –test (Wada & Rasmussen, 1960) and functional Magnetic Resonance Imaging (fMRI). Unfortunately, both are expensive and the first test is too invasive to be used without good medical reason. Hunter and Brysbaert (2008) examined the use of behavioral visual half field (VHF) tasks and reported high correlations between word and picture naming reaction times and the language laterality index as indicated by the number of activated voxels in the left and right Broca's area (pars opercularis/BA 44 and pars triangularis/BA 45) during a silent word generation task in fMRI. Unfortunately, this study was only based on 10 participants. In the current study, we aimed to replicate Hunter and Brysbaert (2008) in a larger sample to test the reproducibility of the VHF technique. Using the same method, we selected 36 participants on the basis of a behavioral word and picture VHF-task: 18 of them showed a left visual field/right hemisphere advantage of more than 10 milliseconds and 18 showed a similar right visual field/left hemisphere advantage. Moreover, we controlled for saccades and central fixation position during stimulus presentation by means of an eye-tracking device. The hemispheric dominance (left or right) was confirmed in the silent word generation task in fMRI (Word VHF: $r = .83$, $p < .001$; Picture VHF: $r = .79$, $p < .001$). The results did not differ using either a combination of BA 44 and BA 45 or analyzing the three subregions of Broca's area separately (Word VHF: BA44: $r = .81$, $p < .001$, BA45: $r = .82$, $p < .001$, pars orbitalis/BA47: $r = .77$, $p < .001$; Picture VHF: BA44: $r = .75$, $p < .001$, BA45: $r = .80$, $p < .001$, BA47: $r = .72$, $p < .001$). In sum, behavioral VHF-tasks can be used to assess language laterality as defined by the dominance of Broca's area. This opens the opportunity to screen large groups of participants for right language dominance, making it possible to compare laterality patterns for various functions in reasonably large groups of participants with typical and atypical dominance. At the same time, our results indicate that the behavioral tasks only provide useful information about language dominance and not about the lateralization degree. The LI of people with small VHF-differences needs to be predicted by fMRI. Hunter, Z.R., & Brysbaert, M. (2008). Visual half-field experiments are a good measure of cerebral language dominance if used properly: Evidence from fMRI. Neuropsychologia, 46, 316-325. Wada, J., & Rasmussen, T. (1960). Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Journal of Neurosurgery, 17, 266–282.

Slide Session B

Friday, November 12th 2:30 – 4:30 p.m. Aragon Ballroom.

Session chairs: Yosef Grodzinsky (McGill University, Canada) and Kuniyoshi Sakai (Tokyo University, Japan)

1. 2:30 – 2:45 p.m.

White matter correlates of syntactic deficits in primary progressive aphasia

Wilson, S.M., Galantucci, S., Tartaglia, M., and Gorno-Tempini, M.L. University of California, San Francisco, Department of Neurology, Memory and Aging Center, San Francisco, CA, USA.

Syntactic processing depends on a network of left-lateralized cortical regions connected by white matter fiber bundles. The aim of this study was to determine which white matter tracts are important for syntactic processing, by identifying relationships between white matter damage and measures of syntactic production and comprehension in primary progressive aphasia (PPA). We used diffusion tensor imaging (DTI) to examine white matter tracts in 25 patients with PPA (non-fluent variant: $N = 10$; semantic variant: $N = 10$; logopenic variant: $N = 5$). Probabilistic tractography was applied in each hemisphere of each participant to track the inferior longitudinal fasciculus, the uncinate fasciculus, and the superior longitudinal fasciculus (SLF) (including the arcuate fasciculus). Starting seeds were defined for each tract on color-coded directionality maps overlapped on fractional anisotropy maps in white matter regions unambiguously belonging to the tract in question. We calculated mean fractional anisotropy (FA) for each tract, and correlated this with measures of syntactic production (elicitation of specific syntactic structures via brief narrative contexts) and syntactic comprehension (two-alternative forced-choice auditory sentence comprehension). Of the three left-hemisphere tracts examined, only in the SLF was reduced FA associated with deficits in syntactic production and comprehension (both $p < 0.0001$). In contrast, FA was not correlated with either syntactic measure in the inferior longitudinal fasciculus or the uncinate fasciculus (all $p > 0.54$). When the left and right SLF were both included as explanatory variables, only the left SLF predicted syntactic production and comprehension performance (both $p < 0.0001$). The predictive value of the SLF was not due to consistent differences between PPA variants, because when PPA variant was included as a covariate, the SLF continued to be associated with both syntactic production ($p = 0.0005$) and comprehension ($p = 0.008$). Voxel-based

morphometry showed that both syntactic production and comprehension deficits were associated with volume loss in left posterior inferior frontal cortex, but when tissue volume in this region was included in the model, the left SLF continued to make a significant contribution to predicting both production and comprehension performance (both $p < 0.0001$). Our results suggest that the left SLF, which links anterior and posterior language areas, is crucial for syntactic processing, whereas damage to ventral tracts does not significantly impact syntactic processing. In sum, syntactic deficits in PPA likely reflect not only cortical atrophy, but also microstructural damage to white matter.

2. 2:45 – 3:00 p.m.

Decomposing animacy effects between Agent- and Psych-verbs: An ERP study

Bourguignon, N. (1,2), Drury, J.E. (2), Valois, D. (1), and Steinhauer, K. (2). 1. Université de Montréal, Department of linguistics, Montreal, QC, Canada. 2. McGill University, School of Communication Sciexnces and Disorders, Montreal, QC, Canada.

Objectives: The present ERP-study investigates whether deviant verb-argument dependencies involving animacy give rise to distinct processing effects between A[gent]-V[erbs] (e.g., 'eat') and "P[sych]-V[erbs]" (e.g. 'fear/frighten' [6], see PDF for references). Previously, "semantic P600" effects have been observed for subject-verb animacy clashes (e.g., '...the eggs would eat...' [3;4]), and the nature of such effects remains controversial. However, though there are theoretical reasons for thinking animacy might be implicated differently in processing AVs versus PVs (see [1;2]), the only study contrasting animacy violations for both verb-types [8] focussed exclusively on Verb-Object dependencies and reported non-distinct N400/P600 patterns. Here, we tested Subject-Verb clashes for both verb-types, hypothesizing that animacy may entail various semantic dimensions selected differently depending on the verbs involved and the nature of their arguments (Agents vs. Experiencer) [2]. Further, to ensure the reliability of our results, we included control correct/violation comparisons to replicate ERP effects for word-category (LAN-P600, see [7]) and conceptual-semantic incongruities (N400 [5]). Methods and predictions: ERP data from 12 native speakers of English were recorded in a reading/judgement study conducted in English. Besides PV Verb-Object mismatches (e.g. 'The girl has frightened *the storm'), we also compared Subject-Verb animacy clashes for both PVs (e.g. 'The drinks have *liked the tourists') and AVs (e.g. 'The fries have *eaten the boys'). Following [8], we expected an N400/P600 pattern for the Verb-Object cases. The Subject-Verb mismatches were expected to replicate semantic P600s for the AVs [3,4] and -- if the verb types are processed in a uniform way -- for the PVs as well. Results and discussion: All conditions introduced to replicate previous findings yielded the expected patterns, including: (i) a LAN/P600 for syntactic word-category violations, (ii) an N400 for conceptual-semantic anomalies, (iii) an N400/P600 pattern for Verb-Object animacy clashes involving PVs (replicating [8]), and finally: (iv) a "semantic P600" effect (with no N400) for the AV Subject-Verb clashes (see Figure). Strikingly, Subject-Verb clashes involving PVs yielded an N400 effect with no discernable subsequent P600 modulation. These qualitatively different patterns for AVs and PVs provide compelling evidence that animacy is indeed processed differently depending on verb type. While the "semantic P600" may be typical of violations bearing on Agentivity, as initially suggested [3;4], the N400 we observed for PVs may reflect the special nature of Experiencer-arguments in psych-verbs, the behaviour of which is known to pose intriguing questions with respect to the syntax-semantic interfaces [1,6]. These results point to the importance of distinguishing verb-types in investigations of the way verbs and their arguments are linked in the temporal dynamics of language comprehension, and they also provide a promising basis for future inquiry aimed at advancing our understanding of the nature of language-related ERP components.

3. 3:00 – 3:15 p.m.

Dissociating age of acquisition from fluency: Linear mixed-effects modeling of proficiency and N400 amplitude in native speakers and bilinguals

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While it is generally accepted that later learning of a second language (L2) leads to lower ultimate proficiency, the degree of variability in proficiency also increases. This creates confounds in neuroimaging studies comparing native (L1) and L2 learners as differences in brain activation may arise due to age of acquisition (changes associated with maturation and/or experience) or simply due to increased effort in less proficient language users (regardless of age of acquisition). Indeed, high proficiency L2 learners have been found to show more similar processing to native speakers than low proficiency individuals. However, because age of acquisition and proficiency tend to be highly collinear, separating these factors is challenging. Further, studies have often divided proficiency into arbitrarily-defined categories of "high" and "low", nor are the effects of proficiency on L1 processing well understood. In order to address these issues, we applied linear mixed-effects modeling to data from two event-related potential (ERPs) experiments in which we included proficiency (measured from all participants) as a continuous variable. In the first experiment, we recorded ERPs to lexical-semantic violations in L1 and late L2 learners of English (the latter being native Spanish speakers, age of acquisition at least 18 years). English proficiency was measured with a standardized test (TOAL-3) in all subjects. For

N400 amplitude, a 4-way interaction between proficiency, group (native/late learner), violation, and electrode position was obtained. Post-hoc testing revealed that this interaction reflected a differential influence of proficiency on N400 amplitude between groups, at specific scalp regions. Further analyses aimed to distinguish the collinear effects of learner status and proficiency by residualizing one of these variables against the other. Across multiple approaches to analysis, proficiency was found to predict N400 amplitude, and once proficiency was accounted for L1/L2 status did not add significant predictive power to the model. The second experiment employed a morphological priming paradigm using regularly- and irregularly-inflected French verbs. Participants were L1 and L2 speakers of French. Proficiency was measured using a French conjugation test. Linear mixed effects modeling showed that N400 amplitude increased with proficiency for all words. Morphological priming effects (reduction in N400 amplitude for regular/1st declension infinitive forms preceded by inflected forms), however, were found to be largest for low proficiency individuals, becoming smaller as proficiency increased. Together these studies illustrate the power of including proficiency measures as covariates in neuroimaging data analysis, and suggest ways in which the collinearity of proficiency and age of acquisition may be disentangled.

4. 3:15 – 3:30 p.m.

Towards a knowledgebase for the architecture of speech and language brain systems

Bohland, J.W. (1), Saperstein, S. (2), Kim, E. (3), and Zeid, O. (2). 1. Boston University, Department of Health Sciences, Boston, MA, USA. 2. Boston University, Department of Cognitive & Neural Systems, Boston, MA, USA. 3. University of Maryland, Baltimore County, Baltimore, MD, USA.

Localizing different aspects of speech and linguistic behavior to particular brain regions and/or circuits has been an important line of research for at least the past century. Well-known, but now outdated, conceptual models of these circuits emerged from early lesion studies. More recently, a rapidly expanding library of functional imaging results has led, on the one hand, to a sharper view of these brain systems, but on the other hand, to a nearly unmanageable set of data points that lie scattered throughout the extant literature. In addition, a more recent direction in speech / language research has begun to explore the molecular / genetic level, particularly in attempts to associate specific developmental disorders with genetic abnormalities. Here we present preliminary efforts to integrate diverse knowledge about the underlying architecture of the neural systems supporting speech and language through the mechanism of common spatial localization. In particular, we present a spatial database system (i.e., geographical information system) that allows users to query available knowledge about speech / language systems for any given brain location. Specifically, we have implemented a relational database system and simple user interface, which will be made available over the web. We have curated a list of candidate genes for

disorders that impact linguistic behaviors, and, where possible, mapped these genes to specific brain regions based on spatiotemporal expression profiles. In addition, we have curated information about focal gray or white matter abnormalities observed in individuals with speech/language disorders. We have begun to compile a database of previous relevant brain imaging results mapped into this common space, with corresponding metadata and links to the primary sources of information. Additionally, we will provide mechanisms for users to easily enter and annotate additional results. Finally, we will incorporate existing knowledge about anatomical brain connectivity and observed inter-regional functional correlations, allowing users to visualize information about interacting neural systems rather than looking at individual regions in isolation. This project will be an ongoing effort which we hope will provide a powerful and currently unavailable public resource to the speech / language neuroscience community.

5. 3:30 – 3:45 p.m.

Using independent component analysis to detect changes in cortical regions during implicit language learning

Fidler, L.J. (1), Dailey, N.S. (1), Almyrde, K.R. (1), Fridriksson, J. (2), and Plante, E. (1). 1. Department of Speech, Language, and Hearing Science, The University of Arizona, Tucson, AZ. 2. Department of Speech and Hearing Sciences, The University of South Carolina, Columbia, SC.

Introduction: Studies show that humans are able to implicitly learn novel grammatical language rules after a short exposure to previously unheard language strings. This learning has been shown to involve progressive recruitment of distinct functional brain regions. Cortical areas that are implicated during language learning tasks are frontal regions including the lateral precentral gyrus/sulcus, the inferior frontal gyrus and the anterior insula. Parietal regions include the angular gyrus and temporal parietal junction. We used functional magnetic resonance imaging (fMRI) and Independent component analysis (ICA) to investigate cortical changes during this language learning task. We were interested to see if ICA would contribute a clearer picture of how functional cognitive areas relate to task over time. The purpose of this study was to see if cortical changes would be evident after a relatively short learning period. Methods: Healthy participants listened to sentences while undergoing fMRI scans. A block design was used with three conditions; listen, response, and control. Sentences were presented using a recording of a male native Icelandic speaker. Each run consisted of a listening block (task condition) consisting of six grammatically correct sentences, a response block consisting of six sentences

that were either grammatically correct or incorrect, and a control block consisting of six sentences presented in reverse. There were four runs altogether, thus 36 sentences from each block were heard. Participants were asked to make a judgment on the grammaticality of the sentences during the response block using a button press task. Participants received no feedback during the task. fMRI data were analyzed using group ICA to identify components of interest. A general linear model approach was used to identify task related components. Bonferroni-corrected z-score component maps were produced for each of the surviving components. These maps were then visually compared to identify changes in activation patterns after repeated exposure. Results: fMRI analysis showed that activation of functional brain regions differed between initial and final exposure to sentences. There was bilateral activation of the anterior cingulate gyrus for both initial and final sentence exposure. During the initial exposure, there was bilateral activation of both the anterior insula, auditory cortex, and the postcentral gyrus (BA 2), as well as activation of the right cerebellum. During the final exposure, participants showed additional bilateral activation of the inferior frontal gyrus (BA 45), middle frontal gyrus (BA 10), middle temporal gyrus (BA 21) and precentral gyrus (BA 6). Cerebellar activation was lateralized to the left hemisphere during final sentence exposure. In addition, bilateral cuneus and right precuneus activation was observed. In the final exposure, participants also showed bilateral activation in the basal ganglia, left angular gyrus (BA 39), and the right temporal parietal junction. Behavioral data showed above chance performance for all runs. In addition, participants showed improvement in their ability to detect grammatically correct sentences after four exposures to the stimuli. Conclusions: We have shown that after a short period of exposure to novel language strings individuals progressively recruit different functional brain regions to deal with task demands. Both run one and four showed activation in areas implicated in attention and acoustic processing, such as the cingulate gyrus and the insula. Run four showed additional cognitive areas within multiple components that suggest greater neural processing and a change in resource allocation over time. Areas associated with language processing and learning were implicated. Right lateralized temporal parietal junction, BA45, and inferior frontal gyrus. Left lateralized cerebellum and bilateral basal ganglia. This study showed that after a short exposure to previously unheard language strings particpants utilized different cognitive resources. In addition, we have shown that the signature wave forms of ICA can potentialy explain differential activation as they relate to separate cognitive processes.

6. 3:45 – 4:00 p.m.

Brain regions associated with rapid word-by-word sentence processing: An MEG study

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Introduction: Sentence comprehension involves a host of highly interrelated processes, including syntactic parsing, semantic composition, and pragmatic inferencing. In neuroimaging, a primary paradigm for examining the brain basis of sentence-level processing has been to compare brain activity elicited by word lists vs. sentences (e.g. Friederici et al. 2000; Mazoyer et al., 1993, a.o.). These studies find a focal effect of increased activity for sentence processing in the anterior temporal lobe (aTL), a region that has been hypothesized to be involved in basic combinatoric operations (Hickok & Poeppel, 2007). These focal results are, however, highly unexpected given the variety of computations engaged during sentence comprehension. We examined whether a broader network of regions could be identified for the sentence vs. word list contrast using magnetoencephalography (MEG), a technique with millisecond-level temporal resolution that is better matched to the rapidity of sentence processing than slow hemodynamic techniques. In addition to the left anterior temporal lobe, we tested whether increased activation was observed in a number of other regions that have been hypothesized as language related, including the left inferior frontal gyrus, aka Brocaís area's posterior temporal regions, typically thought to be involved in lexical level processing, and the ventromedial prefrontal cortex, implicated in a series of studies as participating in semantic composition (e.g., Pylkkänen & McElree, 2007). Methods: Nine participants were presented with a story using rapid serial visual presentation during an MEG recording (500ms per word, 300ms between words). In a block design, participants also saw the same words presented in pseudo-randomized lists. Subjects answered comprehension (story) or recall (lists) questions during the experimental blocks to assess attention. We employed a cortically constrained distributed source model to estimate brain activity in 8 anatomically defined ROIs previously implicated in language processing using individual subject MRIs (4 subjects) or an average cortical surface (5 subjects). Focusing on 4-5 character open-class words, activity within 100-600ms post stimulus onset was compared time-point by time-point in each ROI using multi-level regression (adjusting for multiple comparisons using simulation.) Results: Sentences vs. Lists Significantly increased activation for the story condition was found in the aTL (peaking at approximately 370ms), as well as the pars triangularis (350ms), pars orbitalis (350ms), and ventromedial prefrontal cortex (400ms). A subsequent wholebrain analysis over 76 regions spanning the cortex further corroborated these findings. Conclusion: Contrary to the focal aTL effects of hemodynamic studies, MEG revealed a broader network of regions as related to sentence processing, consistent with the rather robust computational contrast between sentences and word lists. This set of regions included the aTL, consistent with hypotheses linking this region to basic composition (Hickok & Poeppel, 2007; Brennan et al., 2010), as well as inferior frontal and ventromedial regions, hypothesized to reflect the processing of more complex syntactic structures and semantic composition, respectively.

Finally, our results show that the aTL effect as well as the other effects are time-locked to each word, supporting the incrementality of sentence processing, a conclusion that cannot be reached from the hemodynamic sentence vs. word list literature. References: Brennan et al. (2010). Brain & Language, doi:10.1016/j.bandl.2010.04.00. Friederici et al. (2000). Brain and Language, 75(3), 465--477. Hickok & Poeppel, (2007). Nature Reviews Neuroscience, 8(5), 393--402. Mazoyer et al. (1993). Journal of Cognitive Neuroscience, 5(4).

7. 4:00 – 4:15 p.m.

The effect of mood on discourse comprehension: Evidence from the N400

Egidi, G. (1) and Nusbaum, H.C. (2). 1. University of Trento, CIMeC - Center for Mind/Brain Sciences, Trento, Italy. 2. University of Chicago, Department of Psychology, Chicago, IL, USA.

People shift moods throughout the day. Behavioral research shows that moods can affect specific cognitive processes (e.g., judgment and memory) and can determine whether different processing strategies are employed. However, little is known about the influence of mood on language comprehension, and the underlying neural mechanisms by which mood affects linguistic processes are poorly understood. In this research, we used EEG to investigate how mood biases the integration of information consistent with one's mood in discourse comprehension, and whether mood more generally influences neural activity during integration of linguistic information. Three groups of participants were induced to experience mild sadness, mild happiness, or a neutral mood. Following this, they performed a discourse comprehension task in which two variables were manipulated: the valence of a critical sentence and whether the valence of this sentence could be understood either in absence of any reference to prior context (local integration) or only via integration with prior context (global integration). Specifically, participants listened to stories ending with either positive or negative information. This information was either given by the sentence itself (e.g., Trev passed the exam vs. Trev failed the exam) or via integration of the sentence with earlier portions of the story (e.g., The doors were open vs. The doors were locked following a context indicating that a person needs to enter a bank). We examined ERP patterns of EEGs collected while participants listened to these endings. We analyzed N400 peak amplitude and latency, 300-500 ms after the onset of the critical word in the sentence (e.g., the beginning of the word passed in Trev passed the exam). The analysis of peak amplitudes showed that ending valence induced a stronger N400 deflection when it mismatched participant's mood (mood congruence effect). For neutral mood, negative endings produced a stronger N400 deflection than positive endings (negativity bias). These findings constitute the first evidence of the occurrence of mood congruence and negativity bias during discourse comprehension as early as 400 ms after stimulus onset. To the extent that N400 reflects the integration processes involved in sentence understanding, these results suggest that mood forms a meaningful context for sentence comprehension. Although mood is not part of the linguistic contextual information of the story, it influences the comprehension of the critical sentence in similar ways. The analysis of peak latencies revealed that global integration delayed the N400 peak compared to local integration—a result consistent with increased information integration demands. Importantly, this effect was modulated by participants' mood, indicating that mood also biases cognitive processing strategies. Taken together, these results document for the first time the impact of mood on brain activity subserving discourse integration. Neural activity reflects congruence between listeners' mood and valence of linguistic information and demonstrates negativity bias. These findings have important implications for neural and functional theories of language, since they suggest that mood constrains information integration. They also suggest a broader definition of meaning from a neural perspective; one in which interpretation of linguistic content is integrated early on with the comprehender's mood.

8. 4:15 – 4:30 p.m.

Lexical processing of emotion words: ERP indexes of an early interaction between emotional valence and arousal

Citron, F.M.M. (1), Weekes, B.S. (2), and Ferstl, E.C. (1). 1. University of Sussex. 2. The University of Hong Kong.

Emotion recognition has been characterised according to a two-dimensional structure: valence describes the extent to which an emotion is positive or negative and arousal refers to the intensity of an emotion i.e. how exciting or calming it is. It is known that the emotional content of verbal material influences cognitive processing on a range of experimental tasks testing recollection memory, language comprehension and face processing. More recent work has also shown that emotionally valenced single words (positive or negative) tend to be processed faster than neutral words, as revealed by lexical decision latencies and event-related potentials (ERPs). These results suggest that emotional content affects word recognition (Scott et al., 2009). However, other studies report slower recognition of negative words compared to positive words suggesting an additional effect of automatic vigilance (Algom et al., 2004). These contradictory results are likely due to lack of control over important lexical and semantic features of single words (Larsen et al., 2006). Furthermore, few studies have considered the effects of emotional arousal on word recognition and the relationship between emotional valence and arousal (Kanske & Kotz, 2007; Kissler et al., 2009). This is a critical question given recent brain imaging data showing that valence modulates the increase in activation due to increasing arousal at the neural level (Lewes et al., 2007). The aim of the present study was to disentangle the effects of valence and arousal on word recog-

nition and to determine at what stage of processing emotional effects take place; in an ERP experiment both variables were manipulated and a direct measure of lexical access was used, namely lexical decision. Reaction time results showed a significant effect of arousal and a significant interaction between arousal and valence: high arousal words were responded to faster than low arousal words, and this difference was more pronounced for negative words. There was no effect of valence once correlated lexical variables were controlled. ERP data were examined for early posterior negativity (EPN), a component showed to index discrimination between valenced and neutral stimuli. An interaction was observed on this component between 200-300 ms, with higher amplitudes for both negative-low arousal and positive-high arousal words. Although no previous study has tested for interactions between valence and arousal, the present results suggest a higher processing load for emotionally conflicting stimuli which elicit contrasting reactions (Robinson et al., 2004). Specifically, positively valenced and low arousal words both elicit an approach schema (mental set) whereas negatively valenced and high arousal words both elicit an avoidance mental set. More generally, the ERP results suggest that valence and arousal interact at a relatively early stage of lexical access. Our findings highlight the importance of emotional arousal and suggest that accounts of emotion effects on word recognition must integrate both valence and arousal in models of early lexical access. Implications for understanding effects of valence and arousal in affective disorders, neuropsychology and rehabilitation will be outlined. References: Algom, D., Chajut, E. & Lev, S. (2004). A rational look at the emotional Stroop phenomenon: A generic slowdown, not a Stroop effect. Journal of Experimental Psychology, 133, 323-338. Kanske, P. & Kotz, S.A. (2007). Concreteness in emotional words: ERP evidence from a hemifield study. Brain Research, 1148, 138-148. Kissler, J., Herbert, C., Winkler, I. & Junghofer, M. (2009). Emotion and attention in visual word processing ñ An ERP study. Biological Psychology, 80, 75-83. Larsen, R.J., Mercer, K.A. & Balota, D.A. (2006). Lexical characteristics of words used in emotional Stroop experiments, Emotion, 6, 62-72. Lewis, P.A., Critchley, H.D., Rotshtein, P., & Dolan, R.J. (2007). Neural correlates of processing valence and arousal in affective words. Cerebral Cortex, 17, 742-748. Robinson, M.D., Storbeck, J., Meier, B.P. & Kirkeby, B.S. (2004). Watch out! That could be dangerous: Valence-arousal interactions in evaluative processing. Personality and Social Psychology Bulletin, 30, 1472-1484. Scott, G.G., OíDonnell, P.J., Leuthold, H. & Sereno, S.C. (2009). Early emotion word processing: Evidence from event-related potentials. Biological Psychology, 80, 95-104.

Poster sessions

Poster Session A

Thursday, November 11th 10:15 a.m. – 12:30 p.m.

Comprehension and semantics

1. 10:15 a.m. -11:15 a.m.

Grammar and sequencing in natural language: The role of hierarchically-ordered cognitive control signals in prefrontal cortex

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Sequencing is a major component of language processing: since linguistic forms (speech, text or gestures) unfold over time, the order in which individual words are encountered necessarily influences how complex meanings can be constructed in real time. Importantly, the relative ordering of two words (A and B) is determined by a number of qualitatively different information types. Arguably, the two most important of these are: (i) the relative inherent ""prominence"" of A and B; and (ii) the relative importance of A vs. B for the message being conveyed / the broader discourse. Whereas the former draws upon inherent properties of A and B themselves, the latter is independent of inherent properties and rather involves relating A and B to external events (see 1). (1) a. Examples of prominence-based sequencing animate > inanimate; subject (NOM) > object (ACC). b. Aboutness-based sequencing topic > comment

In a recent fMRI study, Bornkessel-Schlesewsky et al. [1] observed that the dissociation between aboutness- and prominence-based sequencing correlates with activation differences along the anterior-posterior dimension of the left inferior frontal gyrus (lIFG). They related these findings to a current information theoretical model of how executive functions are implemented in prefrontal cortex [2], according to which there is a hierarchically ordered gradation of control signals along the anterior–posterior axis of lateral prefrontal cortex. From this perspective, aboutness-based sequencing correlates with activation in more anterior portions of inferior frontal cortex than prominence-based sequencing because it involves more abstract control signals (i.e. control signals dissociated more strongly from inherent, or local, properties of the current input). Here, we argue that the notion of hierarchically ordered control signals in frontal cortex can provide a unified account of sequencing processes in language (for a general link between cognitive control and sequencing, see [3]). We present a meta-analysis of eight fMRI studies on word order processing in simple, declarative sentences in German, which demonstrates differences in the activation maximum of the word order contrast along an anterior-posterior dimension according to the degree of abstraction of the sequencing cue (ranging from y=6 for the inherent semantic feature animacy [4] to y=24 for the pragmatically determined feature aboutness [5]).

Furthermore, we suggest that a hierarchy of control signals could potentially explain the proposed difference between recursive and non-recursive grammars: artificial grammar studies have demonstrated that violations of the former engender activation in the lIFG, whereas violations of the latter engender activation in the deep frontal operculum, which is cytoarchitecturally comparable to premotor cortex [6]. We argue that, rather than reflecting different types of grammars, these functional-neuronatomical distinctions reflect the processing of non-local vs. local (i.e. stimulus-driven) control signals. [1] Bornkessel-Schlesewsky et al. (provisionally accepted). Brain and Language. [2] Koechlin & Summerfield (2007). Trends in Cognitive Sciences. [3] Thothathiri et al. (2010). Brain and Language. [4] Grewe et al. (2006). Neuroimage. [5] Bahlmann et al. (2007). Human Brain Mapping [6] Friederici et al. (2006). PNAS.

2. 11:30 a.m. - 12:30 p.m.

To what extent does the coding of order rely on language systems?

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In everyday life, we experience environments that vary in intrinsic order-: some environments reflect the output of stable generators that induce repetitive patterns, while others are more random. There has been little work addressing the neural systems that subserve the coding of order, but two prior studies using meaningless visual or auditory (syllable) stimuli suggest that this role is assigned to regions falling within the scope of "Wernicke's area" (left posterior and central STG and SMG [1][2]). Indeed, some have suggested [1] that Wernicke's area may be performing "a generic predictability function" that expands beyond language processing.

To examine this issue we conducted a fast event-related (FER) study (4T scanner, TR=2.2sec, N = 15, # of volumes = 1100) that examined neural responses to series varying in order and input modality. Events were defined as 8sec series composed of 32 elements presented at a rate of 4Hz. The elements used in these series were either tones, shapes, or tone/shape combinations. There were four unique elements in each series, and their order of presentation was determined by statistical features of transition matrices differing in 1st order Markov entropy. Maximal entropy (i.e., complete randomness) was associated with a transition matrix where the transition probability between each of the four stimuli was 25%. We identified several regions that were uniquely sensitive to the order of auditory, visual, and audiovisual stimuli. In particular, the Planum Temporale (bilaterally) tracked the order in auditory series, but was not sensitive to the order of audiovisual series, suggesting that the additional demands involved in processing of visual input reduced sensitivity to order within the auditory component. Sensitivity to order of audiovisual series was found in the superior parietal cortex (bilaterally). We found no region that was uniquely sensitive to order within visual series: interestingly, activity in visual cortex was sensitive to order in auditory series as well. Our findings suggest that the coding of order is strongly modality dependent and does not generally or uniquely rely on systems typically associated with language processing. We discuss the relation between the coding of ordered environments and the coding of linguistic information, and link these findings to a more general theory addressing the coding of order and the role of such systems in generating predictive codes. References: 1. Bischoff-Grethe A, Proper SM, Mao H, Daniels KA, Berns GS. Conscious and unconscious processing of nonverbal predictability in Wernicke's area. Journal of Neuroscience. 2000;20(5):1975-81. 2. McNealy K, Mazziotta J, Dapretto M. Cracking the language code: Neural mechanisms underlying speech parsing. Journal of Neuroscience. 2006;26(29):7629.

3. 10:15 a.m. -11:15 a.m.

Hemispheric asymmetries in interpreting conceptual mappings: An event-related potential study

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Two experiments investigated the cognitive and neural processes underlying the comprehension of literal language that differed in predictability and in the conceptual mapping between the final, target word and its context. EEG was recorded as healthy adults read three classes of linguistic stimuli: Predictable Conventional (PC) Mapping stimuli enforced a default interpretation of the final word. ""The last thing he did when leaving his house was to lock the front DOOR."" ""The spider created a silk thread in order to spin a WEB."" Unpredictable Conventional (UC) Mapping stimuli were less predictable but also enforced a default interpretation of the final word. ""He tried to sneak into the warehouse but couldn't find the DOOR."" ""The scientist spent hours observing the intricate WEB."" Unpredictable Novel (UN) Mapping stimuli enforced an interpretation of the target word in which a nonstandard referent is substituted or mistaken for the usual referent. ""For a good action hero, a window can easily be a DOOR."" ""We used dental floss to make a WEB."" Compared to the cloze-matched UC stimuli, the UN stimuli had less typical conceptual relationships between the sentence context and the final, target word. Sentences were presented visually in the center of a computer monitor, at a rate of one word every 500ms. Event-related potentials (ERPs) were time locked to the onset of sentence-final words. Target words appeared centrally (Experiment 1) and in either the right visual field (rvf) or the left (lvf) (Experiment 2), to test for hemispheric asymmetries in complex semantic processing. Following central presentation, both unpredictable conditions elicited larger N400 than did the PC condition. Relative to the UC condition, UN words elicited a large right frontal P600 response, suggesting the demands of novel mapping integration are evident 600-900ms post-onset. We suggest that just as the N400 may reflect the costs of retrieving a word's semantic features, the P600 in this case may index a second stage of semantic feature retrieval, necessary to construct a novel interpretation of the target word. In Experiment 2, lvf presentation of the UN stimuli elicited larger N400 than low-cloze literals; both effects were more prominent over right-hemisphere electrodes. Following rvf presentation, UC stimuli elicited larger N400 than UN stimuli over left hemisphere sites. With hemifield presentation there were no P600 effects. These data suggest a left hemisphere advantage in processing novel mappings - as indexed by hemispheric asymmetry in the N400 - and an important right hemisphere contribution in the later stages of semantic processing indexed by the P600. The results suggest that partially non-overlapping neural generators mediate the construction of conventional versus novel meanings. We relate these findings to Halgren et al's (2002) observation of distinct N400 sources in the left and right hemispheres.

4. 11:30 a.m. - 12:30 p.m.

Activation patterns associated with semantic and phonological processing during performance of the Wisconsin word sorting task

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Patient studies have shown a double dissociation between semantic and phonological processes suggesting that these language abilities are supported by different brain networks (see Damasio, 1992, for review). Previous functional neuro-

imaging studies provided evidence confirming this hypothesis (for a review see Price, 2000). However, these studies reveal some limitations: the use of simple subtraction analysis and the necessity to compare the results to different subject groups, each performing a different type of language task. In this present study, we aim to address this issue by mapping the regions specifically involved in the phonological and semantic processes in a new language version of the Wisconsin Card Sorting Task (WCST), performed by the same subject during a single experimental session. The newly developed Wisconsin Word Sorting Task (WWST) is a language analog of the computerized WCST used by Monchi et al., (2001) which measures set-shifting abilities as well as the use of different language rules. In this task, the participant is required to match a target word to one of the four reference words according to three language rules: semantic, syllable onset and syllable rhyme. On each trial, he has to find the proper classification rule and apply it based on feedback following each selection. After a fixed number of correct matches, the rule is changed without warning and the participant must shift to a new mode of classification. Using functional magnetic resonance imaging (fMRI), fourteen healthy, native French-speaking participants were scanned. Conjunction analysis was performed using fmristat software to analyze the different types of rules within positive trials. The results reveal the existence of both common and specific networks of regions. Common activation was observed in the left frontal area (BA 47\12, BA 9, BA 6), the supplementary motor area (SMA), the inferior temporal gyrus (BA 37) and the bilateral occipital regions (BA 17, 18, 19). The semantic condition showed specific activations in the bilateral inferior frontal gyrus (BA 47/12), the left inferior frontal gyrus (BA 45) and the fusiform gyrus while the phonological one showed specific activation in the classical language areas (BA 40, 44 and SMA) and bilaterally in the cerebellum. The results showed that some regions within the brain language network are specifically involved in semantic and phonological processes. This finding provide critical support to the existence of separate semantic and non-semantic route devoted to language task posit by J.T. Devlin (2008) i.e.: 1. Components of the non-semantic route that functionally links the posterior fusiform gyrus (BA 37), the temporoparietal junction (BA 40), motor regions as well as posterior frontal region (BA 44). 2. Components of the semantic path that links the fusiform gyrus-ventral temporal lobe and the pars orbitalis (BA 47/45).

5. 10:15 a.m. - 11:15 a.m.

Inferior frontal gyrus is activated during sentence-level semantic unification in both explicit and implicit reading tasks

Zhu, Z. (1), Wang, S. (1), Hagoort, P. (2, 3), Feng, G. (1), Chen, H-C. (4), and Bastiaansen, M. (2, 3). 1. Department of Psychology, South China Normal University, China. 2. Radboud University Nijmegen, Donders Institute (RU/DI-BCB), Nijmegen, The Netherlands. 3. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands. 4. Department of Psychology, Chinese University of Hong Kong, Hong Kong.

Semantic unification, i.e. the process through which individual word meanings are combined into an overall sentence (or discourse) meaning, is important for language comprehension. Previous research has identified left inferior frontal gyrus (LIFG) as an important area for semantic unification. However, there is inconsistence on whether the activation in LIFG is induced by semantic unification per se (Hagoort, 2005) or by task-related strategic processing (Crinion et al., 2003; Van Pettern & Luka, 2006). Employing event-related fMRI and a parametric design, the purpose of this study was to try to disentangle these two interpretations of LIFG activation during sentence-level language comprehension. To manipulate the extent to which participants engaged in strategic processing, participants were asked to read sentences while performing one of three tasks: an explicit task (either a semantic acceptability judgment, or reading for comprehension) and an implicit task (word font judgment). To manipulate semantic unification difficulty, we constructed three types of sentences. High-cloze sentences (HI) were sentences in which a noun at a given position was highly expected. Low-cloze sentences (LO) were semantically correct, but with an unexpected noun at the critical-word position. Finally, in sentences containing semantic violations (SV), the noun at the critical word position did not fit into the sentence context. In total, 216 triplets were constructed, with one HI, LO and SV sentence respectively in each triplet. Each sentence consisted of 11 words, with the critical words in the 6th or 7th word position. During the experiment, the sentences were presented word by word. After sentence presentation, the participants were asked to perform a semantic acceptability judgment, to passively fixate a visual stimulus, or, to indicate whether the font of words was the same as that of the target ("测试", "test" in English translation) or not, in the three task sessions respectively. The BOLD signal time-locked to the critical words showed that significant parametric modulation by semantic unification difficulty (a PM effect) was found for the semantic acceptable judgment task in bilateral middle/inferior frontal cortex, medial frontal cortex/anterior cingulate cortex, and lentiform nucleus. The PM effect in the reading for comprehension task was found in bilateral middle/inferior frontal cortex, medial frontal gyrus, left posterior superior/middle temporal gyrus, and left superior parietal lobule. For the font judgement task (the implicit task), a PM effect was found only in LIFG. Taken together, only LIFG was consistently found to be activated across tasks, demonstrating that the LIFG is important for semantic unification. Furthermore, the observation that the PM effect was also found in LIFG in the implicit task suggests that the activation induced by semantic unification can not be only interpreted as task related strategic processing.

6. 11:30 a.m. - 12:30 p.m.

Cortical regions involved in semantic stages of word production

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Current models of word production delineate multiple stages of processing including lexical-semantic access and phonological encoding (among others). A number of studies have been successful in indentifying brain regions involved in phonological processes with good consensus. The neural correlates of lexical-semantic access is less clear. Here we use a behavioral paradigm that taps semantic level processes. It has recently been shown that reaction times increase in a picture naming task as a function of the number of prior trials involving items named from the same semantic category (Howard et al, 2006). This result has been interpreted as cumulative semantic inhibition, whereby repeated exposure to same category items elicits competition at the level of mapping from semantics to lexical phonology increasing the time it takes to correctly produce a word. It can thus be argued that brain regions in which activity correlates with this measure are involved in semantic-level processes in word production. In an fMRI study using this paradigm we found a network of regions which showed a correlation with repeated exposure to within semantic category stimuli including left anterior IFG, mid-MTG bilaterally and left posterior MTG bordering the temporal-occipital boundary. Based on previous research we suggest that aIFG may be implicated in lexical selection while posterior temporal regions likely support semantic access related processes.

7. 10:15 a.m. -11:15 a.m.

Neural representation of word meaning in healthy seniors: An fMRI study

Grossman, M. (1), Smith, E.E. (2), Gunawardena, D. (1), Dreyfuss, M. (1), Richmond, L. (1), Bonner, M.F. (1), and McMillan, C. (1). 1. University of Pennsylvania School of Medicine, Department of Neurology, Philadelphia, PA. 2. Columbia University, Department of Psychology, New York, NY.

The neuroanatomic representation of word meaning depends on a large-scale network that is vulnerable to age-related changes. In a fMRI study of healthy young adults, we found that judgments of concrete words activate modality-specific association cortex related to perceptual knowledge, and that amodal cortical regions in left prefrontal cortex are also activated in association with word meaning. To assess the neural basis for word meaning in aging, 11 healthy right-handed seniors and 18 young adults judged whether two printed words (e.g. LIME CELERY) share a value of a perceptual feature (e.g. COLOR). We probed color and shape each in 80 pairs of concrete natural and artifact words matched across categories for lexical frequency and familiarity. Half of the words matched in the indicated feature and half did not (according to pretesting). A control condition assessed whether pairs of pseudowords matched according to an orthographic feature (e.g. ending in the same letter). Functional localizers for color and shape were derived from judgments of pairs of meaningless blobs. Young adults and healthy seniors both activated visual association cortex during judgments of word pairs for color and shape. Each of these judgments overlapped with judgments of the corresponding perceptual feature of meaningless blobs in seniors (color peak -44, -52, -12; shape peak -44, -60, -16 and 46, -70, -18, all significant at $p<.05$ FWE). Moreover, healthy seniors, like young adults, recruited left dorsolateral prefrontal cortex during judgments of word pairs (color peak -42, 10, 36; shape peak -46, 42, 10, both significant at $p<.02$ FDR), although this area was not recruited during judgments of meaningless blobs or pseudowords. Direct group comparisons revealed greater activation of temporal-occipital regions in healthy seniors than young adults (peak color-36, -36, -18; peak shape 20, -80, -24; $p<.001$ uncorrected). However, prefrontal activation did not differ for color, and seniors had marginally greater activation than young adults for shape in right prefrontal cortex. Seniors may attempt to increase activation throughout the neural network supporting word meaning in order to maintain lexical semantic processing in healthy aging. However, age-related changes in frontal cortex may prevent this component of the large-scale network from responding as robustly as posterior cortical regions. Taken together, our findings support the hypothesis that a large-scale neural network involving both perceptual and amodal cortical regions supports the neural representation of word meaning, and selective neuroanatomic vulnerability during aging may limit the contribution of an amodal frontal component.

8. 11:30 a.m. - 12:30 p.m.

A functional role for the motor system in language understanding: Evidence from rTMS

Willems, R. M. (1), Labruna, L.,(1,2,3), D'Esposito, M. (1), Ivry, R. (1,2), and Casasanto, D. (4,5). 1. Helen Wills Neuroscience Institute, University of California Berkeley, CA, USA. 2. Department of Psychology, University of California, Berkeley, CA, USA. 3. Department of Health Science, University of Molise, Campobasso, Italy. 4. Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands. 5. Donders Institute for Brain, Cognition & Behaviour, Nijmegen, The Netherlands.

Does language comprehension depend, in part, on neural systems for action? In previous studies, motor areas of the brain were activated when people read or listened to action verbs, but it remains unclear whether this activation was functionally relevant for comprehension, or a by-product of meaning construction. Here we used repetitive transcranial

magnetic stimulation (rTMS) to investigate a causal relationship between activity in premotor cortex and action language understanding. Right-handed participants (n=12) performed lexical decisions on verbs naming manual actions typically performed with the dominant hand (e.g., ' to throw', 'to write') and on non-manual verbs (e.g., 'to earn', 'to wander'). Manual and nonmanual verbs were matched on lexical frequency and word length. We applied theta burst rTMS over left and right premotor cortex in two separate sessions. We predicted that rTMS applied over premotor cortex would modulate reaction times more strongly for manual action verbs than for nonmanual verbs. Moreover, we expected that the strength of this effect would depend on whether rTMS was applied over the left or right premotor cortex based upon the previous finding that manual action verb processing in right-handers is biased towards the left premotor cortex (Willems, Hagoort, & Casasanto, 2010). Data analysis focussed on reaction times in a repeated measures ANOVA with factors HEMISPHERE (left premotor TMS, right premotor TMS) and VERB (manual, non-manual). Results showed the predicted HEMISPHERE x VERB interaction effect ($p=0.028$) (Fig. 1). Stimulation of left premotor cortex led to faster responses to manual verbs compared to stimulation of the right premotor cortex ($p=0.03$). This effect was not observed for the nonmanual verbs ($|t|<1$). There were no other main effects or interactions. Response times for the pseudowords showed no main effects or interactions, attesting to the specificity of the observed effects for action verbs. These results show that perturbation of the premotor cortex specifically affects lexical decision reaction times for manual action verbs. This effect challenges the skeptical view that premotor activation during linguistic comprehension is epiphenomenal. Rather, perturbation of neural processing in premotor cortex influences lexical decision time, a classical indicator of lexico-semantic processing. These data demonstrate a functional role for premotor cortex in language understanding. Reference: Willems, R. M., Hagoort, P., & Casasanto, D. (2010). Body-specific representations of action verbs: Neural evidence from right- and left-handers. Psychological Science, 21(1), 67-74. F

9. 10:15 a.m. -11:15 a.m.

Sentence processing in the left ventral premotor cortex: rTMS evidence

Tremblay, P. (1), Sato, M. (2) and Small, S.L. (1). 1. The University of Chicago, Department of Neurology, USA. 2. Gipsa-Lab, CNRS & Grenoble Universités, France

It has been argued that understanding action-related language requires the enactment (covert simulation) by the motor system of the action being described. Consistent with this idea, a number of functional imaging studies have shown activation in motor and premotor areas during language tasks such as passively attending to action words and phrases. In a recent fMRI study, we also showed robust activation in the superior part of the left ventral premotor cortex (sPMv) during sentence listening, but also during sentence repetition and sentence generation, demonstrating that the left sPMv is a core region for sentence processing. Moreover, our results showed that activation in sPMv was modulated by semantic content (action, object), suggesting a role for this region in sentence processing at a semantic level. The goal of this study was to examine the importance of sPMv during sentence processing using 1 Hz low-frequency repetitive TMS (rTMS). To this aim, 16 right-handed students from The University of Chicago were recruited. The experiment consisted of two rTMS and sham sessions, which were separated by 1 hour and fully counterbalanced across participants. The sPMv stimulation site was located with frameless stereotaxy at the beginning of each session on the basis of each participant's anatomical MRI scan. In both sessions, the TMS coil was positioned over the left sPMv using the same localization procedure. In the TMS session, 900 pulses were applied at a frequency of 1 Hz, with stimulation intensity at 110% of individual resting motor threshold. The sham stimulation was performed by presenting participants with recorded TMS noise mimicking actual stimulation. Participants underwent two identical experimental sessions following rTMS and sham stimulation. On each trial, a short concrete sentence was presented, which was followed by a target word that was either semantically related to the sentence or not (e.g., "The hammer is rusty"/"Nail"). Participants were asked to decide whether the target word was semantically related to the sentence by pressing one of two buttons. The sentences described either manual actions, manipulable objects, non-manipulable objects or orofacial actions. A three-way repeated-measures ANOVA was performed with TMS (rTMS, SHAM), Semantics (manual actions, manipulable objects, non-manipulable objects or orofacial actions) and Priming (related, unrelated) as the within-subject factors and reaction-timed (RT) as the dependent variable. Results revealed a strong 2-way interaction between TMS and priming ($p = 0.00001$). While the experimental manipulation resulted in a classic priming effect (facilitation) following SHAM, with related trials being processed more quickly than unrelated trials, no such priming occurred after TMS stimulation. Furthermore, a 3-way interaction demonstrated that this effect was maximal for the manual action sentences. These results confirm that the left sPMv is involved in processing sentences and, consistent with a functional role for the motor system in language comprehension, demonstrate that this region is sensitive to their semantic content. Interestingly, our previous fMRI results failed to show activation of sPMv during action observation, which suggest that the process by which action sentences are understood cannot be fully accounted for by a simple motor enactment explanation.

10. 11:30 a.m. - 12:30 p.m.

Sentence context effects for unconsciously processed items

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Two event-related brain potential (ERP) studies addressed whether unconsciously processed words were subject to the classic N400 effect, i.e. N400 is reduced for congruous completions of sentences relative to incongruous completions. In the first study, ERPs were recorded from 12 native English speakers as they read sentence fragments such as, "The Coca Cola logo is white and" presented one word at a time. Sentence fragments ended either congruously ("red") or incongruously ("green"). Sentence final words were visually presented for 48 ms, and were both preceded and followed either by 200 ms of blank screen (unmasked condition) or by 200 millisecond letter masks, such as CVrX9cb (masked condition). ERPs were time locked to the onset of the sentence final word. For both masked and unmasked words, congruous completions elicited less negative ERPs than incongruous ones between 300 and 500 ms after word onset (N400). Relative to the unmasked words, congruity effects in masked words were much smaller, began slightly later, and displayed a more anterior distribution. The efficacy of masking parameters was assessed in a separate behavioral task (completed by the same participants) in which sentence final words from Experiment 1 (e.g. red) served as target words, and were preceded either by the same word (red) or by a different word (green). Presentation parameters for targets were the same as in Experiment 1, and participants' task was to judge whether or not the target word was the same as the prime. Participants' d' scores indicated they were able to read unmasked [One sample t-test $t(15)=9.68$, $p=.000$] but not masked words [One sample t-test $t(15)=1.08$, $p=.30$]. Experiment 2 involved a comparison of ERPs to lexically associated words, such as "life" and "death", in sentence contexts where they either made sense together, as in "When someone has a heart attack a few minutes can make the difference between life and death," (associated/congruous) or, did not, as in "The gory details of what he had done convinced everyone that he deserved life in death," (associated/incongruous). Word- and sentence- level context were fully crossed via the inclusion of congruous sentences without associates "The gory details of what he had done convinced everyone that he deserved life in prison," (unassociated/congruous), and incongruous sentences without associates "When someone has a heart attack a few minutes can make the difference between life and prison," (unassociated/incongruous). Half of the words in each condition were masked; half unmasked. The presentation of sentence final (target) words was identical to that used in Experiment 1, and as in Experiment 1 a separate behavioral task revealed participants could read unmasked but not masked words. ERPs to congruous targets elicited less N400 than incongruous ones. Relative to the unmasked targets, congruity effects in masked words were much smaller, and displayed a more anterior distribution. Results suggest that while controlled processes predominate, automatic processes do contribute to the N400 sentence congruity effect. Data are interpreted as suggesting a link between the neural generators of the N400 and conceptual short-term memory, a dynamic process for conceptual activation and structuring that is triggered by perceptual input.

11. 10:15 a.m. -11:15 a.m.

P600 effects in semantic processing

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Debate continues to wage over the underlying linguistic processes revealed by the various ERP components. In particular, the significance of the P600 effect has been a polemic topic. Recently, several studies have shown that the violation of thematic constraints can give rise to a P600 effect as opposed to a variation in the N400 component (Kim & Osterhout, 2005; Kuperberg et al., 2005; van Herten et al., 2005;). We ourselves have found that purely semantic anomalies can give rise to a biphasic N400 ñ P600 response, for two independent subject groups using the same materials (Sneed & Frenck-Mestre, unpublished; Carrasco & Frenck-Mestre, 2007). The current study was designed to further investigate the factors that drive this effect. While seminal ERP work has shown that cloze probability (i.e. the probability of a wordís occurrence in a given sentential context) can elicit modulation of the N400 response to a target word (Kutas & Hillyard 1984, Kutas et al. 1984), we examined whether cloze probability could also elicit variation in the P600 response. Materials were adapted from Robichon et al. (1996), a replication in French of Kutas & Hillyardís semantic norming study (1980). Each semantic context was comprised of three sentences: high-probability , low-probability and anomalous . The anomalous target matched the low-probability target in number of letters and in frequency ((New 2006). Participants showed a robust biphasic N400ñP600 effect for anomalies relative to high-probability targets. For low-probability relative to high-probability targets, a P600 effect alone was observed. Crucially, this pattern was observed across subjects and was not due to some participants showing N400 effects and others showing P600 effects for the same items. Behavioral responses showed that participants correctly rejected anomalous sentences (73.3%) and accepted high- (75.8%) and low-probability sentences without anomalies (67.7%). These data imply that the P600 is indeed a hallmark of revision processes but is in no way limited to the computation of syntactic dependencies.

12. 11:30 a.m. - 12:30 p.m.

A neuroimaging investigation of idiom comprehension in auditory sentences

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Objective: Prior neuroimaging implicates both neural hemispheres in Idiomatic Phrase (IP) comprehension (Zempleni et al., 2007), yet much of this experimental work relies on visual stimuli presentation or presentation of IPs apart from sentence context. Work with aphasic patients indicates that the left hemisphere is involved in successful IP comprehension (Cacciari et al., 2006; Papagno et al., 2004), but the specific neural substrates supporting IP comprehension in auditory sentences remain underspecified. Here, we employed event-related BOLD FMRI to investigate the neural loci underlying comprehension of IPs in auditory sentences. Methods: Forty ambiguous IPs were chosen, each with a plausible literal or figurative interpretation. IPs were three words long, with a V + NP form (e.g. hit the sack). We constructed minimal pair sentences for each IP (80 items total): one sentence disambiguated the phrase towards its figurative meaning (1), and one disambiguated the phrase towards its literal meaning (2). These matched sentences were identical except for the disambiguating phrase (immediately following the IP). Sentence length and syntactic complexity were controlled across items.1) The toddler in a dinosaur shirt hit the sack at 8 o'clock after a long day of playing outside 2) The toddler in a dinosaur shirt hit the sack with a fist after a long day of playing outside Sentences were recorded by a native English speaker at a normal speech rate, and sentence stimuli were were counterbalanced across two lists. Participants heard sentences, one at a time, during an event-related FMRI paradigm (Single-shot gradient-recalled echo-planar imaging, TR=2000 msec; TE=30 msec; 32 interleaved slices; 4mm slices; flip angle=90 ∫; FOV=240mm; matrix=64 x 64.) Null trials and stimuli were jittered, and each sentence's onset was time-locked to a TR. Data were analyzed using a deconvolution analysis in AFNI (Analysis of Functional Neuroimages; Cox, 1996) to model the hemodynamic response function following the offset of the disambiguating phrase. A cluster threshold of $p < 0.01$ was applied. Results: Findings thus far (N=8, 5 Female; Mean age = 38.6, additional data collection/analysis is ongoing) indicate significant BOLD signal increases when participants heard figuratively-biased IPs (Example 1), as compared to literally-biased IPs (Example 2), in the following left hemisphere regions: Superior Temporal Gyrus (BA 21, 22, 38, 41) Middle Temporal Gyrus (BA 21), and Inferior Frontal Gyrus (BA 44, 47), as well as in the following right hemisphere regions: Superior Temporal Gyrus (BA 13, 21, 22, 38, 41) and Inferior Frontal Gyrus (BA 44, 47). In the reverse contrast of literally-biased vs. figuratively-biased IPs, no significant BOLD signal increases were found. Conclusions: These results implicate similar neural networks for comprehension of IPs in figuratively- or literally-biasing contexts, but suggest that figuratively-biased IPs elicit stronger and more extensive recruitment of these neural regions. The involvement of traditional left hemisphere language regions (STG, IFG, MTG) in auditory comprehension of IPs in figurative biasing contexts substantiates neuropsychological evidence of IP comprehension impairments in aphasic patients with damage to these neural regions (Cacciari et al., 2006).

13. 10:15 a.m. -11:15 a.m.

Sound, sight and action in meaning: fMRI evidence of word representations in perceptual and motor cortices

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Many fMRI studies have demonstrated that perceptual and motor regions of the brain are recruited when participants explicitly think about the features of objects and actions. Yet only a small number of these studies have begun to address the question of whether or not such feature representations play a role in word meaning. We used an fMRI lexical decision experiment to examine the role of auditory, visual and motor features in word recognition. Three categories of concrete words were compared to a closely-matched, abstract word baseline. We found that auditory, visual and motor association regions of the brain were recruited during this lexical decision task. In a BOLD fMRI study, healthy, young participants (n=12) viewed single words on a screen and responded by button press to indicate if each word was real or fake. Stimuli included words with strongly associated features (determined in a norming study) in three modalities: Auditory (e.g., thunder; n=40), Motor (e.g., handshake; n=40) and Visual (e.g., goldfish; n=40). An Abstract word condition (e.g., essence; n=40) served as a baseline. Conditions were matched for word length and lexical frequency. Foils were pronounceable pseudowords (n=120). For all three concrete word conditions, we observed activity in corresponding perceptual or motor association cortex (Figure 1): Auditory words recruited superior-temporal and inferior-parietal regions (BA 40, 42) associated with auditory perception; Motor words recruited frontal regions (BA 6, 4) associated with motor planning and execution; and Visual words recruited ventral temporal and occipital regions (BA 21, 22, 19) associated with visual perception. Functional localizers were also administered to identify auditory, visual and motor regions of cortex in the participants. Activations from each of the concrete word conditions overlapped with activations from the corresponding functional localizers, demonstrating that the concrete words are activating perceptual and motor regions of the brain. These results show that even for a simple word recognition task sensory and mo-

tor association cortices are selectively recruited. This is consistent with the hypothesis that word meanings rely in part on representations of feature knowledge in sensory and motor association cortices.

14. 11:30 a.m. - 12:30 p.m.

Context-dependent interpretation of words: Temporal dynamics in magnetoencephalography

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A fundamental property of language comprehension is that word meanings are dynamically computed in context. Here we use magnetoencephalography (MEG) to examine the brain mechanisms underlying context-dependent interpretations. Previous behavioral studies indicate that ambiguous words in contexts ("to bowl" vs. "the bowl") initially activate multiple meanings but after 200ms, the network settles on an interpretation (Simpson, 1984). Event related potential studies moreover show ambiguity and context effects around 200ms, continuing into 400-500ms (Federmeier et al., 2000). Functional magnetic resonance imaging has localized these effects in the left inferior frontal gyrus (LIFG) and the posterior middle temporal gyrus (PMTG), which is associated with motion/action processing (Gennari et al., 2007). 80 object-action-ambiguous words ("bowl") were presented in noun contexts ("the bowl") or verb contexts ("to bowl"), as did unambiguous controls ("the jug", "to wipe"). Manipulable objects or tool actions were used to engage previously associated regions (manipulability = ventral pre-motor, PMTG = action). We ask which regions are engaged in disambiguation over time and specifically, whether initially active regions reflect multiple meanings and/or contexts, and whether content-specific regions occur later, when settling on an interpretation. Method: equibiased ambiguous words were matched for frequency with unambiguous controls (Gennari et al, 2007). 20 participants were instructed to read the phrases ("the bowl"), presented for 1000ms, and to answer questions about their meanings ("found in kitchens?") whenever asked (20% of trials). Inter-trial times were randomly varied. A separate study indicated that processing was completed by 700ms, with ambiguous verb phrases being more difficult than noun phrases. We used beam-forming source localization to identify cortical power changes at different time windows and localize them in participants' brains via co-registration. These solutions were entered into group analyses, normalized to standard space. Differences in power were computed across conditions at several 200ms windows. Significant power differences in representative windows are shown in Figure 1. Results: ambiguous verb phrases activated anterior LIFG between 50-250ms. Next, they also activated more posterior LIFG and pre-motor regions, together with PMTG. LIFG was active at several windows. In contrast, ambiguous noun phrases initially and briefly activated posterior LIFG and later, pre-motor regions with no PMTG activity until after 300ms. Additional content-specific activations occurred thereafter (inferior parietal lobe, associated with action understanding, for verb phrases (400-600ms), and pre-motor regions for noun phrases). Importantly, contrasting "to bowl" vs. "the bowl" elicited a pattern similar to verb phrases, suggesting early context effects. Discussion: early frontal activity was sensitive to both ambiguity and syntactic context, suggesting initial parallel activation of multiple stimulus properties. Next, posterior LIFG and pre-motor activity occurred for both phrase types, but verb phrases engaged PMTG earlier and LIFG for longer than noun phrases, suggesting early strengthening of motion/action associations for actions, with more semantic competition. Other regions ignited thereafter presumably consolidating relevant category-specific properties such as manipulability for objects and action representations for actions. Overall, results suggest initial multiple activations followed by context-appropriate activity, but there was differential involvement of PMTG and LIFG across phrase types as a function of difficulty.

15. 10:15 a.m. -11:15 a.m.

An on-line investigation of lexical and syntactic processing during sentence comprehension: Monitoring eye-movements in a sentence-picture matching task

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In the present experiment we measured eye-movements during a sentence-picture matching task to investigate, in patients with left-hemisphere lesions, lexical and syntactic processing over the time-course of the sentence. To minimize the influence of semantic knowledge, we used shapes (e.g. square, cross), in place of animate actors (Chaterjee , Maher, Gonzalez Rothi, & Heilman, 1995; Schwartz, Saffran, & Marin, 1980). Measuring eye-movements provides fine-grain information regarding how participants incorporate relevant lexical and syntactic information (Dickey, Choy & Thompson, 2007). If participants are quick to use this information, we expect significantly more looks to the Target during regions of disambiguation. The goal is to use this data to create a more detailed description of the degree to which lexical and syntactic factors influence processing difficulty, at select points in the sentence, over various syntactic structures. In the sentence-picture matching task, participants selected one of four pictures described by a sentence. Each picture depicted an event (e.g. kicking), between two shapes. An arrow placed between the shapes represented the verb such that the action began at the Agent and ended at the Patient. Each display of four pictures consisted of a Target picture, a Competitor that shared at least one shape with the Target, and two distracters that did not share any shapes with the target or competitor. We manipulated Sentence-Type (Active, Passive, Subject-Cleft, Object-Cleft), and Contrast, which refers to the region in the sentence where the Target picture becomes unambiguous, (NP1, NP2, Verb-Nonreversible,

Verb-Reversible). In effect, NP1 and NP2 test lexical processing, while Verb-Nonreversible and Verb-Reversible test syntactic processing, (Figure 1 depicts the Contrast conditions for the sentence, ìThe square kicked the crossî). Preliminary results indicate that controls were both more accurate and generally more likely to use lexical and syntactic information earlier than patients. Controls were over 90% accurate while patients were 73% accurate (58% Reversible, 79% in the other three Contrast conditions). For the factor Sentence-Type, controls had a significantly higher proportion of looks to the target, during the region of disambiguation, in the Passive, Subject-Cleft and Object-Cleft conditions, while for the patients there was no difference in any of the conditions. For the factor Contrast, controls had a significantly higher proportion of looks to the target, in the Verb-Reversible and Verb-Nonreversible conditions, while again there was no difference in any condition for the patients. In sum, while both controls and patients eventually had a higher proportion of fixations to the target, controls were more likely to look at the target shortly after hearing the disambiguating information. The results indicate that even when patients make the correct choice, it takes them longer to incorporate relevant lexical and syntactic information. This highlights the claim that comprehension difficulties can result from multiple underlying problems. In the future, we plan to perform a more detailed analysis of performance across Sentence-Type and Contrast. Furthermore, we plan to analyze the relation between lesion site and performance.

16. 11:30 a.m. - 12:30 p.m.

The effect of world knowledge is modulated by distance during pronoun resolution

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Previous ERP studies have consistently revealed that pronoun interpretation occurs immediately when a pronoun is recognized. In addition, mismatch costs are always found when a pronoun violates world knowledge, such as the gender stereotype of its referent. However, it is still a matter of debate what the nature of these mismatch costs may be. Specifically, some studies have reported a P600 effect for incongruent compared to congruent pronouns, whereas other studies have revealed a larger N400 effect. Given that the distance between a pronoun and its antecedent varied across different studies, this factor may be responsible for the inconsistent results. Using ERPs, the present study assessed whether and how distance between a pronoun and its referent would modulate the effect of gender stereotype on pronoun resolution during Chinese reading. Participants read sentences for comprehension. Each sentence included three clauses, and contained a personal name as the antecedent and an unambiguous pronoun as the anaphor. The anaphor was either consistent or inconsistent with the stereotypical gender of the antecedent. The pronoun always appeared in the third clause of a sentence, while the antecedent appeared either in the second clause (i.e., the short distance condition) or in the first clause (i.e., the long distance condition). One example would be: (1) Because the pictures need to be processed in a fast pace, Tom Wang wants to buy a new computer, so he/she asks around to find the best brand. (2) Tom Wang wants to buy a new computer, because the pictures need to be processed in a fast pace, so he/she asks around to find the best brand. In the short distance condition, an enhanced N400-like deflection was found to the incongruent relative to the congruent pronouns. In contrast, in the long distance condition a P600-like effect was found. Moreover, relative to long-distance pronouns, short-distance pronouns elicited a larger sustained negative deflection over anterior sites in both congruent and incongruent conditions. To offer a functional interpretation for the distance effect, using the same design and materials, we conducted a follow-up experiment using the eye-tracking method. Overall, the eye-movement data revealed longer reading times on the pronouns in the short distance than in the long distance condition, which suggests that more working memory resources were devoted to pronoun processing in the short distance condition. According to the eye-movement data, we assume that the larger sustained negative shift found in the short distance condition may resemble the referentially induced frontal negativity (Nref effect) and may be associated with working memory load.

These results suggest that the influence of world knowledge on pronoun processing is rather dynamic and varies as a function of the distance between a pronoun and its antecedent.

17. 10:15 a.m. -11:15 a.m.

Hemispheric inference priming during comprehension of conversational language

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Unique features of conversational language may result in a distinct pattern of lateralized processing during comprehension. This study investigates lateralization of comprehension processes while people listen to conversations that promote causal inferences at elaborative or coherence inference points. An elaborative inference point may occur when an utterance invites integration of external information for predictions about upcoming utterances. Coherence inferences occur at the offset of the later utterance when inferential information must be incorporated in order to maintain coherence. Some evidence for inference generation during comprehension comes from studies showing priming for inferences, that is, faster recognition for inference-related than –unrelated words when inferences are generated during

comprehension. Our objective was to find evidence of bilateral priming for inferences embedded in conversation. We tested 40 undergraduates at coherence points and 40 other undergraduates at elaborative points while they listened to conversations. 60 total inferences were promoted across 23 conversations. Target words were presented to the left visual field-right hemisphere (lvf-RH) or to the right visual field-left hemisphere (rvf-LH) at inference points. Targets were piloted to ensure their strong relatedness to the promoted inferences, but no strong semantic relation to any individual words in the dialogue up to the inference points. We compared average priming across hemispheres and found significant priming in both hemispheres at coherence inference points. At elaborative inference points, we found significant priming in RH, but not in LH. These findings suggest drawing inferences from conversation necessitates heavy reliance on RH integration processes. Previous work shows only RH priming at elaborative points and only LH priming at coherence inference points in narrative (Beeman, 2000). Here, we show RH is not only primed at elaborative inference points, but maintains activation for inference-related concepts through coherence inference points in conversation. Ultimately, we demonstrate that inferences can be promoted within conversation and highlight a potentially important lateralization distinction for comprehension of conversational language. Beeman, M.J., Bowden, E.M., & Gernsbacher, M.A. (2000). Right and left hemisphere cooperation for drawing predictive and coherence inferences during normal story comprehension . Brain and Language, 71, 310-336.

18. 11:30 a.m. - 12:30 p.m.

Comprehending familiar and unfamiliar metaphors

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The present Event Related potential (ERP)-study investigated the comprehension of familiar and unfamiliar metaphors within a sentence context. Previous research investigating metaphor comprehension mainly focused on conventional (familiar) metaphors. However it is plausible that new (unfamiliar) metaphors are processed differently. Some pragmatic models suggest that the figural meaning is activated in parallel with the literal meaning (Glucksberg, 2003). In contrast, other models suggest that the most frequently used meaning is activated first (Giora, 1997). This last model predicts that the figural meaning is activated first in familiar metaphors, whereas the literal meaning precedes in unfamiliar metaphors. Recently, Arzouan, Goldstein and Foust (2007) found that unfamiliar metaphors elicited a larger N400 than familiar metaphors, showing that there is a difference in processing of familiar and unfamiliar metaphors. In their study, metaphors only consisted of two words, thus there was no sentence context to comprehend the metaphors. In daily life however, metaphors are commonly present within a sentence. Therefore, we used a sentence context to investigate the comprehension of familiar and unfamiliar metaphors. Four types of sentences were constructed in Dutch: familiar metaphors, unfamiliar metaphors, literal sentence and semantically anomalous sentences. We used the same critical word in every condition; this is an advantage in comparison to previous studies, which used different words in each condition. The metaphors were first rated on familiarity, based on these ratings familiar and unfamiliar metaphors were selected for the experiment. During the ERP-study participants had to silently read the sentences. The results showed a modulation of the N400 amplitude, the smallest N400 was present in the literal sentence, with increasing amplitudes for the familiar metaphors, unfamiliar metaphors and the anomalous sentences. There were no significant differences in later time-windows. These results show that the integration of the familiar metaphor into the sentence context is easier than the integration of the unfamiliar metaphor. We argue that in the familiar metaphors the figural meaning is activated immediately and is used very fast to interpret the sentence. The difference between the literal sentences and the familiar metaphors is very small, suggesting that familiar metaphors are comprehended almost in the same way as literal sentences. Additionally, the results showed that it is easier to integrate the unfamiliar metaphor than the anomalous word. This suggests that the figural meaning is also activated very fast in the unfamiliar metaphors, which helps the reader to integrate the word into the sentence. We argue that the present results support the conceptual blending theory, which states that several cognitive models are constructed during language comprehension and that mappings have to be made between the different components (Coulson & Van Petten, 2002). In unfamiliar metaphors it is harder to map the different components, as reflected by a larger N400, because these components are further apart.

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Giora, R. (1997). Cognitive Linguistics, 8(3), 183-206.
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19. 10:15 a.m. -11:15 a.m.

Trial-by-trial coupling of concurrent EEG and fMRI identifies BOLD correlates of the N400

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N400 is one of the most extensively investigated language related ERP components. It is usually seen as an index of semantic unification load. However, studies that have tried to identify the neural generators of N400 have yielded in-

consistent results (Hagoort, Baggio & Willems, 2009; Liljestrom, Hulten, Parkkonen, & Salmelin, 2009). To shed more light on these imaging modality-based inconsistencies, we provide an integrated analysis of simultaneously recorded EEG and fMRI, in an experiment in which we parametrically manipulated semantic unification difficulty. We hypothesized that, if a region contributes to the generation of N400, then trial-by-trial variations in the BOLD signal in this region should co-fluctuate with single-trial variations of the N400. To manipulate semantic unification difficulty, we constructed three types of sentences. High-cloze sentences (HI) were sentences in which a noun at a given position was highly expected. Low-cloze sentences (LO) were semantically correct, but with an unexpected noun at the critical-word (CW) position. Finally, in sentences containing semantic violations (SV), the noun at the critical word position did not fit into the sentence context. Twenty-four right-handed, native Dutch speakers were asked to read sentences for comprehension without explicit task, in both inside and outside MR scanner sessions. Sentences (54 trials for each type in each session) were visually presented word by word, with a 600 ms SOA. The stimulus materials induced a parametrically modulated N400. The fMRI results showed parametrically modulated activation in bilateral inferior frontal gyrus, left posterior temporal gyrus. For the integrated analysis, a model only with N400 amplitude regressor (DM-) shows that N400 amplitude negatively correlated with BOLD change in bilateral inferior frontal gyrus and bilateral inferior parietal lobule. When the condition regressors (design matrix, DM) were added (DM+), only the bilateral inferior parietal lobule correlations between N400 amplitude and BOLD signal remained. No significant positive correlations were found between N400 and BOLD. Thus, our data are in line with a recent meta-analysis which showed consistent activation for semantic unification in inferior frontal gyrus (Hagoort et al., 2009). The lack of activation of frontal regions in the DM+ model is tentatively explained as follows: Trial-by-trial N400 estimates (captured with the EEG regressor) capitalize on neural activity in a very limited time range (300-500 ms after the presentation of the critical word). In contrast, standard BOLD activations integrate neural activity over several seconds. It seems therefore not unreasonable to hypothesize that the different patterns of BOLD-EEG correlations in LIFG in the DM- and DM+ models are produced by the fact that neural activity in IPL is more precisely time-locked to the occurrence of the CW compared to the neural activity in LIFG, a suggestion that has been made by others as well (Liljestrom et al., 2009).

20. 11:30 a.m. - 12:30 p.m.

Localization of nonverbal semantic impairment in aphasia

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Although semantic deficits in post-stroke aphasia are most evident on verbal tasks, co-occurring nonverbal deficits are often identified with measures like the Pyramids and Palms or Camel and Cactus Test (CCT). An important question is whether nonverbal semantic deficits in aphasia arise from lesions that impact (a) semantic representations in left temporal areas, or (b) semantic control processes in ventrolateral prefrontal cortex (VLPFC) and/or temporoparietal junction (TPJ) (Noonan et al., 2010). To answer this question, we carried out lesion-symptom mapping of CCT in a large, diverse aphasia cohort. 86 right-handed aphasics with chronic left hemisphere (LH) stroke performed the all-pictures, 64-item CCT, which requires a 4-choice, closest associate match. Scores were entered as the dependent variable in voxel-based lesion-symptom mapping (VLSM) featuring manual segmentation of lesions, automated warping to template, and False Discovery Rate control ($q = .02$). To further explore effects in VLPFC and TPJ, we correlated CCT with percent damage in nine Brodmann areas (BA) (BA 44, 45, 46, 47; 40, 39, 37, 22, 21), selected a priori from the semantic control literature. The range of CCT scores was 25 - 95% (Mn 77; Stdv 13). Lesion coverage was good in all relevant LH regions, including anterolateral temporal areas implicated in multimodal semantic processing (e.g., Pobric et al., 2010). VLSM yielded 3,635 significant voxels, with the largest cluster (2,329) in VLPFC and underlying white matter (see Figure). No supra-threshold voxels were identified in TPJ. In the regional analysis, correlations with CCT were significant (.05) only for BA 44, 45, 46 and 47. When these four areas, along with total lesion volume, were entered as predictors into a multiple regression model, the model significantly predicted CCT ($R2 = .16$; $p = .015$) with BA 44 making a significant independent contribution (Std beta = -.36; $t = -2.0$; $p = .05$). In conclusion, CCT scores were associated with lesions in left VLPFC, an area known to be important for regulating retrieval and selection of semantic information. We take this as support for the semantic control account of nonverbal semantic impairment in aphasic stroke. On the other hand, we did not confirm previous reports of equivalent effects from lesion in VLPFC and TPJ (Noonan et al., 2010). CCT scores were not associated with lesion status in TPJ, or in voxels occupying posterolateral and anterolateral temporal regions implicated in semantic processing. If these regions house semantic representations relevant to judging relations among pictured objects, there must be sufficient redundancy within the left hemisphere or, more likely, in homologous areas on the right, to compensate for the impact of unilateral, chronic lesions. References: Noonan, K. A., Jefferies, E., Corbett, F., & Lambon Ralph, M. A., et al. (2010). Elucidating the nature of deregulated semantic cognition in semantic aphasia: Evidence for the roles of prefrontal and temporo-parietal cortices. Journal of Cognitive Neuroscience, 22, 1597-1613. Pobric, G., Jefferies, E., & Lambon Ralph, M. A. (2010). Amodal semantic representations depend on both anterior temporal lobes: Evidence from repetitive transcranial magnetic stimulation. Neuropsychologia, 48(5), 1336-1342.

21. 10:15 a.m. -11:15 a.m.

Underlying causes of the late positive component to semantic anomalies as revealed by ERPs

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It is well-known that, within Event Related Potential (ERP) paradigms of sentence processing, semantic anomalous words elicit N400 effects (Kutas and Hillyard, 1980). Less clear, however, is what happens after the N400 time window. In some cases the N400 effect is followed by a Late Positive Component (LPC) (Juottonen et al., 1996, Severens and Hartsuiker, 2009), whereas in other cases such an effect is lacking (Kutas and Hillyard, 1980, Hagoort et al., 2004). Moreover, there seems to be no clear consensus about the functional interpretation of the LPC. We investigated whether experimental context is a potential factor contributing to the LPC. We performed two ERP experiments in which participants read Dutch sentences in a word-by-word presentation. Both experiments contained the same semantic manipulation (correct control: Whipped cream tastes sweet and creamy, semantic anomalous: Whipped cream tastes anxious and creamy). However, the experimental context was varied between the experiments. One experiment contained, amongst others, a second manipulation known to elicit N400 effects (the ëhigh-frequent N400 experimentí), whereas the other experiment did not contain such sentences (the ëlow-frequent N400 experimentí). In this way, the overall percentage of sentences leading to an N400 effect was higher for the ëhigh-frequent N400í (21.2%) as compared to the ëlow-frequent N400í experiment (9.6%). In both experiments the semantic manipulation elicited an N400 effect, but in the ëlow-frequent N400 experimentí the N400 effect was followed by a LPC effect, which was absent in the ëhigh-frequent N400 experimentí. This indicates that experimental context plays a critical role in eliciting the LPC, especially as this effect evolved over the course of the ëlow-frequent N400 experimentí. Moreover, it suggests that the LPC, in part, could reflect the P3b component, which is known to be larger for infrequent stimuli (Donchin, 1981). Interestingly, further analyses revealed inter-individual differences as another factor contributing to the LPC. About half of the participants of the ëlow-frequent N400 experimentí showed the LPC, whereas the other half did not (see figure). We will report whether the individual variation can be explained by differing polymorphisms of the language-relevant gene CNTNAP2 (Vernes et al., 2008). In conclusion, we identified experimental context and inter-individual variation as possible candidates underlying the LPC to semantic anomalies. These findings indicate that, while investigating language processing, experimental context and inter-individual variation are factors to be taken into account. References: Donchin E. (1981) Surprise!...Surprise! Psychophysiology 18:493-513. Hagoort P., Hald L., Bastiaansen M., Petersson K. M. (2004) Integration of word meaning and world knowledge in language comprehension. Science 304:438-441. Juottonen K., Revonsuo A., Lang H. (1996) Dissimilar age influences on two ERP waveforms (LPC and N400) reflecting semantic context effect. Cognitive Brain Research 4:99-107. Kutas M., Hillyard S. A. (1980) Reading senseless sentences - Brain potentials reflect semantic incongruity. Science 207:203-205. Severens E., Hartsuiker R. J. (2009) Is there a lexical bias effect in comprehension monitoring? Language and Cognitive Processes 0:1-18. Vernes S. C., Newbury F., Abrahams B. S., Winchester L., Nicod J., Groszer M., AlarcÚn M., Oliver P. L., Davies K. E., Geschwind D. H., Monaco A. P., Fisher S. E. (2008) A functional genetic link between distinct developmental language disorders. The new England Journal of Medicine 359:2337-2345."

22. 11:30 a.m. - 12:30 p.m.

What part of the temporal lobe is critical for picture naming? Divergence of activation studies and dementia lesion studies

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Semantic memory and access to phonological representations are critical stages in naming pictures, and both clearly involve activity in the left temporal lobe (LTL) in most individuals. We report of series of studies pointing to a divergence in the localization of naming in the LTL depending on whether data is derived from activation studies in normal individuals, or associated with brain damage. In a series of activation studies in normal young and old subjects using fMRI and oxygen 15 PET, picture naming for pictures of decreasing was most associated (in regression analysis and in subtraction analysis) with activation in posterior left temporal regions. In VBM work with semantic dementia, Grossman and colleagues have demonstrated association with inferior and anterior temporal lobe. In separate work from our laboratory, correlation of anomia with cortical thinning in a large set of Alzheimer's Disease subjects (n = 180) in the ADNI (Alzheimer's Disease Neuroimaging Initiative) study, similarly demonstrated largely anterionr LTL localization which correlated with degree of anomia. Thus a distinction between posterior sites most associated with activation in normal individuals, and anterior temporal correlations with anomia in various forms of dementia, appears to be the rule

rather than the exception. Various hypotheses will be put forward to explain this discrepancy, including technical features of activation studies, and compensatory mechanisms after brain damage.

23. 10:15 a.m. -11:15 a.m.

An electrophysiological investigation of word learning across the hemispheres

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In recent years there has been increasing interest in the neural correlates of word learning in adult's native language. Numerous studies have shown that the N400, which is an electrophysiological index of semantic expectancy and integration, is sensitive to rapidly acquired information about a novel word's appropriate usage and meaning. Additionally, when the N400 component has been used as an index of novel word acquisition, it reflects differences in knowledge acquired due to variation in the strength of contextual constraint in which a word is initially exposed. The possibly differential contributions of the two cerebral hemispheres to these word learning effects remain unknown. We explore the impact of initial learning context on how this knowledge is represented across the hemispheres, by using a hemifield presentation paradigm in combination with ERP recordings. Twenty-four college-aged participants first saw via central presentation (to both hemispheres) sentence contexts that strongly or weakly constrained the meaning of sentence-final word – either known or unknown (novel). For example, a high constraint sentence context might be: "Peter sat gaping at the centerfold. He asked his friend if he could borrow the MAGAZINE/YERGE," while a low constraint context might look like: "The package was rectangular and heavy and suspiciously academic. Bianca was disappointed that her uncle was giving her a BOOK/SHUS." The impact of initial context on hemispheric differences in word knowledge was subsequently assessed via a lateralized semantic priming task. In the priming task, known and unknown words appeared centrally as primes for synonymous (e.g. yerge or magazine would prime MAGAZINE) or unrelated target words (e.g. yerge or magazine would prime ACCIDENT) that were laterally presented to the right visual field / left hemisphere (RVF/LH) or left visual field / right hemisphere (LVF/RH). In this way, we could probe how each hemisphere represents newly acquired words. Figure 1 shows that priming effects were observed in the N400 window (300-500ms) as well as in a subsequent positive-going wave (500-900 ms). As expected, smaller N400 amplitudes were elicited by target words preceded by identical (vs. unrelated) Known words, regardless of visual field of presentation When Unknown words served as primes, N400 modulations to synonymous target words was found only if the unknown word had been acquired under High sentential constraint; targets in the LVF/RH elicited both a small N400 effect and modulation of a subsequent late positivity whereas those presented in the LVF/RH elicited modulation only on the late positivity. Unknown words that were initially seen in Low constraint contexts showed priming effects in a late positivity in the RVF/LH only. Strength of contextual constraint clearly has an important impact on the hemispheres rapid acquisition of novel word meanings. The N400 modulation for novel words under strong contextual constraint in the LVH/RH only is in line with current views of word representation in the right hemisphere as "coarse," "diffuse," or "distributed." More extensive and bilateral semantic processing seems to come in later.

24. 11:30 a.m. - 12:30 p.m.

Implicit and explicit mechanisms of word learning in a narrative context

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The vast majority of word meanings are learned simply by extracting them from context, rather than by rote memorization or explicit instruction. Although this skill is remarkable, little is known about the brain mechanisms involved. In the present study, ERPs were recorded as participants read stories in which pseudowords were presented multiple times, embedded in consistent, meaningful contexts (referred to as meaning condition, M+) or inconsistent, meaningless contexts (M-). Word learning was then assessed implicitly using a lexical decision task and explicitly through recall and recognition tasks. Overall, during story reading, M- words elicited a larger N400 than M+ words, suggesting that participants were better able to semantically integrate M+ words than M- words throughout the story. In addition, M+ words whose meanings were subsequently correctly recognized and recalled elicited a more positive ERP in a later time-window compared to M+ words whose meanings were incorrectly remembered, consistent with the idea that the late positive component (LPC) is an index of encoding processes. In the lexical decision task, no behavioral or electrophysiological evidence for implicit priming was found for M+ words, though real English words showed some evidence of implicit priming. In contrast, during the explicit recognition task, M+ words showed a robust N400 effect. The N400 effect was dependent upon recognition performance, such that only correctly recognized M+ words elicited an N400. This pattern of results provides evidence that the explicit representations of word meanings can develop rapidly, while implicit representations may require more extensive exposure or more time to emerge.

25. 10:15 a.m. -11:15 a.m.

An items-level event-related potential analysis of initial and later stages of sentence comprehension in younger and older adults

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Age-related changes in language comprehension proceed along multiple trajectories. For example, it has been shown that while word-level processing seems similar for younger and older adults, quantitative and qualitative changes are seen at higher levels of processing, such as in the use of sentential context. Electrophysiological studies have shown that older adults are delayed in the initial impact of sentential context on word processing by as much as several hundred milliseconds. Further, these studies have demonstrated that older adults rely on a different configuration of neural mechanisms, as they are less likely to engage in an anticipatory, predictive mode of comprehension compared to young adults. In this study, we used the event-related brain potential (ERP) to examine the effects of the amount of contextual information for sentence-final words with a continuous parametric manipulation of cloze probability (an empirically determined measure of the predictability of a word in its sentence context). We used an items-level approach to investigate processing in young adults with a more fine-grained examination than has been used before, and to compare these findings to those from older adults. We find that, concordant with prior studies in young adults, cloze probability has an inverse, linear relationship with the amplitude of the N400, an ERP component reflecting initial semantic access elicited by meaningful stimuli such as words. These findings are taken as evidence that increased contextual information facilitates word processing. For older adults, increased cloze probability is also associated with smaller (and delayed) N400s, but overall, older adults show less facilitation from context, particularly for weak and moderate levels of cloze, also consistent with other studies. The change in the use of contextual information is attributed to the decreased reliance on beneficial top-down predictive processing for older adults. Both groups also show a later effect in the form of a left-lateralized frontal negativity, specific to moderately strong contexts for young adults, but also in very strong contexts for older adults. Using an items-level analysis, we find that the negativity is larger for sentences with fewer possible completions, as determined by norming. We interpret the effect as reflecting effort associated with reinterpretation when multiple interpretations of a sentence are likely. We hypothesize that the engagement of predictive mechanisms by younger adults allows them to more easily converge on a single interpretation in very strong contexts, mitigating the need to engage in reinterpretation compared to older adults. Thus, age-related changes in comprehension can be compounded and lead to differential engagement of resources for older adults, resulting in qualitatively different processing strategies.

26. 11:30 a.m. - 12:30 p.m.

White matter pathways subserving the language comprehension network

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Language comprehension is subserved by a left peri-slyvian network. Lesion (Dronkers et al., 2004) and functional imaging (Binder et al., 2009) studies have identified the middle temporal gyrus (MTG), anterior superior temporal gyrus (STG), posterior superior temporal sulcus (STS) and the angular gyrus (AG), orbital part of inferior frontal gyrus (BA 47) and the middle frontal gyrus (BA 46) as key nodes in this network. Here, we assessed the structural and functional connectivity of the regions that were to be found to be critical for sentence comprehension in a voxel-based lesion-symptom mapping analysis (Dronkers et al., 2004). We used diffusion imaging and resting state functional MRI data from healthy subjects as well as lesion data from aphasic patients. Fiber tractography and functional connectivity analyses indicated that MTG, anterior BA 22, STS/AG and BA 47 comprise a richly interconnected network. The inferior fronto-occipital fasciculus, inferior longitudinal fasc., superior longitudinal fasc. and middle longitudinal fasc. were found to be the white matter pathways that are critical for language comprehension (Fig 1). These findings highlight the importance of long association fiber systems for the integrated functioning of the cortical regions which together support comprehension (Duffau, 2008, Saur et al., 2009), and have implications for the diagnosis and recovery of aphasic patients with comprehension deficits.

27. 10:15 a.m. -11:15 a.m.

Electrophysiological investigation of argument structure processing in healthy and agrammatic aphasic adults

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Introduction: Successful sentence comprehension requires that the information associated with the verb such as number and type of arguments is processed (Friederici & Frish, 2000; Friederici & Meyer, 2004; Frisch, Hahne, & Friederici, 2004; Thompson et al., 2009). Previous studies indicate that verbs are highly tied to their arguments. Verbs prime for their arguments and automatically activate their argument structure during sentence processing (Ferretti et al., 2001; Shapiro et al., 1991). However, research shows that language disorders resulting from brain damage can slow down or

interfere with these processes (Blumstein et al., 2000; Friederici & Kilborn, 1989; Kim & Thompson, 2004). Event related potentials (ERPs) can be particularly useful in studying thematic aspects of sentence processing because they provide excellent temporal resolution in order of milliseconds. ERP data from patients with Brocaís (agrammatic) aphasia indicate that these individuals do not demonstrate left anterior negativity (LAN) to syntactic violations, although late centroparietal positivity (P600) and N400 to semantic violations are present (Friederici et al., 1998, 1999; Hagoort et al., 1996). In the present study ERPs were examined while healthy adults and patients with stroke-induced agrammatic aphasia made acceptability judgments to auditorily presented sentences. The aim of the study was to investigate on-line processing of verb argument structure in individuals with Brocaís aphasia and concomitant agrammatism. Methods: ERP was used to study processing of argument structure during sentence comprehension in healthy adults (n = 11) and patients with agrammatic aphasia (n = 8), by recording ERP responses while participants listened to sentences containing arguments structure violations (e.g., Susan sneezed the doctor and the nurse*). We also included conditions examining structures with semantic (Susan visited the doctor and the socks*) and syntactic errors, for comparison (e.g., Susan visited the doctor the nurse*). Results: For the healthy control participants argument structure violation elicited a biphasic N400-P600 response and bilaterally distributed anterior negativity, with increased negativity (N400 response) found in the semantic mismatch condition at central and parietal sites, and P600 found in the syntactic violation condition. Analysis of the agrammatic patients indicated attenuated but relatively preserved N400 to semantic violations and P600 for the syntactic condition. However, ERP responses to the verb argument structure mismatches (LAN) were delayed in this patient group, as compared to normal controls. In contrast, they displayed normal P600 effect. Conclusions: Preliminary findings indicate that in healthy adults processing of semantic and argument structure information in sentence context is associated with distinct electrophysiological responses. Further, disorders of language processing are associated with different patterns of responses to semantic, syntactic, and argument structure anomalies. Individuals with agrammatic aphasia are sensitive to semantic violations; however, they are delayed in assigning thematic relations based on verb argument structure requirements. The processes of syntactic reanalysis and repair as reflected by P600 seem to be preserved in this population. The finding that argument structure processing is associated with N400-P600 pattern is consistent with fMRI studies reporting recruitment of posterior regions for argument structure processing.

28. 11:30 a.m. - 12:30 p.m.

Agrammatic comprehension and activation changes caused by a glioma in the left frontal cortex: The fronto-temporal network revealed by fMRI

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In our previous functional magnetic resonance imaging (fMRI) study, we used a picture-sentence matching task with different sentence types, and demonstrated that the opercular and triangular parts of the left inferior frontal gyrus (L. F3op/F3t), left lateral premotor cortex (L. LPMC), and the left posterior superior / middle temporal gyrus (L. pSTG/MTG) were selectively involved in syntactic processing of sentences (Kinno et al., 2008). Using the same paradigm, we have recently found that a glioma in L. F3op/F3t or L. LPMC is sufficient to cause agrammatic comprehension (Kinno et al., 2009). The present study is conducted to clarify the functional connections of these two syntax-related regions in the fronto-temporal network of sentence processing by examining activation changes caused by a glioma in the left frontal cortex. We examined 21 patients with a glioma in L. F3op/F3t, L. LPMC, and other left frontal regions, as well as normal controls. Our task included three main conditions of sentence types: canonical / subject-initial active sentences (AS: "○ pushes □"), noncanonical / subject-initial passive sentences (PS: "□ is affected by ○'s pushing it"), and noncanonical / object-initial scrambled sentences (SS: "As for □, ○ pushes it"), and one sentence control condition: subject-initial active sentences with intransitive verbs (SC: "○ and □ run"). Activation changes were measured with fMRI and analyzed with SPM8. An analysis of variance (ANOVA) with two factors (glioma location [L. F3op/F3t-damaged patients, L. LPMC-damaged patients, other patients] × condition [AS – SC, PS – SC, SS – SC]) revealed a significant interaction of glioma location by condition in L. F3op/F3t, L. LPMC, and L. pSTG/MTG (FWE corrected, $p < 0.05$). In L. F3op/F3t (Figure A), L. LPMC (Figure B), and L. pSTG/MTG (Figure C), the normal controls and other patients showed condition-selective activations (paired t-test; $p < 0.05$), while the L. F3op/F3t- and L. LPMC-damaged patients did not show such selectivity, indicating the disruption of normal connections among these three regions due to a glioma. Significantly enhanced activation in L. F3op/F3t for L. LPMC-damaged patients (Figure A) and enhanced activation in L. LPMC for L. F3op/F3t-damaged patients (Figure B) suggested the existence of reciprocal inhibitory connections between L. F3op/F3t and L. LPMC. Moreover, significantly reduced activation in L. pSTG/MTG for L. F3op/F3t-damaged patients (Figure C) suggested the existence of an excitatory connection from L. F3op/F3t to L. pSTG/MTG. These results demonstrate the visualization of functional connections in the fronto-temporal network of sentence processing for the first time, further clarifying that the disruption of the network inevitably leads to marked symptoms of agrammatism. References

Kinno, R., Kawamura, M., Shioda, S., & Sakai, K. L. (2008). Neural correlates of noncanonical syntactic processing revealed

by a picture-sentence matching task. Human Brain Mapping 29, 1015-1027. Kinno, R., Muragaki, Y., Hori, T., Maruyama, T, Kawamura, M. & Sakai, K. L. (2009). Agrammatic comprehension caused by a glioma in the left frontal cortex. Brain and Language 110, 71-80.

29. 10:15 a.m. -11:15 a.m.

Analysing the representational content of object representations using magnetoencephalography: Testing category-specific and feature-based accounts of semantic knowledge

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Our ability to name visual objects rests upon the ability to visually decode the stimulus and activate the appropriate semantics before naming processes can begin. Current theories regarding the organisation of semantic knowledge in the human brain can be divided into two broad classes; those claiming meaningful information is contained in category-specific stores (Caramazza & Shelton 1998, Mahon et al., 2009), and feature-based accounts that argue for a more distributed system where meaningful representations are embodied by their semantic and perceptual features (McRae, de Sa & Seidenberg, 1997, Tyler & Moss, 2001). A key claim of feature-based accounts is that statistical measures that characterise the relationships amongst features, both within and across concepts, provide an explanation of apparent category-specific effects. To test the efficacy of category-specific and feature-based models to account for neural data, and to determine the temporal sequence of these effects, we apply the principles of multi-voxel pattern analysis (MVPA; commonly used with fMRI data) to spatiotemporal patterns recorded with magnetoencephalography (MEG). The MEG signals were recorded while participants named objects taken from the McRae et al. (2005) feature norms. Representational similarity analysis (RSA; Kriegeskorte, Mur & Bandettini, 2008) was applied to MEG data and statistically compared to theoretical perceptual and semantic models. MEG signals were found to reflect the perceptual similarity of objects after approximately 100 ms showing that early responses contained information about objectsí perceptual properties. We found significant effects of feature-based models between 150 and 250 ms. Specifically, the MEG signals contained information about number of features (NoF), the strength of feature co-occurrence, and the relative amount of shared/distinctive information. Finally, we found significant effects of both the object-category and shared/distinctive models beginning after 300 ms. Comparisons of the two models revealed that the shared/distinctive model accounted for more of the variance in the MEG data than the object-category model. Our results highlight both the transition from perceptual to semantic encoding of information over time and that semantic models, based on statistical distributed feature-based accounts, provide more explanatory power than object-category models. Therefore our results provide strong support for feature-based representations of semantic knowledge. In addition we show the application of RSA to spatiotemporal MEG patterns can reveal critical information about the temporal evolution and nature of object representations, while providing a valuable method to directly test between competing theoretical accounts of the neural basis of object representations.

30. 11:30 a.m. - 12:30 p.m.

Individual differences in effects of lexical association in auditory sentence contexts: An ERP study

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Previous work has shown that effects of lexical association in sentential contexts vary as a function of working memory capacity in reading (Van Petten, 1993; Van Petten et al., 1997). Our study aimed to further explore this in the auditory modality using ERPs as well as a battery of five behavioral measures. We recorded ERPs while participants listened to sentences containing embedded associated (e.g. apples and oranges) or unassociated (e.g. apples and bread) word pairs. All sentences were congruent; association strength averaged 39.8%, based on pretest ratings (see Camblin et al., 2007) and the Edinburgh Associative Thesaurus (Kiss, Armstrong, Milroy & Piper, 1973). Targets were matched across conditions on word length and frequency (Francis & Kucera, 1982). In addition, all participants completed a Listening Span task (adapted from Daneman & Carpenter, 1980), a Stroop task (adapted from Van Veen & Carter, 2005), a Digit Span task, a Conceptual Span task (adapted from Haarmann et al., 2003; 2005), and the Nelson-Denny standardized vocabulary and comprehension tests. Sessions always began with the ERP portion of the experiment, followed by the behavioral battery in pseudo-random order such that each task appeared in all presentation positions (this was done in order to combat performance differences across tasks due to order of presentation). Across all participants, a robust N400 effect of association was observed, with unassociated target words being significantly more negative than associated targets ($p = 0.002$) in the canonical N400 time window (300-500ms post word onset). This shows that at the group level, participants are rapidly sensitive to lexical associative relationships between words in a sentence, even when both associated and unassociated targets are congruent with the sentence context. However, our results suggest that multiple factors influence individual differences in the latency and distribution of the lexical association effect for

words embedded in spoken sentences. Specifically, early N400 effects may be due to more automatic processing of lexical associations, while later N400 priming effects may reflect a ìmixed bagî of processes, including more controlled processing (consistent with higher control and better Nelson-Denny performance correlating with late N400 priming effects). This may have implications for the functional significance of the N400 effect, such that early, more automatic effects may be best explained by lexical retrieval accounts (e.g. Kutas & Federmeier, 2000; Lau et al., 2008; Van Berkum, 2009), and later, more controlled effects may be more consistent with integrative accounts (e.g. Hagoort et al., 2004).

31. 10:15 a.m. -11:15 a.m.

ERP evidence for hemispheric involvement in semantic integration and constraint violation processing

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In previous work (DeLong, 2009) we found evidence for an event-related brain potential (ERP) response in the form of an enhanced late positivity (LP) between 500-900 ms to centrally presented low cloze probability written words continuing strongly, but not weakly, constraining sentences. These results are compatible with a predictive language parser that engages in additional processing when pre-activated semantic trajectories are disconfirmed by the input. This effect occurred in conjunction with the N400, a well documented ERP component whose amplitude decreases as a function of increasing semantic fit, but which is unaffected by degree of contextual constraint violation. Following the proposal that left hemisphere (LH) language processing is more anticipatory and right hemisphere (RH) processing more bottom-up (Federmeier & Kutas, 1999), we surmised that the LP/N400 dissociation might shed light on the contributions of the individual cerebral hemispheres in anticipatory language comprehension. In particular, if the LH processes language more predictively, then we would expect more pronounced LP effects for right visual field (RVF)-LH than left visual field (LVF)-RH processing of constraint violations in a visual hemifield study. Graded sensitivity to contextual semantic fit (indexed by the N400), however, should be similar for the two hemispheres if both are sensitive to message level constraint – a point which has been debated in the literature. To this end, we conducted an ERP study using the visual half-field paradigm. The EEG was recorded as young adults read sentence pairs with noun targets randomly presented to either the left or right of central fixation. Stimulus materials manipulated sentential constraint and offline expectancy over their full ranges (0-100%). In general, our prediction of a greater LP to more constraint-violating low cloze nouns for RVF than LVF presentation was upheld. Over several types of analysis, the LP findings indicated that the LH – more than the RH – exhibits a graded sensitivity to violations of constraint, consistent with comprehension models positing more top-down processing for the LH. Contrary to the RH/integrative proposal, though, we observed that when contextual constraint was at ceiling (for the most constraining contexts), RH processing, too, reflected a consequence to pre-activating but not receiving upcoming linguistic information. Additionally, we observed that the graded inverse relationship of cloze probability with N400 amplitude ($r \approx 0.9$) typical of centralized presentation was similarly high and widely distributed over the scalp for both RVF- and LVF-initiated processing. These results signaled that both the LH and RH are sensitive to message-level contextual cues and experience similar levels of integration ease/difficulty for incoming words. In sum, while both hemispheres seem to benefit from the buildup of sentence (message) level constraint, the LH appears to show a greater sensitivity to pre-activating but not receiving linguistic input. These findings are consistent with cognitively broader interpretations of the LH being biased toward processing based on perceived probabilities of upcoming events (the role of "interpreter"), in contrast to the RH processing more "veridically", with less generalization away from the input (e.g., Gazzaniga, 2000).

32. 11:30 a.m. - 12:30 p.m.

Unpacking the effect of effector: The effect of using the dominant versus non-dominant effector to respond to embodied language

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Research on embodied cognition involves determining how the interaction between the environment and body affects the processing and representation of conceptual knowledge. Some researchers have used body-object-interaction (BOI) ratings as a measure of how easily the human body can physically interact with an object, and thus the extent of embodiment of an object. Siakaluk et al (2008) found that words rated high in BOI (e.g., mask) are responded to faster and more accurately in a semantic categorization task than are low BOI words (e.g., ship). Objectives: The goal of our research was to examine the behavioural effects of the effector stimulus (objects used by the arm versus leg) and the dominant versus non-dominant effector response (i.e., responding with the dominant arm versus dominant leg; or with the non-dominant arm versus non-dominant leg) and whether the behavioural effects are related to BOI ratings. Experiment 1 Methods: A semantic categorization task (SCT; ìis the object used by the arm or leg?î) was used to examine effector stimulus and dominant response effects. In one block of trials, participants responded with their dominant hand to hand/arm stimuli and their dominant foot to leg/foot stimuli (congruent effector-stimulus response), while in the other block of trials participants responded with their dominant hand to leg/foot stimuli and their dominant foot to

arm/hand stimuli (incongruent effector-stimulus response). Experiment 2 Methods: The same SCT as described in Experiment 1 was used to examine effector stimulus and non-dominant response effects. In one block of trials, participants responded with their non-dominant hand to hand/arm stimuli and their non-dominant foot to leg/foot stimuli (congruent effector-stimulus response), while in the other block of trials participants responded with their non-dominant hand to leg/foot stimuli and their non-dominant foot to arm/hand stimuli (incongruent effector-stimulus response). Experiment 1 Results: When participants responded with either their dominant hand or foot, with either a congruent or incongruent effector response, there was a significant negative relationship between BOI and reaction time (RT). Experiment 2 Results: When participants responded with their non-dominant hand to arm/hand stimuli there was a significant negative relationship between BOI and RT. Furthermore, when participants responded with their non-dominant leg to foot/leg stimuli there was a significant negative relationship between BOI and RT. However, when the stimulus was incongruent to effector response (i.e., non-dominant hand responding to foot/leg stimuli) there was no relationship between BOI and RT. Conclusion: Our results show that when participants respond with their dominant effectors, regardless of effector-stimulus response congruency, there is a significant relationship between how embodied an object is (high BOI) and how quickly a participant can respond. However, when participants respond with their non-dominant effectors, the incongruent effector-stimulus response does not show a relationship between embodiment of the object and RT. Our results provide support for the embodied cognition framework; however, our results further suggest that the effector-stimulus response congruency is important.

33. 10:15 a.m. -11:15 a.m.

Neural representation of word meaning: An fMRI study

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The neuroanatomic representation of word meaning has proven elusive. While some studies emphasize perceptual feature knowledge in modality-specific association cortex, other work underlines the contribution of amodal cortical regions to word meaning. We assessed the neural basis for perceptual and amodal components of word meaning with fMRI. Eighteen young adults judged whether two printed words (e.g. LIME CELERY) share a value of a perceptual attribute (e.g. COLOR). We probed color and shape each in 80 pairs of concrete natural and artifact words matched across categories for lexical frequency and familiarity. Half of the words matched in the indicated feature and half did not (according to pretesting). A control condition assessed whether pairs of pseudowords matched according to an orthographic feature (e.g. ending in the same letter). Functional localizers for color and shape were derived from judgments of pairs of meaningless blobs. We observed activation of partially distinct areas of visual association cortex for word judgments for each perceptual feature: Color judgments activated ventral temporal cortex (peak -50, -54,-12; $p<.002$ FWE); shape judgments activated ventral temporal-occipital cortex (peak -40, -70, -24; $p<.002$ FWE). Each of these judgments overlapped with judgments of the corresponding perceptual feature of meaningless blobs. These findings are consistent with the contribution of visual association cortex to the representation of perceptual knowledge in word meaning. Moreover, relative to pseudoword judgments, all judgments of word pairs recruited left dorsolateral prefrontal cortex (color peak -44, 46, 0; shape peak -48, 50, -2; both $p<.001$ uncorrected). This area was not recruited during judgments of meaningless blobs. This observation is consistent with the activation of an amodal cortical region during judgments of word meaning. Taken together, our findings support the hypothesis that a large-scale neural network involving both perceptual and amodal cortical regions supports the neural representation of word meaning.

34. 11:30 a.m. - 12:30 p.m.

The neural basis of semantic control: Evidence from neuropsychology and TMS

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Assigning meaning to words, sounds, people and objects requires stored conceptual knowledge plus executive mechanisms that shape semantic retrieval according to the task or context. Despite the essential role of semantic control in cognition, its neural basis remains unclear. Neuroimaging and patient-based research has emphasised the importance of left inferior frontal gyrus (IFG) ñ however, impaired semantic control can also follow left temporoparietal lesions, suggesting this function may be underpinned by a large-scale cortical network. We used repetitive transcranial magnetic stimulation to disrupt processing within two potential sites in this network ñ IFG and posterior middle temporal cortex. Stimulation of both sites selectively disrupted executively-demanding semantic judgements: semantic decisions based on strong automatic associations were unaffected. Performance was also unchanged in non-semantic tasks ñ irrespective of their executive demands ñ and following stimulation of a control site. These results reveal that an extended network of prefrontal and posterior temporal regions underpins semantic control.

35. 10:15 a.m. -11:15 a.m.

Prefrontal cortex supports the coordination of a pronoun's referent during discourse

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Individuals regularly encounter pronouns with underspecified meaning in daily language (e.g., "The client chased the visitor. He laughed"). We propose a two-component model for coordinating the meaning of a pronoun with an interlocutor. First, language-specific mechanisms are required to support lexical semantic and grammatical processes. Second, social decision-making mechanisms are required to coordinate a pronoun's meaning with an interlocutor during conversation. We argue that there is value associated with coordinating meaning and orbital frontal cortex (OFC) has been demonstrated to contribute to value assessment. Additionally, theory of mind is required to take the perspective of an interlocutor and rostral medial prefrontal cortex (rmPFC) has been demonstrated to support theory of mind. In 2 experiments we asked participants to determine a pronoun's referent in mini-discourses, as above. We emphasized that participants must coordinate their choice of referent with the referent preferred by 100 previous participants. Participants completed 4 experimental sessions, each comprised of 8 blocks. Half of the items contained two gender-neutral nouns and participants were rewarded with monetary units for each item if they coordinated with the previous participants. We randomly rewarded responses in experimental sessions 1 and 3, rewarded a subject response in session 2, and rewarded an object response in session 4. The remaining experimental items contained a male and female noun and participants were rewarded for selecting the correct referent. In Experiment 1 we monitored behavioral performance in behavioral-variant frontotemporal dementia (bvFTD) patients, who have a social disorder due to OFC and rmPFC disease, but no aphasia. In the subject- and object-reward sessions, controls successfully coordinated their responses in a manner consistent with the reward pattern by the 4th of 8 blocks. bvFTD did not choose the rewarded referent until the 7th block of the subject-rewarded session and did not differentially choose the rewarded referent in the object-rewarded session. bvFTD patients thus have difficulty coordinating their choice of a pronoun's referent. In Experiment 2, we monitored BOLD fMRI during passive reading of these discourses in early blocks (1-4) and later blocks (5-8) within the subject- and object-reward sessions. In early minus late blocks we observed OFC activation, consistent with assessment of reward. In late minus early blocks we observed rmPFC activation, consistent with the hypothesis that taking the perspective of an interlocutor is required to maintain coordination that is consistent with the reward. Together, these experiments emphasize the role of prefrontal cortex to support social decision-making required to coordinate meaning during a discourse.

36. 11:30 a.m. - 12:30 p.m.

A picture is worth a 1000 words, sometimes: ERP differences in nouns and verbs during a picture identification task

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Nouns and verbs seem to activate distinct cortical networks, however, the underlying cause of this difference is under debate (Cappa & Perani, 2003). Some researchers claim that conceptual differences between nouns and verbs drive this effect (Bird, Howard, & Franlin, 2003). However, there are also phonological, prosodic, and word length differences that may contribute to the noun-verb distinction (Black & Chiat, 2002). In this study, we investigate the processing of noun and verb concepts distinct from the influences of their linguistic forms by measuring ERP responses elicited when a word is followed by a congruent or incongruent picture representing the concept. Thirty-one right handed, English speakers completed an EEG task, in which they listened to a word followed by a picture and then pressed buttons to indicate if the label matched the picture or not. The pictures were still images normed to elicit specific verbs (Stark, 1994). The study included only pictures depicting both an object and an action with early-acquired noun and verb referents (e.g., sit and chair). There were 52 items in each of four conditions (noun/ verb congruent, noun/verb incongruent). Each picture was used once per each condition acting as its own control. Pictures after semantically congruent versus incongruent sentences elicit two ERP effects of interest: an N300-N400 and a later posterior positivity (Ganis, Kutas, & Sereno, 1996; L¸dtke et al, 2008). Investigating the early effect, a 3 (Location: frontal, central, posterior) X 2 (Word Class: noun, verb) X 2 (Congruency: congruent, incongruent) ANOVA on the amplitudes between 325-450 ms revealed a significant interaction, $F(2, 62) = 19.67$, $p < 0.0001$. Post-hoc analyses revealed significant negative deflections for incongruent nouns and verbs over frontal and central areas. Over the posterior areas, there was no significant congruency finding for nouns, but for verbs the incongruent items elicited a significant positive effect. Inspection of the waveforms indicates that this is the beginning of the late positivity. An analysis of these posterior effects between 325 ms and 750 ms revealed a significant Word Class - Congruency interaction, $F(1, 62) = 11.76$, $p < 0.001$. T-tests revealed no congruency differences for nouns, but a significant difference for verbs, $t(31) = 5.707$, $p < 0.0001$. These results revealed an N300-N400 effect for both nouns and verbs, but a late positivity only for verbs. L¸dtke et al (2008) argued that this late positivity is similar to a P600. In the current study, such an effect could reflect syntactic processes specific to verbs, because verbs hold more grammatical information. Another possibility is that it reveals a reanalysis to

match a picture with the preceding word. Objects often have one preferred basic-level label, while the same event can equally be labeled using multiple verbs (i.e., buy, sell, purchase . . .), When a target action is not seen, after an early response, a reanalysis is performed to attempt to make the verb congruent with the picture. Future studies are needed to determine if this late positivity is driven by syntax or number of potential referents.

37. 10:15 a.m. -11:15 a.m.

The language-number interface in the brain: A complex parametric study of quantifiers and quantities

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Humans and primates share the ability to compute and manipulate quantities, which relies on a common fronto-parietal brain network. However, only humans seem to posses complex linguistic representations of numerosity. Thus, does the processing of numbers and their linguistic representations rely on the same neural structures? Or, alternatively, by which neural interface are the two systems specialised for numerosity vs. language linked to each other, enabling man but not monkey to cope with higher, even abstract quantities? We present neurological evidence for a parietal posterior-to-anterior processing gradient from early numerical analysis to linguistic representations of quantity. The present fMRI study teased apart numerosity processes and semantic representations by having subjects match auditory sentences (phase 1) with visual arrays of circles (phase 2). The sentence contained a quantifier expression (e.g. ìfew of the circles are blueî) which did, nor did not, fit with the actual proportion of circles on the screen. The fit was judged by the subjects in a truth value judgement task. Non-linguistic NUMEROSITY was parameterised by the actual proportion (PROP) of circles in the mentioned colour. Semantic REPRESENTATION was operationalised by reaction time (RT) - a measure of processing difficulty that follows from the structure of the internal number line (i.e., is best described by a logarithmic function in accordance with Weber's Law). Both PROP and RT served as parameters for the modulation of the BOLD signal, thus providing continuous measures of increasing quantity and increasing semantic processing difficulty. Analyses revealed adjacent networks for NUMEROSITY and REPRESENTATION predominantly in left parietal and frontal cortex. NUMEROSITY recruited left posterior intraparietal cortex, whereas REPRESENTATION involved parietal cortex directly anterior to the NUMEROSITY effect, and also more inferior in left supramarginal gyrus. The data suggest a processing gradient in left parietal cortex, extending from posterior-superior to inferior-anterior parietal regions including supramarginal gyrus. This interpretation is further supported by the fact that semantic difference effects were only found in the anterior-inferior REPRESENTATION region. When comparing quantifiers of higher order (e.g. ìmore-than-halfî) vs. first order (e.g. ìmanyî), which pose higher vs. lower processing demands on the semantic system, a distinction was present in the REPRESENTATION region but not in the NUMEROSITY region. This distinction reveals linguistic structure, demonstrating how semantic processing in inferior-anterior parietal cortex differs from visual-numeric processing in superior-posterior parietal cortex. Our data thus reveal a number-language interface in left parietal cortex, containing increasingly abstract stages in numerical processing from visual impression to semantic representation. Most crucially, they imply that visual numerosity is translated into amodal semantic number representation along this gradient. Most crucially, they imply that visual numerosity is translated into amodal semantic representation along this gradient. The existence of such neural interface region possibly explains why man but not monkey can deal with high, abstract quantities.

38. 11:30 a.m. - 12:30 p.m.

Inter-subject correlations during comprehension of narratives, sentences and words

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Introduction: Conversation partners develop common ground to understand each other. Development of such a common ground may depend on common brain activation patterns and such processes might not occur when high-level build-up of a common representation is not possible. In this functional MRI (fMRI) and magneto-encephalography (MEG) study, we performed a first test of this hypothesis by comparing correlations in brain activity across subjects when they were listening to a story to when they were listening to stimuli lacking such a coherent overall representation. Methods: Twelve participants listened to 7-minute stimuli in the MRI-scanner: a story, a sentence list, a word list, reversed speech, and a resting state run. The word- and sentence lists consisted of the story materials in a different order (Lerner et al., Human Brain Mapping meeting, 2010). We computed inter-subject correlation maps for each condition by calculating for each voxel for each participant the correlation with the mean of all other participants. We calculated paired-sample T-values by comparing each subject's correlation map in two conditions and conducted randomization tests by permuting the assignment of runs to conditions: for each permutation the cluster with the maximum

summed t-values was inserted in a null-distribution of cluster-weights, thereby solving the multiple-comparisons problem (Maris & Oostenveld, J Neurosci Methods, 2007; van Kesteren et al., PNAS, 2010). This allowed for direct statistical comparison between inter-subject correlations in different conditions. Similar analyses were performed on MEG data from the same subjects, we focus on the fMRI data here. Results: Sentences elicited significantly stronger intersubject correlations than words in the bilateral middle temporal gyri, bilateral inferior parietal lobes, bilateral inferior frontal gyri and right precuneus. Stories elicited stronger correlations than sentences in the right inferior frontal gyrus, right superior parietal lobule, and right cuneus. Conclusion: Listening to sentences generates stronger correlations than listening to isolated words in left-hemispheric areas known to be involved in syntactic parsing (a sentence-level process), but also in bilateral areas associated with build-up of semantic representations both at and beyond the sentence level. Several areas showed an additional increased correlation in stories compared to sentences, suggesting some areas are specifically involved in building an overarching representation. These preliminary results highlight the importance of direct statistical comparisons between inter-subject correlations across conditions: they allow direct inferences of differences in common brain activation patterns depending on the type of linguistic input.

39. 10:15 a.m. -11:15 a.m.
Interpreting associative processing of nouns and verbs in the brain: Benefits of item analyses in fMRI

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A critical assumption in cognitive neuroscience relates to external validity; that is, that the results of an experiment generalize to tell us something about the fundamental organizational principles of the brain. Generally we assume this is true with regard to both a population of humans (beyond the sample of subjects tested) and a population of stimuli (beyond the sample of specific items tested). However, despite decades of precedence for assessing the statistical validity of both subject and item inference in psycholinguistic research, to date only a handful of neuroimaging studies assess the latter (e.g., Bedny et al., 2007; Yee et al., 2010). This is unfortunate, as including item analyses permits inferences about non-tested items. As an added benefit, item-level estimates of neural activity provide another independent variable with which to assess the influence of item-level factors. In the current fMRI study we used both subject and item analyses to investigate associative processing of nouns and verbs in the brain. Associative processing requires not only activating concepts from their prototypical lexical indices, but appreciating the relationships between these concepts. Although grammatical class may influence the brain networks involved, we hypothesized that lexical-semantic factors (i.e., imageability, category structure) moderate associative processing. For each trial, three words appeared on the screen. Participants were instructed to look at the top word, and then select which of the two bottom words was most closely conceptually associated. We used 51 Noun triads from the Pyramids and Palm Trees task, a common test of semantic processing. We also used 49 verb triads from the Verb Association Test; these were equally divided between Action Verbs (e.g., run, kick) and Cognition Verbs (e.g., think, wonder). We also included a nonword baseline task to control for low-level orthographic processing and decision-making. We performed two complementary analyses on the data. For the subject analysis, each condition was modeled as a single regressor. For the item analysis, each trial was modeled as a single regressor, and then averaged across subjects to obtain an estimate of neural activity for each item. For both analyses, the resulting first-level parameter estimates were entered into second-level analyses. To assess where associative processing differed by word type we performed whole-brain pairwise comparisons for both subject and item analyses, shown in Figure 1A. The conjunction reflects voxels significant for both subject and item analyses, and thus are likely to generalize to both new participants and new items. Results suggest angular gyrus, left IFG, and right temporal cortex are most critical for noun processing; no additional activations were required for Action Verbs > Nouns; and a region of left STS was consistently more active for Cognition Verbs > Action Verbs. In addition we were able to perform regression analyses on the item-level parameter estimates, an example of which is shown in Figure 1B. Together our results show dissociations between and within grammatical class in associative processing, and more generally illustrate the utility of item analyses in functional neuroimaging, particularly when item-level psycholinguistic information is available.

40. 11:30 a.m. - 12:30 p.m.
Chronic hypoperfusion in aphasia: A possible relationship to behavioral variability

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Objective: The literature reports widely variable performance by aphasic patients on both receptive and expressive measures (Gordon, 1998), within and across aphasia typologies. Despite prior research that has attempted to link behavioral deficits and patient variability to site and extent of neural lesion (Dronkers et al., 2004), a good deal of dis-

agreement remains in the literature. The current project investigates a possible neurophysiological source of this variability: cerebral blood flow (CBF). In this study, we asked whether hypoperfusion (decreased CBF in structurally intact neural regions) underlies seemingly aberrant behavioral patterns among individuals with chronic aphasia (> 1 year post-onset). Methods:Participants: As examples of our approach, data are offered from three individuals with chronic aphasia, each of whom present with distinct symptomotology based on standardized assessments (e.g. BDAE) and clinical consensus (see Table 1). All received tests of auditory comprehension Procedure: Neuroradiological examinations measured extent and localization of neural trauma as well as CBF using an arterial spin labeling methodology (ASL-FAIR; Kwong et al., 1995). Each participantís neural lesion was manually outlined and regions of neural damage were analyzed. Results: All 3 participants incurred approximately the same extent of overall neural trauma (≈14%). LHDFY presented with the most severe aphasia (Brocaís) diagnosis and has the largest lesion of the group (see Table 1). He performed below chance on a test of non-canonical sentence comprehension (SOAP) but evinced somewhat better performance than LHDWC on the BDAE auditory comprehension task. Moreover, the percent involvement of L-IFG is smaller in LHDFY than that found in the other two patients. In order to understand this discrepant pattern, CBF was examined within intact regions of BA44 and 45 in left inferior frontal gyrus (LIFG), regions typically associated with complex sentence comprehension. A region of interest (ROI) analysis extracted CBF values in each participant, and CBF ratios were calculated by dividing CBF in LIFG by the CBF in the right hemisphere homologue (a region of the same number of voxels). Perfusion ratios are shown in Table 1. LHDFY evinced a much lower perfusion ratio than the other participants, which indicates more severe hypoperfusion in the intact LIFG in this individual than in either LHDWC or LHDPY. Discussion: We find decreased CBF (hypoperfusion) in all three participants, but a more profound deficit in LHDFY, despite the comparable volumes of neurological damage. We suggest that this hypoperfusion may contribute to each individualís pattern of deficits, and in particular may explain LHDFYís greater severity compared to the other participants. These results argue that CBF should be measured in individuals with aphasia, and that a regional analysis of CBF may clarify patterns of deficits and variability in this population.

41. 10:15 a.m. -11:15 a.m.

Testing asymmetries in non-cognate translation priming: Evidence from RTs and ERPs

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We present a further exploration of masked translation priming, with the specific aim of providing information about the time-course of such priming effects from L1 to L2 and L2 to L1. Most important is that we used a somewhat longer prime duration (and thus a longer SOA) than in prior research that found little evidence for priming from L2 to L1 (see Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009, for a recent review of behavioral masked translation priming studies, using the lexical decision task). In this study, English-French bilinguals performed a lexical decision task while reaction times (RTs) and event related potentials (ERPs) were measured to L2 targets (e.g. POMME [APPLE]), preceded by non-cognate L1 translation primes (e.g., apple) versus L1 unrelated primes (Experiment 1a), and vice versa (Experiment 1b; e.g., pomme-APPLE). We investigated whether specific ERP components can provide evidence for the existence of the much debated L2 to L1 priming effect, and its lexical or semantic locus. Finding a N400 effect in this condition would indicate early semantic activation in L2. Significant masked translation priming was observed, indicated by faster reaction times and a decreased N400 for translation pairs as opposed to unrelated pairs, both from L1 to L2 (Experiment 1a) and from L2 to L1 (Experiment 1b), with the latter effect being weaker (RTs) and less longer lasting (ERPs). These clear N400-priming effects indicate semantic involvement during priming in both directions. The asymmetry of the N400 effects is mostly likely caused by the 100-ms processing delay for L2 targets. A translation priming effect was also found in the N250 ERP component, but this effect was stronger and earlier in the L2 to L1 priming direction than the reverse. These asymmetric N250-effects possibly indicate traces of a strong lexical route of processing when priming from L2 to L1.References: Schoonbaert, S., Duyck, W., Brysbaert, M., & Hartsuiker, R. J. (2009). Semantic and translation priming from a first Language to a second and back: Making sense of the findings. Memory & Cognition, 37, 569-586."

42. 11:30 a.m. - 12:30 p.m.

Lexico-semantic processes indexed by the infant N400m rely on similar left frontotemporal language areas as in adults

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Background: Learning to understand language is critical to being human. Although much is known about language development from a behavioral perspective, research on its neural basis has been seriously limited because of the difficul-

ties in assessing functional brain activity during infancy. Consequently, it is unclear whether infants depend on the same underlying neural structures adults use to understand words. Advances in magnetoencephalography (MEG) combined with magnetic resonance imaging (MRI) now make it possible to study this population. This method, dynamic statistical parametric mapping (dSPM), has been extensively validated during language processing in adults. We report the first application of this method to study one-year-old infants, and reveal that lexico-semantic neural processes indexed as the adult N400 event-related component are functional during early stages of word learning and depend on similar brain areas. Methods: During a MEG scan, 12-18months old infants (n=12) watched and listened to pairs of pictures and familiar auditory words that were either congruously (<picture-cat>-<word-cat>) or incongruously matched (<picture-cat>-<word-ball>). Infantsí individual high-resolution structural MRI scans were obtained during natural sleep and used to constrain source estimations of brain activity detected with MEG. Results: Incongruous words evoked a characteristic response that was larger in amplitude than congruous words peaking ~400ms after word onset in left frontotemporal gradiometer MEG channels. dSPM analysis localized generating sources of the differential response to left frontotemporal areas. Region of interest analysis (ROI) confirmed that primarily left temporal areas, including the superior temporal sulcus ($t(11)=2.46$, $p<0.03$), anterior inferior temporal sulcus ($t(11)=2.76$, $p<0.02$) and posterior inferior temporal sulcus ($t(11)=2.97$, $p<0.01$), and temporal pole regions ($t(11)=2.07$, $p<0.06$ trend) were responsible for generating the differential semantic response. In homologous right hemisphere regions, only the anterior temporal pole demonstrated an incongruous > congruous significant response ($t(11)=2.77$, $p<0.02$). Conclusions: Semantically modulated word activity in infants has similar latency, location, and cognitive correlates as is typical for the adult N400 event-related component. The ontogenetic stability of the N400, implies that very similar processes are used for encoding lexico-semantic information across the lifespan. "

43. 10:15 a.m. -11:15 a.m.

Early lexical activation interacts with visual word form processing during word recognition: Evidence from ERPs

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Models of word recognition disagree over whether lexical-semantic representations are accessed within the earliest stages of visual word processing (approximately the first 200 msec). While some neurophysiological (EEG and MEG) studies report that semantic context modulates brain-responses as early as 100-170 msec after word-onset (e.g., [1]), other studies find no evidence for early lexical access (e.g., [2]). "Late-access" proposals posit an initial stage of word recognition, which is sensitive to visual word form and simpler sensory features and precedes lexical-semantic access (e.g., [2],[3]). Late-access models can explain most early effects of semantic context in terms of predictive activation of word-form representations, which is mediated by prior context ([2]). We investigated the neural mechanisms of visual word recognition by recording event-related potentials (ERPs), while participants read sentences like 1-4. Pseudoword targets occurred in contexts that either supported a similar real word (2; supported pseudoword) or did not (3; no-support pseudoword). We also studied illegal non-words (4). 1. She measured the flour so she could bake a cake … CONTROL 2. She measured the flour so she could bake a ceke … SUPPORTED PSEUDOWORD 3. The gardener used a shovel to pile the ceke … NO-SUPPORT PSEUDOWORD 4. She measured the flour so she could bake a srdt … ILLEGAL NONWORD The pseudoword in 2 is similar to a contextually predictable word ("cake"), while in 3 the pseudoword deviates from predictable word-forms (e.g, "dirt" and "sand"). We hypothesized that the pseudoword in 2 would drive early lexical activation (CAKE), mediated by its feature-overlap with the required input and by contextual pre-activation (early-access). This lexical activation may provide rapid top-down feedback that sharpens a prediction for the visual word-form "cake" and allows rapid sensitivity to the discrepancy between predicted and actual input ("cake" vs. "ceke"). Early lexical activation is less likely when orthographic features and context do not converge on a particular word (3 and 4), and prediction-error will be lower than in 2. If word processing is incapable of lexical access during the initial stages of processing (late access), then early brain responses can be mediated only by predictions established prior to a word's onset. Under these conditions, the flagrant prediction-error in 3 and 4 should be detected more rapidly than the minor prediction-error in 2. Consistent with early lexical access, supported pseudowords (2) elicited early brain responses in the form of an enhanced positivity over occipital electrodes at 135 msec (P135), relative to control words (see Figure). No-support pseudowords (3) and illegal nonwords (4) elicited a later enhanced negativity, largest at occipito-temporal electrodes (N170; see Figure). The finding of early sensitivity to small orthographic deviations ("ceke" vs "ceke") is consistent with rapid feedback-dynamics between visual word-form processing mechanisms and higher-level lexical representations. The activation of lexical representations may mediate rapid sharpening of a prediction ("cake"), which enhances prediction-error generated by "ceke". [1] B. Penolazzi, O. Hauk, and F. Pulvermüller, "Early semantic context integration and lexical access as revealed by event-related brain potentials," Biological Psychology, vol. 74, Mar. 2007, pp. 374-388. [2] O. Solomyak and A. Marantz, "Lexical access in early stages of visual word processing: a single-trial correlational MEG study of heteronym recognition," Brain and Language, vol. 108, Mar. 2009, pp. 191-196. [3]

L. Pylkkänen and A. Marantz, "Tracking the time course of word recognition with MEG," Trends in Cognitive Sciences, vol. 7, May. 2003, pp. 187-189.

44. 11:30 a.m. - 12:30 p.m.

Neural correlates of the effects of semantic coherence and derivational family entropy on processing of morphologically complex words

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Objective: During visual lexical decision tasks, the MEG signal has been shown to correlate with various factors of linguistic interest. In particular, at around 300-400 ms post-stimulus onset, the M350 response from the temporal lobe displays many of the hallmarks of lexical access, and the Anterior Midline Field (AMF) has been shown to reflect semantic properties of the combination of words (Pylkkanen & McElree, 2007). In this experiment, we developed a statistical measure of the semantic coherence of morphologically complex words based on the residuals from a regression model involving surface frequency, base frequency, and biphone transition probability. Based on previous research (Moscoso del Prado Martin et al., 2004), we also investigated the influence of derivational family members as indexed through the entropy of their respective lexical frequency distributions, as compared with the surface frequencies of the morphologically complex words. Methods: MEG data was obtained from 12 subjects performing a visual lexical decision task. The stimuli were composed of a monomorphemic stem and suffix. There were 200 real words, 50 each from the suffix families "-er," "-ness," "-ly," and "-able," along with 200 non-words from the English Lexicon Project. Trials consisted of a fixation point displayed for 350 ms, followed by the stimulus displayed for 300 ms. Structural MRIs were obtained from each of the subjects. We used MNE and FreeSurfer to generate cortically-constrained minimum norm estimates for analysis of activity in source space. On the basis of automatically parcellated anatomical regions of interest (ROIs), we investigated the correlation of neural activity in selected regions with various properties of the stimuli. To investigate the M350 response, we used left temporal ROIs, and to investigate the AMF, we used orbitofrontal ROIs. Activity in these ROIs was tested against variables such as base frequency, surface frequency, derivational family entropy, and our statistical measure of semantic coherence. Results: During the time window ~250-400 ms post-stimulus onset, derivational family entropy correlates with activity in the left temporal ROIs. Surface frequency also correlates with activity in this region around 450 ms post-stimulus onset. The sign of the correlations suggests a facilitatory role for these variables. At ~400-500 ms post-stimulus onset, activity in the left orbitofrontal cortex correlates with semantic coherence. Conclusions: The significance of derivational family entropy for a response associated with lexical access supports the notion that suffixed words are decomposed into stems and affixes for recognition. The significance of our statistical measure of semantic coherence shows that orbitofrontal cortex contains a neural signature of the semantic fit of stems and affixes. Discussion of significance: The results of this experiment show that statistical measures based on lexical frequency can provide a window into the spatiotemporally-differentiated stages of neural processing during visual word recognition. Additionally, they provide evidence of the effects of morphological decomposition on lexical access, and argue for an equivalence between the neural basis of semantic composition between words and within words.

45. 10:15 a.m. -11:15 a.m.

Distinct neural mechanisms for puns and non-meaningful sentences

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A pun is a play on words that uses different meanings or similar sounds of words to cause deliberate confusion. Previous research on figurative language processing (metaphors, irony, jokes) often suggested right hemisphere (RH) plays a special role in non-literal language processing. Functional Magnetic Resonance Imaging (fMRI) research also reported RH involvement in anomalous sentence processing. The present study used event-related functional magnetic resonance imaging to investigate potential hemispheric lateralization and neural substrates involved in processing puns and anomalous sentences. Sixteen participants (10 females, 6 males) read either puns (Math teachers have lots of problems), literal (Math teachers have lots of students), or non-meaningful sentences (Math teachers have lots of door handles) and had to press buttons with both thumbs when they finished reading the sentences. Images were preprocessed and analyzed using SPM5 package. Imaging results demonstrated that activation of the opercularis and triangularis of left inferior frontal gyrus (LIFG) was shared by both non-meaningful sentences and puns but not by literal sentences. A direct comparison of the activation for puns versus that for literal sentences revealed significantly greater left-lateralized activation for puns than literal sentences in the opercularis, traingularis and orbitalis of LIFG, the inferior temporal gyrus and the angular gyrus. However, in the non-meaningful sentence condition minus the literal sentence condition, significantly more activations were observed in bilateral inferior frontal, inferior and middle temporal and pre-central gyri, left fusiform gyrus, and supplementary motor area. These results suggest that comprehension of puns involves more left-lateralized regions traditionally reported to be responsible for semantic retrieval and selection, whereas processing of

non-meaningful sentences engages bilateral motor and frontal selection regions, which indicated higher-order cognitive operations typically involved in irony and inference.

46. 11:30 a.m. - 12:30 p.m.

Revisiting the relationship between the P600 and the P300: On the role of decision-making in language comprehension

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The interpretation of the P600 is still controversial – particularly the question of whether it is a member of the domain-general P300 family (e.g. Coulson et al. 1998; Osterhout et al. 1996). Here, we present evidence for the hypothesis that some P600s are instances of the P3b and that they reflect a binary decision-making process by which a word or sentence is categorized (Donchin & Coles, 1988). We hypothesized that a "categorization-P300" in language comprehension should vary (1) with the availability of complete information and, accordingly, the level of confidence in decision-making (Hillyard et al., 1971) and (2) with violations of binarity. In order to test these hypotheses, we reanalyzed the data from three existing ERP studies. Experiment 1 (Kretzschmar et al., 2009) used concurrent EEG-eyetracking measures to modulate the temporal availability of information necessary for categorization. The critical stimuli were antonym relations (X is the opposite of Y) in which the sentence context generates a prediction of one word form and one meaning. Thus, the predicted antonym is categorized based on prelexical (orthographic) and lexical-semantic information. With RSVP presentation, antonyms elicit a P300 in the N400 time window; non-antonyms elicit a P300 following the N400 (Kutas & Iragui, 1998; Roehm et al., 2007). During natural reading, by contrast, prelexical information is acquired parafoveally (before the first fixation on the antonym), whereas lexical-semantic information is acquired foveally (with the first fixation). This temporal dissociation should affect the antonym-P300, since the predictions about the antonym's orthographic form and meaning cannot be met concurrently. Indeed, Experiment 1 showed no parafoveal or foveal P300 to antonyms, but a foveal P300 for non-antonyms. Hence, only if all information sources relevant for categorization are provided simultaneously, can the categorization-P300 occur. Experiments 2 and 3 (Bornkessel-Schlesewsky et al., under revision) were used to examine the concept of binary decision-making in "semantic reversal anomalies" in Turkish and Chinese. These anomalies emerge when grammatical role assignments conflict with the most plausible interpretation (e.g., the hearty meal was devouring; Kim & Osterhout 2005; Kuperberg et al. 2003). In English, reversal anomalies engender P600 effects, whereas in German, they evoke a biphasic N400-P600 pattern (Schlesewsky & Bornkessel-Schlesewsky 2009). We assume that the critical word initiates categorization of the utterance as well-formed or ill-formed. Thus, if a language permits another structural analysis that avoids the semantic anomaly, there should be no categorization-P300, because the structural ambiguity introduces two non-anomalous competitors. Experiments 2 and 3 presented NP-NP-V structures with an anomaly-inducing verb. Due to the existence of prenominal relative clauses in Turkish and Chinese, these strings in principle permit both a mono-clausal and a bi-clausal reading. As predicted, reversal anomalies did not engender a late positivity (and only an N400) under these circumstances. These findings provide compelling evidence for categorization-based P300s in language processing and suggest that the P600-P300 relationship should be re-examined with manipulations other than experimental stimulus probability.

47. 10:15 a.m. -11:15 a.m.

Combined ERP/fMRI evidence for lexical effects in the language formulation area

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The Recognition Potential (Rudell, 1991), a left-lateralized negativity that peaks at about 200-250 ms, is one of the most interesting of the early latency ERP reading components. It is the first to consistently display lexicality effects (larger for words vs. non-words) and possibly semantic effects. It has therefore been suggested to reflect an early confluence of lexical and semantic processing (Martín-Loeches, 2007). The lexicality effect seems to be largely invisible unless the stimuli are temporally flanked by masks at an SOA of about 250 ms (Iglesias et al., 2004). It has been suggested that its generator is either the Visual Word Form Area (Martín-Loeches, Hinojosa, Gómez-Jarabo, & Rubia, 2001) or the Language Formulation Area (Dien, 2009), a portion of the posterior inferior temporal gyrus (Nielsen, 1946) that has been reported to respond to cloze probability of sentence stimuli (Dien et al., 2008). In this experiment, twenty-three participants underwent the task while having high-density 129-channel ERP data collected and a separate sample of fifteen participants underwent the task while having fMRI data collected in a 3T scanner. Examination of the ERP data confirmed that a standard Recognition Potential effect was produced. The only corresponding effect in the fMRI data was in the Language Formulation Area, confirming it as a more likely source for the Recognition Potential. Based on the neu-

roanatomical location and the temporal information, suggestions are made regarding the nature of the process indexed by the Recognition Potential. It is suggested that it may be a primary convergence point between the orthographic and phonological pathways of reading comprehension.

48. 11:30 a.m. - 12:30 p.m.

Cortical systems for early semantic processing in word recognition

Graves, W.W., Baillet, S., Desai, R., and Binder, J.R. Medical College of Wisconsin, Department of Neurology, Milwaukee, WI, USA.

Much has been discovered about the spatial distribution of neural systems for word recognition on the one hand, and the time course of word recognition on the other. Considerably less is known about how word recognition unfolds in the brain over time and space. We used magnetoencephalography (MEG) to examine the spatial distribution of neural systems for word recognition as a function of time. Word stimuli were of either high or low frequency, and rated as having either high or low imageability. We hypothesized that areas engaged in semantic (word meaning) processing would show activation for high compared to low levels of word frequency and imageability. Participants (N = 10, mean age = 26, all right-handed, native English speakers) were asked to indicate that a letter string was an English word by tapping with the index finger of one hand, or that it was not by tapping with the index finger of the other hand. To ensure similarity in terms of orthographic and phonological characteristics, the 312 pronounceable nonwords (pseudowords) were matched to the 312 words in terms of number of letters and did not differ reliably in terms of bigram and trigram frequency or orthographic neighborhood size. Similarly, across levels of word frequency and imageability, words did not reliably differ in terms of number of letters, bigram and trigram frequency, orthographic neighborhood size, or spelling-sound consistency. Stimuli were displayed for 400 ms and replaced with fixation. The mean response time (RT) for words (827 ms) was significantly faster than for pseudowords (897 ms, $t = 11.9$, $p < 0.001$). Differences in terms of RTs and error rates between levels of word frequency, imageability, and their interaction also followed the typical pattern: a significant main effect of faster RTs for high compared to low levels of frequency and imageability, and a significant interaction, i.e. a greater effect of imageability for low frequency words and a greater effect of frequency for low imageability words. Neuronal responses to words occurred in three waves of posterior to anterior activity, each centered at about 170, 220, and 310 ms. Differences across word conditions occurred primarily in the left angular gyrus (AG), an area identified in a recent meta-analysis as a major component of the lexical semantic system. The greatest difference in this area occurred in an early time window of 110-150 ms, with greater activity for words of high frequency and high imageability compared to those of low frequency and low imageability. Although preliminary, these results suggest that semantic processing begins early in the course of word recognition, and that the left AG is prominently involved in this process.

49. 10:15 a.m. -11:15 a.m.

Do you know who that is? Processing ambiguous anaphors with real-world referents

Johns, C. (1,2,4), Long, D. (1,2,3), and Swaab, T. (1,2). 1. University of California, Davis. 2. Center for Mind and Brain. 3. University of Central Lancashire, Prestion, U.K. 4. Now at Haskins Laboratories.

Discourse comprehension is predicated on constructing and maintaining a coherent mental model of incoming text. One way to maintain discourse coherence is to establish connections within and across sentences via coreferential processing, which allows readers to track ""who is doing what to whom"". Readers accomplish this by linking referring expressions known as anaphors (e.g., pronouns, repeated names) to semantic representations of previously mentioned discourse entities (antecedents). In experimental stimuli, readers typically know little about discourse entities. However, outside the laboratory, readers frequently possess substantial information about them. This study investigates whether ""real-world"" reference affects coreferential processing. Consider this sentence: ""Bill handed John some tickets to a concert and he asked for nothing in return."" Comprehenders must first establish reference for two characters in memory. Like most experimental characters, Bill and John are very similar (readers know only that they are both singular males). Research has shown that such semantic similarity can engender processing difficulty: sentence comprehension was impaired when two characters were established with the same type of noun phrase, with the greatest difficulty evident when two proper names were used (Gordon et al., 2001). What kind of mental representation results if comprehenders know that ""Bill"" is Bill Clinton, and ""John"" is John Travolta? For most readers, these names are associated with considerable information from long-term memory; at minimum, the resulting mental representations should be richer in semantic detail than if readers had no prior knowledge about them. Event-related potentials were recorded as twenty participants read sentences containing ambiguous pronominal references (""she"" or ""he""); these anaphors contain important semantic information about the sex of their antecedent. When such pronouns mismatch their antecedents (e.g., ìsheî referring to a male) the result is a P600 effect (van Berkum et al., 2007), and evidence suggests that the amplitude of this effect is sensitive to multiple sources of information (Hammer et al., 2005). We therefore manipulated semantic information in two ways. First, pronouns either matched or mismatched the sex of their referents; mismatching pronouns thus fail to refer to either discourse entity. Second, antecedent entities were either fictional or real, famous individuals; this information, while not crucial to comprehension, may nevertheless be used in

constructing the discourse representation. Pronouns were disambiguated only at the ends of the sentences. Mismatching pronouns elicited the expected P600 effect relative to matching pronouns ($p < .05$); however, this effect's amplitude was significantly greater when sentence characters were real ($p < .05$). Moreover, matching pronouns elicited a P600-like effect ($p < .05$) when their antecedents were fictional rather than real, suggesting that pronouns retrieving fictional referents were more difficult to process. Finally, sentence-final words elicited an N400 effect following mismatching pronouns relative to congruent pronouns ñ but only when referents were fictional ($p < .01$), whereas final words in real-reference conditions were processed similarly regardless of pronoun mismatch. Our results suggest that the presence of high-quality representations in a discourse model facilitates the processing of coherent coreference, both immediately at the pronoun and downstream following disambiguation.

50. 11:30 a.m. - 12:30 p.m.

Long-term storage and unification: Distinguishing the respective roles of the MTG and IFG in language comprehension with rTMS

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Previous research has demonstrated an anatomical dissociation between brain regions supporting the storage of lexical-syntactic information in long-term memory from those supporting the integration/unification of this information in sentence comprehension. Snijders et al. (Cerebral Cortex, 2009) compared word-class ambiguous words (e.g., noun/verb ambigous words like run) to unambiguous control words (e.g., jacket) in the context of two behavioral tasks that either did or did not require unification (i.e., reading random lists of words vs. sentence comprehension). Results showed that while regions of the left, middle temporal gyrus (MTG) were sensitive to the ambiguity of the material regardless of the task, regions of the left inferior frontal cortex (IFG) only showed an ambiguity effect for sentences. These results thus provide evidence for a division of labor between regions supporting the long-term representation of lexical-syntactic information in the MTG from those involved in unifying that information into a coherent message in the IFG. In the present investigation, we use repetitive transcranial magnetic stimulation (rTMS) to test whether the MTG and IFG are causally involved in the storage and unification of lexical-syntactic information respectively. Using the same materials as Snijders et al., we manipulated word-class (nount/verb) ambiguity in the context of a self-paced reading paradigm which required subjects to read sentences word-by-word followed by a sensibility judgment. Sentences were constructed in such a way that the ambiguous word would initially activate both noun and verb readings, followed by material that disambiguated the word. Non-sensical sentences were the same, except that the ambiguous material was followed by a neutral, unrelated context which did not resolve the ambiguity. Thus, sensical and non-sensical sentences were matched through the ambiguous word, but varied in the extent to which they engaged the unification process. In order to test whether the MTG and ITG are causally involved in the representation and unification (respectively) of lexical-syntactic information, an off-line rTMS protocol was used. Brain regions were defined according to the group activation maps in Snijders et al. (2009). Continuous theta burst stimulation (cTBS) was applied over the IFG and MTG on separate days (at least one week apart) at 80% of each subjects active motor threshold for a period of 40 seconds (600 pulses). Following stimulation, subjects performed the self-paced reading task for 30 minutes. We predicted a stimulation region by sentence region interaction on the magnitude of the reaction time difference between ambiguous and unambiguous words. Whereas stimulation of the MTG should modulate the difference between ambiguous and unambiguous material at or shortly after the ambiguous word regardless of the meaninfulness of the sentence, stimulation of the IFG should only influence the ambiguity resolution process, thus differences between ambiguous and unambiguous material should occur at the point of disambiguation. Confirmation of this interaction would provide causal evidence in support of the dissociation of labor between the MTG and IFG in the long-term representation and unification of lexical-syntactic information respectively.

51. 10:15 a.m. -11:15 a.m.

Bilateral hemispheric involvement in sentence processing in older adults

Hyun, J. (1,2), Obler, L.K. (1,2,3), Spiro, III, A. (2,4), Goral, M. (5,1,2), Schnyer, D. (6), Kim, D-S. (7), and Albert, M.L. (2, 3). 1. The Graduate Center of the City University of New York, NY. 2. VA Boston Healthcare System, Boston, MA. 3. Boston University School of Medicine, Boston, MA. 4. Boston University School of Public Health, Boston, MA. 5. Lehman College, City University of New York, NY. 6. University of Texas Austin, Austin, TX. 7. Korea Advanced Institute of Science and Technology.

Research Question: Functional and structural imaging studies report that the aging brain compensates for loss of cognitive abilities including language by increasing right hemisphere involvement (Cabeza et al., 2002; Obler et al., 2010; Wingfield & Grossman, 2006). However, it is not clear which right hemisphere areas are involved in sentence processing. To address this question, we investigated the availability of particular perisylvian left and right hemisphere regions related to successful processing of spoken sentences of three syntactic types. Methods: Twenty two healthy right-handed, native-English speaking older adults (mean age = 69, (range=56-79), mean education=15 years, 10 females) participated in the study. Participants underwent Structural Magnetic Resonance Imaging (MRI) and completed an Em-

bedded Sentences Task. Stimuli were delivered auditorily via headphone at comfortable listening levels and participants were asked to judge whether each sentence was ìunlikely to be trueî or ìlikely to be trueî by pressing a button. Task accuracy and response time were recorded by E-Prime software. The Embedded Sentences Task comprised three substructures of increasing levels of difficulty: 24 sentences with no embeddings, 24 with Subject-relative embeddings and 24 with Object-relative embeddings. Results: The behavioral results were consistent with those from Goral et al. (submitted) for a larger group of which the current group was a subset, confirming the difficulty hierarchy for both accuracy and response time. Separate multiple regressions were run predicting accuracy or response time for average volume and thickness for each of the 13 perisylvian regions selected. To adjust for the large number of analyses, we used $p < 0.01$ as the cutoff. Results are summarized in Table 1 for each task, only for those regions and stimulus types showing significance. Higher left hemisphere volume of planum temporale was linked to more accurate processing of the most difficult structure, Object-relative sentences, while higher right hemispheric volume (particularly total right gray matter, pars opercularis, and superior temporal gyrus) strongly predicted more accurate and faster sentence processing for both Subject-relative and Object relative embedded sentences. Conclusion: Older adults who have relatively faster and more accurate sentence processing skills appear to rely not only on left hemisphere but also on right hemispheric regions. The specific regions implicated and their patterns relative to accuracy and response time differed for the several syntactic structures. Significance: Our findings are consistent with the functional imaging studies of Wingfield and Grossman (2006) and with Cabezaís (2002)'s model of hemispheric asymmetry reduction in older adults (HAROLD). As we found for lexical retrieval in the same participants (Obler et al., 2010), these results demonstrate right hemisphere regions to be linked to good sentence processing among older adults. In addition, our comprehension data confirm the importance of left planum temporale for comprehension of the most difficult syntactic structure.

52. 11:30 a.m. - 12:30 p.m.

Adaptive significance of right hemisphere activation in aphasic language comprehension

Meltzer, J.A., Wagage, S., and Braun, A.R. National Institute on Deafness and Other Communication Disorders, NIH, Bethesda, MD, USA.

Aphasic patients often exhibit increased activity in the right hemisphere during language tasks, but the significance of this is poorly understood. It may represent takeover of function by regions homologous to the left-hemisphere language networks, adaptation of alternate strategies, or even maladaptive interference. We tested language comprehension in 20 aphasic patients and 24 controls using an online sentence-picture matching paradigm while recording MEG. Oscillatory neuronal activity was quantified and mapped using SAM beamforming. Control subjects exhibited left-lateralized perisylvian activation in the form of 8-30 Hz desynchronization during comprehension of semantically reversible sentences compared to nonreversible ones, and wide-spread left fronto-parietal activation during a memory delay for sentence content. MEG activation closely matched fMRI data from the same task. Aphasic patients performed the task very well for nonreversible sentences, but performance on reversible sentences ranged from perfect to chance, and was not correlated with general aphasia severity as measured by WAB, but only with the WAB auditory-verbal comprehension subtest. Aphasic patients exhibited strong MEG activation that was more frontal and bilaterally distributed than controls, and was strongly right-lateralized as a group. Right hemisphere perisylvian activation during the sentence was correlated with overall aphasia severity and lesion size, but not with task success. Rather, comprehension performance was correlated with right hemisphere activation of frontal-parietal working memory areas, especially during the memory delay. These findings suggest that adaptive recruitment of the right hemisphere in aphasia reflects the use of effortful strategies in comprehension, involving reanalysis of language input in working memory.

53. 10:15 a.m. -11:15 a.m.

Voxel-based lesion-symptom mapping reveals a critical role for temporo-parietal cortex in reversible sentence comprehension

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Researchers continue to debate the role of left ventrolateral prefrontal cortex (VLPFC) and temporo-parietal cortex (TPC) in sentence comprehension. Semantically reversible sentences have featured strongly in this debate, as they provide a means of exploring ìsyntactic comprehensionî unconfounded by real-world knowledge. We explored the causal role that VLPFC and TPC play in reversible sentence comprehension using voxel-based lesion-symptom mapping (VLSM) in a large patient cohort. Methods: We analyzed structural images (MRI/CT) and behavioral scores from seventy-nine left hemisphere chronic stroke patients who passed a lexical comprehension screen. Patients were asked to indicate which of two pictures corresponded to an auditory sentence. We tested thirty reversible sentences including 5 each of actives, actives with prepositional phrases, passives, locatives, subject relatives and object relatives. Because the lexical content in the target and distractor pictures was the same, participants could succeed only by computing the sentence structure (The man serves the woman. Target: man serving woman. Distractor: woman serving man). Our

primary behavioral measure was accuracy aggregated across all structures (RevComp). We also analyzed data from just the sentence types with non-canonical mappings (passives, object relatives). Association between behavioral scores and +/- lesion status was examined at each voxel, with false discovery rate (FDR) correction for multiple comparisons. We first examined results at a stringent FDR=.01 threshold, using more lenient thresholds (FDR=.03, .05) only when it was important to further explore a null result. Results and Discussion: VLSM of RevComp scores identified a large cluster of significant voxels in the TPC region (BA 21, 22, 39; Fig. 1a). With a more tolerant threshold (FDR=.03), a second, smaller cluster was identified in VLPFC, near BA 45/46. When we restricted the analysis to non-canonical sentence types, we again found supra-threshold voxels in the TPC region (Fig. 1b). There were no significant voxels in VLPFC, even at FDR=.05. The effect in TPC remained after we controlled for phonological working memory by residualizing RevComp scores on non-word repetition accuracy (Fig. 1c) and rhyme probe span (not shown). Evidence from Brocaís aphasia is often cited in favor of a critical role for VLPFC in sentence comprehension. Comprehension accuracy in our sample of 21 Brocaís aphasics spanned the spectrum, suggesting no special relationship (10 scored <=65%, 6 scored >=80%, 5 scored in between). As a further confirmation, we compared percent damage in BA 39 and BA 44 for two groups of roughly matched Brocaís aphasics (N=8). This showed that while many good and poor comprehenders had extensive BA 44 damage, the poor comprehenders on average had greater damage in BA 39 (Fig. 1d). These results show a significant association between impaired sentence comprehension and damage in left TPC (especially BA 39) but not left VLPFC (including Brocaís area). We interpret these results as indicating a crucial role for TPC in sentence level relational processing. In contrast, the involvement of Brocaís area may reflect task-specific executive functions that are not central to interpreting sentences.

54. 11:30 a.m. - 12:30 p.m.

Assessing the directionality of N400 and P600 effects with simultaneous EEG and MEG

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Introduction: Functional interpretations of ERP effects require understanding the directionality of the effects, i.e., which experimental condition is associated with more intense brain activity. For example, it only makes sense to hypothesize that the P600 is related to reanalysis if the ill-formed condition is indeed what elicits an increase in activation. However, since traditional language-related ERP components such as the N400 and P600 are defined as difference waves, it is unclear whether these effects are driven by increased activation in the ill-formed or the well-formed condition. In fact, an fMRI study by Kuperberg et al. (2003) found a decrease in left temporal and inferior frontal activity for the P600 ill-formed condition. FMRI, however, lacks the temporal resolution for assessing the direct relationship of these findings to the P600 effect. To examine what brain activity is affected—and in what way—by classic N400 and P600 manipulations, we used the P600 materials of Osterhout and Holcomb (1992) and the N400 materials of Johnson & Hamm (1999) during a simultaneous EEG+MEG recording, the latter allowing relatively detailed source reconstruction. Methods: During a simultaneous EEG+MEG recording, nine subjects read 80 semantically anomalous 'N400' sentences (+ well-formed controls) and 60 ungrammatical 'P600' sentences (+ well-formed controls). As in Johnson & Hamm (1999), N400 stimuli were not formally matched on any variable other than length. EEG Results In our EEG data, we replicated both the N400 findings of Johnson & Hamm and the P600 findings of Osterhout and Holcomb. MEG Results N400m: Using L2 minimum norm estimates, whole brain source analysis revealed increases onsetting at 300ms in the left temporal lobe (LTL), left inferior frontal gyrus (LIFG) and right superior intraparietal sulcus (RSIPS) for the ill-formed condition. N400 correlation analysis: Mixed effects modeling identified significant correlations between the EEG N400 difference wave and the N400m source difference wave in the LTL, LIFG, and RSIPS, suggesting that these sources indeed contribute to the EEG N400 effect. P600m: In the P600 time window, the most reliable effects showed increased activity for the well-formed condition. The foci of these increases were in the left inferior temporal lobe (ITL) and occipital regions. P600 correlation analysis: Correlation analyses between the EEG P600 difference wave and the P600m source difference waves indicated that the ITL and occipital sources in fact correlated with the EEG P600 effect. Conclusion: Our N400 MEG results are broadly consistent with previous MEG findings showing a widespread increase in activation for the ill-formed condition in temporal cortex (Halgren et al., 2002; Helenius et al., 1998). Our MEG findings on the P600, however, suggest that increased activity is primarily observed for the well-formed condition, plausibly reflecting some aspects of the ongoing computation of the well-formed structure. Several researchers have (informally) suggested that the P600 is not observed in MEG. Our results, however, suggest an alternative account: namely that the P600 is indeed observed but the directionality of the effect is not what one would expect based on the typical functional interpretations of this effect in the ERP literature. References: Halgren, E., Dhond, R., Christensen, N., Van Petten, C., Marinkovic, K., Lewine, J., Dale, A.,(2002). N400-like magnetoencephalography responses modulated by semantic context, word frequency, and lexical class in sentences. NeuroImage 17, 1101–1116. Helenius, P., Salmelin, R., Service, E., Connolly, J., (1998). Distinct time courses of word and context comprehension in the left temporal cortex. Brain 121, 1133–1142. Johnson, B. W., & Hamm, J. P. (2000). High-density mapping in an N400 paradigm: Evidence for bilateral temporal lobe generators. Clinical Neurophysiology, 111, 532–545. Kuperberg, G. R., Holcomb, P. J., Sitnikova, T., Greve,

D., Dale, A. M., & Caplan, D. (2003). Distinct patterns of neural modulation during the processing of conceptual and syntactic anomalies. Journal of Cognitive Neuroscience, 15, 272–293. Osterhout, L., & Holcomb, P. J. (1992). Event-related brain potentials elicited by syntactic anomaly. Journal of Memory and Language, 31, 785–806.

55. 10:15 a.m. -11:15 a.m.

Adaptation process of a French battery for aphasia assessment to its Brazilian Portuguese version

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The assessment of neuropsychological and linguistic abilities in aphasia is a complex process. Therefore, standardized tests designed to evaluate these abilities in aphasic patients need to be adapted to their linguistic and sociocultural realities to more precisely and accurately detect subtle characteristics, so to properly guide therapy planning. A regular worldwide practice in aphasia assessment has been the administration of translated batteries, designed mainly in English-speaking countries, whose linguistic and social reality does not match the one of the targeted population. In addition, international norms are used to base clinical diagnosis. Aim: to propose a model for the adaptation of a battery to assess linguistic and neuropsychological abilities in aphasic individuals from a determined linguistic and sociocultural reality to another. To do so, the procedures adopted to adapt the Protocole d'examen linguistique de l'aphasie Montréal-Toulouse (MT-86) (Nespoulous et al., 1986) to Brazilian Portuguese – the Bateria Montreal-Toulouse de Avaliação da Linguagem - Bateria MTL – Brasil (Bateria MTL Brasil) (Parente et al., in press) are discussed. The battery comprises sub-tests assessing oral and written comprehension and production, whose linguistic abilities measured range from syntactic, semantic, discursive to pragmatic levels, assessed by means of pictorial and verbal stimuli, in varying levels of complexity. The majority of the tasks are related to left hemisphere specializations, while some relate to assess the participation of both hemispheres. Method: The adaptation process required a rigorous control to produce matching stimuli between the original and the adapted battery in terms of the constructs they intend to measure, and the complexity of linguistic stimuli. Moreover, a flowchart previewing all stages involved in the process needed to be designed and followed. In this way, all the steps could be foreseen, including the necessary characteristics of the sample (sociodemographic ones, such as schooling and age levels, reading and writing habits), and the various associated adaptation stages developed by neurolinguists, neuropsychologists, speech therapists and non-specialist judges. Three general procedures were conducted: translation, experts' judgment and pilot study. In the first one 3 translators participated. In the second one 200 non-experts judges answered to psycholinguistic criteria tasks judging stimuli based on their daily knowledge. After developing the first version of the adaptation, the results of this judgment were analyzed and mainly discursive and complex syntactic stimuli were changed. Then, 12 experts (in neuropsychology (4), psycholinguistics (4) and speech therapy (4)) analyzed the adequacy of the quality of each stimulus to the respective task (content validity). With the semifinal version, a pilot study with 12 individuals was conducted. Next steps will be the reliability, validity and normalization processes. Conclusion and importance of the study: the guidance provided by the flowchart and the rigorous reflection on the stimuli design processes resulted in only minor changes required after data analyses of the pilot study. These procedures guaranteed all the steps to occur within the estimated time. The adaptation process here reported intends to provide useful guidelines for future adaptations of neuropsychological batteries which contain mainly verbal stimuli, from a sociocultural and linguistic background to another.

56. 11:30 a.m. - 12:30 p.m.

Characterizing lexical complexity computations in the fronto-temporal language network

Bozic, M., Su, L., Wingfield, C., and Marslen-Wilson, W. MRC Cognition and Brain Sciences Unit, Cambridge UK

Bilateral fronto-temporal systems play a key role in speech comprehension. Evidence suggests that their activation is modulated by variations in the lexical complexity of the incoming input. General processing demands for linguistically simple words (e.g. dark) activate a bilateral subsystem, while combinatorial processes reflecting the presence of linguistic complexity (e.g. regular inflectional morphemes, play+ed) engage a left hemisphere perisylvian subsystem (Marslen-Wilson & Tyler, 2007). We applied Representational Similarity Analysis (RSA; Kriegeskorte et al, 2008) to assess the information carried by a pattern of activation across multiple voxels and test the type of computation performed in fronto-temporal areas during processing of these different input types. Consistent with findings from univariate analyses, results showed that combinatorial processes triggered by the presence of inflectional suffixes (-ed) produce intercorrelated patterns of activation in superior parts of the left inferior frontal gyrus (BA 44/45). Competition between multiple candidates for lexical access (e.g., in words with embedded stems, claim-clay), which increase general processing demands, correlated with the representation pattern in bilateral pars orbitalis (BA 47). In a follow-up study we varied combinatorial and general processing demands in both inflected and derived words (e.g. played vs bravely), to test

further how different complex inputs modulate the computations performed in fronto-temporal areas. The results show that inflected and derived words present different challenges for the speech processing system, and suggest a dynamic modulation of the type of computation performed in different linguistic contexts. This novel approach to studying language comprehension allows more precise characterization of the information carried and processed in the fronto-temporal language network. Marslen-Wilson WD & Tyler LK (2007) Morphology, language and the brain: the decompositional substrate for language comprehension. Phil Trans R Soc B 362:823ñ836; Kriegeskorte N, Mur M & Bandettini PA (2008) Representational similarity analysis: connecting the branches of systems neuroscience, Front. Syst. Neurosci, 2, 1-27.

57. 10:15 a.m. -11:15 a.m.

Semantic ambiguity resolution is impaired in the absence of directed attention: fMRI studies

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When comprehending sentences containing words with multiple meanings (e.g., "bark"), listeners must select the appropriate meaning for the current linguistic context (e.g., dog or tree). These disambiguation processes are associated with increased activity in a fronto-temporal network for activating, maintaining and selecting between competing meanings. Ambiguity-associated activation in patients with disorders of consciousness and disruption by sedation allow ambiguity resolution to be used as a marker for intact comprehension. However, the degree to which ambiguity resolution relies on directed attention in awake participants is unclear. We report two fMRI studies in which listeners heard sentences containing ambiguous words (ithe shell was fired towards the tankî) along with matched control sentences. Attention was manipulated by presenting multiple concurrent stimuli and instructing participants to respond to sentences or distractors. In Experiment 1, the concurrent task was a visual, non-linguistic target detection. Results showed that left inferior frontal ambiguity effects were diminished but not obliterated when participants attended to the distractor task while left anterior fusiform ambiguity responses were less affected by distraction (Figure 1a). In Experiment 2, participants performed one of two concurrent tasks: auditory target detection or visual lexical decision. Inferior frontal ambiguity responses were absent when the sentences were not attended to (Figure 1b) whereas anterior fusiform activation remained when participants attended to auditory distractors, but not when they attended to linguistic visual distractors. Hence we see that inferior frontal responses are susceptible to disruption by distractor tasks that load on overlapping sensory or linguistic processes whereas inferior temporal responses are preserved for all but the most severe disruption. This graded degradation of neural responses associated with comprehension suggests differing levels of automaticity within frontal and temporal language regions.

58. 11:30 a.m. - 12:30 p.m.

Electrophysiological evidence for impaired discourse processing but spared associative priming in schizophrenia

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Studies of cognitive deficits in schizophrenia have shown clear evidence for impairments in the controlled maintenance of contextual information. This has been related to dysfunctions of the dorsolateral prefrontal cortex (DLPFC) and the middle prefrontal cortex. These areas of the brain are also essential to the establishment of a coherent discourse representation, which crucially relies on the maintenance of contextually relevant information. Previous studies of schizophrenia patients have related their language impairments to increased effects of lexical priming ('hyperpriming') or to difficulties in processing linguistic context. The present study used ERPs to test whether schizophrenia patients have difficulty exerting control over the process of maintaining language context to constrain word meanings during spoken language comprehension. We directly assessed effects of discourse congruence and lexical priming in the same patients and age- and education-matched control subjects using the N400, an ERP component that is sensitive to semantic aspects of the input. All participants were right handed mono-lingual speakers of American English. The patients were medicated and stable at the time of testing; they showed impaired performance relative to the control subjects on a measure of cognitive control, the AX continuous performance task (AX-CPT), which requires the maintenance of a context relevant cue in order to select an appropriate behavioral response. During the language study, participants listened to three-sentence passages containing associative word pairs culled from existing norms. The terminal word in the third sentence varied in overall discourse congruence and lexical association with a preceding prime word as in the following example: Incongruent: Sarah had nightmares for several weeks after watching the cow being slaughtered at the ranch. She became a vegetarian and tried to get the rest of her family to give up meat. In the mornings she would serve her family a tasty meal of eggs and bacon (associated) /sausage (unassociated). Congruent: Nicole's mom wasn't able to cook the family breakfast after she went back to work. Without being asked, Nicole took it upon herself to

cook breakfast for the whole family. In the mornings she would serve her family a tasty meal of eggs and bacon (associated) /sausage (unassociated). ERPs were measured to the final words in all conditions. The results showed significant N400 effects of associative priming in both the schizophrenia patients and the control participants. There was no evidence that the N400 priming effects were enhanced in the schizophrenia patients. Furthermore, and in contrast to control participants, schizophrenia patients did not show N400 effects of discourse context (see figure 1). Our findings indicate that hyperpriming alone cannot account for language problems in schizophrenia. Additionally, schizophrenics did not show immediate effects of discourse congruence on lexical-semantic processing of the critical word, indicating difficulties with maintaining the overall discourse representation. We suggest that this latter deficit is related to their deficits in cognitive control.

Manual gesture and sign language

59. 10:15 a.m. -11:15 a.m.
Neural processing of co-speech iconic gestures

Mok, E.H. (1), Dick, A.S. (3,1), Raja Beharelle, A. (4,5,1), Zinchecnko, E. (1,2), Demir, O.E. (2), and Small, S.L. (1,2). 1. The University of Chicago, Department of Neurology, Chicago, IL, USA. 2. The University of Chicago, Dept. of Psychology, Chicago, IL, USA. 3. Florida International University, Department of Psychology, Miami, FL, USA. 4. Rotman Research Institute of Baycrest Centre, Toronto, ON, Canada. 5. University of Toronto, Department of Psychology, Toronto, ON, Canada.

Abstract: Gestures are an integral part of communication. One specific type of manual gesture, iconic gestures, clarify and elaborate information conveyed in spoken language, but the neural basis of gesture comprehension is not well understood. Previous functional MRI (fMRI) studies implicated the inferior frontal gyrus (IFG), middle temporal gyrus (MTG) and posterior superior temporal sulcus (pSTS) in the integration of speech and gesture (Holle et al., 2008; Willems et al., 2007). In those studies, the authors manipulated the congruency of the gesture with the accompanying speech. Here we investigate the nature of the specific information contributed by gesture when that information is not present in speech. Method: During fMRI, 23 adult participants passively listened to short audiovisual stories that were or were not accompanied by co-speech iconic gestures. When gestures accompanied speech, they contributed information that was either redundant to or supplementary to the speech (e.g., a flapping wings gesture accompanying the spoken word ""parrot"" versus spoken word ""pet"" in the two conditions). Results: Comparing audiovisual narratives with vague language (e.g., ""pet"") accompanied by disambiguating gestures to those without gestures, we found activity in early visual regions, left IFG (both anterior and posterior portions), left pSTS, and left posterior MTG (figure 1), consistent with other studies. The left anterior inferior frontal gyrus has been implicated in processing the incongruency between gesture and speech (Willems et al., 2007), and here we show that this region processes meaningful gesture that is not incongruent with the message of the narrative. In addition to these previously reported regions, we also observed activity in the right posterior superior temporal gyrus extending to the supramarginal gyrus. This latter result suggests an important role of right posterior temporal/inferior parietal regions in integrating meaning from gesture with speech.

60. 11:30 a.m. - 12:30 p.m.
Gesture in time - how temporal alignment affects gesture-speech integration

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In everyday face-to-face conversation, speakers not only use speech to convey information but also rely, amongst others, on co-speech gestures. Various studies have shown that, for instance, iconic co-speech gestures can affect speech comprehension (e.g. Kelly, Kravitz, & Hopkins, 2004; Wu & Coulson, 2005; Holle & Gunter, 2007; Özyürek, Willems, Kita, & Hagoort, 2007). Although being widely recognized as one of the crucial factors for gesture-speech integration (cf. the semantic synchrony rule by McNeill, 1992), the temporal aspects of this process have been understudied so far. Recent ERP studies provide first evidence for this assumption (Habets, Kita, Shao, Özyürek, & Hagoort, in press; Obermeier, Holle, & Gunter, in press). In the present experiment, we investigated the significance of timing for gesture-speech integration on a sentence level in more detail. For this purpose, we used a disambiguation paradigm. Participants were presented with short video clips of an actress uttering sentences like 'She was impressed by the BALL, because the GAME/DANCE…'. The ambiguous noun was accompanied by a dynamic iconic gesture fragment containing the minimal necessary amount of information to disambiguate the noun. We used four different temporal alignments between the noun and the gesture fragment: the uniqueness point of the noun was either prior (+120 ms condition), synchronous with (0 ms condition) or lagging behind the end of the gesture fragment (-600 ms/-200 ms conditions). Both evoked as well as induced potentials were analyzed. ERPs triggered to the uniqueness point of the critical noun (i.e. BALL, immediate integration) showed that integration with the gesture fragment depended on timing, as all but the -600 ms condition resulted in N400 effects. In contrast, ERPs elicited at the later target word position (i.e. GAME/DANCE, delayed

integration) showed N400 effects independent of timing. Thus, although there seems to be a crucial time window for immediate gesture-speech integration, even gesture information present beyond this time window can exert a disambiguating influence.

61. 10:15 a.m. -11:15 a.m.

The biology of linguistic expression impacts neural correlates for spatial language

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Signed languages differ dramatically from spoken languages with respect to how spatial information is encoded linguistically. Rather than using closed-class prepositions or affixes, signed languages encode location and motion information via classifier constructions, in which a handshape morpheme represents an object of a specific type (e.g., long and thin; vehicle) and the location and/or movement of the hands in signing space iconically depict spatial relations and movement. We conducted an H2 15O-PET study to identify the neural systems that are engaged when Deaf ASL signers produce such spatial classifier constructions. Eleven Deaf native ASL signers viewed line drawings that showed the location or path movement (illustrated by lines and arrows) of a figure object in relation to a ground object (a table in a room); see Figure. Participants overtly produced the following (two runs each): a) Locative classifier constructions specifying spatial location: Varied location with respect to the table; constant classifier handshape (round object: a mirror or a clock) b) Locative classifier constructions specifying object type: Constant location (on the table), varied classifier handshape (objects of various types and shapes) c) Motion classifier constructions specifying movement: Varied movement with respect to the table, constant classifier handshape (specifying a ball or a toy car) d) Motion classifier constructions specifying various objects with varied path movements e) ASL lexical nouns for different objects located on the table (the same pictures as in b) The contrast between (a) locative constructions that depict varied locations and (b) those that indicate distinct objects in one location revealed greater activation in the superior parietal lobule (SPL) bilaterally for the production of spatial locations and greater activation in left inferior temporal (IT) cortex and left inferior frontal cortex for the production of distinct object classifier handshapes. The contrast between locative constructions (a) and motion constructions (c) (both with non-varying figure objects) revealed increased activation in left inferior parietal lobule (IPL) for locative constructions and left lateral occipital cortex (near MT+) for motion constructions. The contrast involving (c) motion constructions that depicted varied motion with the same object vs. (d) varied motion with different objects also revealed greater activation in left IT for the production of distinct object classifier handshapes. Finally, the contrasts between naming the figure object (e) and producing classifier handshape morphemes (b) in response to the same pictures revealed greater activation in bilateral anterior temporal cortex for the production of lexical signs and greater activation in bilateral SPL for classifier handshape morphemes in a locative construction. Together these results suggest that the production of locative constructions in ASL engage bilateral parietal cortices, while motion constructions engage left MT+, and classifier handshape morphemes that specify object type/form engage left inferior temporal cortex. With this study, we begin to identify the functional neuroanatomy of language and space when visual-spatial schemas are isomorphically mapped to visual-gestural representations, rather than to non-iconic vocal expressions.

62. 11:30 a.m. - 12:30 p.m.

Learning-induced changes in processing of bimanual signs

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Hand movements can be used to encode meanings, in a similar way to spoken words, in human communication. Successful nonverbal communication requires (1) that the observer is aware of the communicative intent of the actor and (2) that she/he knows the meanings of the actorís hand movements. Here, we used functional MRI to investigate how neural processing of another personís hand movements changes when the observer becomes aware of their communicative nature and learns to associate meanings with some of them. We presented videos of bimanual signs that are meaningful in British sign language to 16 right-handed non-signers in a 3T scanner. The participants indicated after each block of 5 videos whether they had seen any repeated hand movements by pressing buttons. Importantly, the participants did not know that the presented hand movements were meaningful signs during the first scanning session. After this session, the participants were taken out of the scanner and trained to associate meanings with half of signs they saw in the first session and half of a new (previously unseen) set of signs. Then, they were scanned again while observing the same set of signs as in the first scanning session and the new set. In the pre-training session, we found bilateral activations in the occipital lobe, superior parietal lobule and precentral gyrus during observation of signs compared to baseline (observation of videos with no hand movements). In the post-training sessions during which participants were aware of the communicative nature of the signs, we found increased activity during observation of signs (relative to the

pre-training session) in the inferior frontal gyrus (IFG), anterior intraparietal sulcus, inferior parietal lobule and posterior inferior temporal gyrus. The increased activity in these regions was left-lateralized. Moreover, observation of signs with known meaning activated these regions more than observation of signs with unknown meaning. The findings suggest that this left-lateralized fronto-parieto-temporal network is specifically involved in processing of another person's hand movements when their communicative nature is realized. The frontal node of this network, i.e., the left IFG, is one of the key language areas in the human brain. Its posterior part (pars opercularis) was equally activated during observation of known and unknown signs in the post-training session, whereas its anterior part (pars triangularis) showed greater activity during observation of known than unknown signs. This finding supports the idea that the subdivisions of the IFG play different roles in nonverbal communication, as they do in verbal communication.

63. 10:15 a.m. -11:15 a.m.

Electrophysiological evidence for fused phonological and semantic representations in American Sign Language (ASL)

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The notion that language forms (phonology) are arbitrarily related to the language meaning (semantics) is often considered a central tenet of the properties of human languages (Hocket, 1959). Spoken languages exhibit an exquisite separation between properties of language form and language meaning, as evidenced by classic neologistic dissociations of literal and semantic paraphasia (Goodglass, 1993) as well as decades of research on speech errors (Fromkin, 1973a,b). Accordingly, theories of lexical access maintain clear separations between properties of th e input/output representations (lexeme) and meaning representations (lemmas) (Levelt, 1989; Fodor et al., 1974). This study provides evidence that this separation of form and meaning does not apply in the same way to natural signed languages. For the first time, we report evidence that perception of American Sign Language (ASL) sign forms are intertwined with the semantic properties of the language. This paper examines the modulation of the N400 event-related potential to semantic and phonologically related signs. EEG was recorded while 17 native signers watched ASL sentences for comprehension. Participants were presented with sentences in which semantic expectancy and phonological form was systematically manipulated one to three signs before the end of the sentence. The three conditions of interest are contrasted to a baseline sentence (BL) with a plausible semantic ending. Violations of expectation were created by ending a sentence 1) with a plausible but non-preferred semantically related with the baseline sign (SEM-REL); 2) a sign that shared only location with the baseline (LOC-REL); or, 3) a sign unrelated and differing in location to the baseline (UNREL). MY COFFEE REQUIRE MILK 0) BL: SUGARloc-chin 1) SEM-REL: COOKIESloc-palm 2) LOC-REL: DENTISTloc-chin 3) UNREL: WATCHloc-wrist Consistent with previous research the UNREL condition yielded a large negative potential peaking approximately 400 msec. after stimulus onset (i.e. classic N-400) (Kutas and Hillyard, 1980, Neville 1997). Particularly interesting was evidence for equivalent early negativities, starting at 350 msec., elicited by signs with non-preferred semantic content (1) or shared location (2). This early negativity provided compelling evidence that that access to semantic and phonological properties are present early in ASL processing, and incur similar on-line processing costs. Finally, consistent with the effects of the intimate relationship between semantics and form, the largest negativity was elicited by the combined violation of semantic form with shared location (2). Electrophysiological data from native deaf signers provides evidence for frank representation differences in the composition of the sign lexicon. The data suggest that both ASL form and meaning share an intimate relationship and interact during online language interpretation. These new electrophysiological data accord and give new meaning to observations such as: widespread patterning of semantic relations with respect to body locations (eg. ASL verbs of cognition are made on the forehead, negative concepts around the nose and gender differentiates based on location etc. (Frishberg, 1975); the acquisition of location before other phonological parameters by deaf children; the early identification of location in gating experiments, as well as the preservation of location in sign paraphasia.

64. 11:30 a.m. - 12:30 p.m.

The timing of phonological processing of American Sign Language: An ERP study

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To determine whether phonological processing of language recruits similar neural processes regardless of language modality, we explored the identity and timing of phonological (sub-lexical) processing of American Sign Language (ASL) in deaf native signers. We recorded event-related potentials (ERPs) during phonological similarity judgments of ASL signs. Participants were presented with a sequence of two signs and decided whether or not they shared the same location and movement: two of the three phonological parameters of signs (Stokoe, 1960). Deaf participants were at ceiling on this task. They demonstrated an enhanced negativity to the non-matching pairs in contrast to the matching pairs (N450 ñ 300-600ms). This was largest over posterior regions of the right hemisphere. Crucially, this pattern is the same as has been reliably observed in hearing adults making rhyme decisions about written words (e.g., Rugg et al.,

1984). This enhanced negativity to non-matching signs continued throughout a later positive-going component (600-1200ms). To assess the linguistic specificity of these effects, hearing sign-naÔve participants were also tested. Since this visual matching task could be conducted very easily in the absence of phonological knowledge of ASL, behavioural performance by hearing participants was also at ceiling on this task. Critically, modulation of the N450 by phonological similarity was significantly smaller in hearing non-signers than deaf signers. Hearing non-signers and deaf non-signers however showed no difference in sensitivity to similarity between signs during the later, positive-going component (700-1200ms). In support of the interpretation of the enhanced N400 to rhyming words, the current data suggest that this component truly reflects sensitivity to sub-lexical components of word or sign structure, since it was observed only in those with sensitivity to the phonological structure of the input - deaf signers. In contrast, the later component appears to reflect sensitivity to form overlap since it is common to those with phonological knowledge of the input and those without. Moreover, these data support the proposal that metalinguistic phonological processing is to some degree, supramodal.

65. 10:15 a.m. -11:15 a.m.

Iconic gestures facilitate word and message processing: The multi-level Integration model of audio-visual discourse comprehension

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Iconic, or depictive, gestures are movements of the body ñ especially the hands and arms ñ that convey meaning in virtue of schematic resemblance to their referents. This study assessed the impact of iconic gestures on the brainís real-time response to speech in multi-modal discourse about concrete topics, and on the brain response to pictures of the objects discussed. Electroencephalogram (EEG) was recorded as 24 healthy adults viewed segments of spontaneous video-recorded discourse in which an individual described everyday objects and events using both speech and iconic gestures. Incongruent control trials were constructed by swapping the audio and video portions of each discourse segment such that the speakerís gestures no longer matched the semantic content of his utterance. After the EEG recording session, participants judged whether the speech and gesture in each trial were congruent or incongruent. Participants were divided into two groups based on their performance in the off-line judgment task: super-integrators, who tended to judge most videos as being congruent, and conservative integrators, who were either unbiased, or exhibited a bias towards incongruent judgments. ERPs to materials in the on-line task were found to differ as a function of participantsí performance on the subsequent off-line judgment task. In both groups, ERPs time-locked to speech in the videos were less negative 400-875 ms when accompanied by congruent relative to incongruent gestures. In conservative integrators, the congruency effect had a posterior topography, not unlike that of the well-known N400 effect. In super-integrators, congruency effects were more broadly distributed, and showed a frontal focus consistent with ERP concreteness effects. In both groups, the brain response to related picture probes differed from unrelated, suggesting a facilitative effect of discourse. However, ERPs to picture probes revealed that only the super-integrators were sensitive to the speech-gesture congruency in the discourse prime. These findings lend support to the Multi-Level Integration (MLI) model, which posits that gestures can impact both lexical and discourse level comprehension, though through somewhat different mechanisms depending on the individual. On the one hand, conservative integrators utilized congruent gestures to facilitate semantic processing of content words in the speech stream, but do not appear to have engaged imagistic processes, and did not benefit from speech-gesture congruency when message-level representations of the discourse were assessed with picture probes. On the other hand, super-integrators benefited from gestures both at the word and the discourse level. The topography of ERP effects to content words in the speech streem suggests that super-integrators engaged image-based processes to construct a representation of speaker meaning that combined visuo-spatial information activated by either his words or gestures. Overall, present study demonstrates that speech-gesture integration during discourse comprehension is not a unitary phenomenon. Rather, it can occur at the level of local lexical processing or during the formulation of the situation model of the objects and events being discussed.

66. 11:30 a.m. - 12:30 p.m.

Phonological processing in German sign language: Evidence from MEG

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Current neuroanatomical findings indicate that both visual sign information and auditory speech information are processed in a similar manner. Analogous to spoken language, a left-hemispheric dominance is observed for processing sign language (Hickok et al., 1996; Corina et al., 1999). Moreover, there is some evidence that perceptual mechanisms of speech processing such as categorical perception also exist in sign language (Campbell et al., 1999; Emmorey et al., 2003; Baker et al., 2005). Magnetoencephalography (MEG) is a time-sensitive, non-invasive brain-imaging method which,

due to its physical properties (e.g., high temporal resolution and good spatial discrimination), is well suited to study phonological processing in the human brain as it allows direct measurements of neuronal function. Knowledge about temporal processing phases is a prerequisite for fully understanding the basic cognitive concepts involved in language processing. So far, time-sensitive methods like MEG have not been applied to the study of sign language perception. In our present study, which fills the research gap for German Sign Language, we used whole-head MEG and adopted an experimental paradigm that has been standardly used for investigating phonological processing in the auditory cortex. Using an oddball design (c.f. Näätänen (2001)) analogous to previous experiments in spoken languages (Ceponiene et al., 2005; Hertrich et al., 2003), 15 deaf native signers (7 female, 8 male; mean age ±29,9 years) and 16 hearing non-signers (8 female, 8 male; mean age ± 30,03 years) were presented signs and non-signs differing only in one phonological parameter (i.e. handshape and place of articulation). Participants were asked to pay attention to the presented stimuli, but didn't have to perform a task or show overt response. In addition to visually evoked responses in the central visual system, the results show an M100-like component with a source in the auditory system for deaf signers when processing sign language (cp. Finney et al. 2003). For hearing participants activation for this period was mainly observed in the visual cortex. A further bilateral field component peaking at 170 ms in non-signers showed a significantly shortened latency in the left hemisphere of deaf signers (150 ms). In the auditory domain, electrophysiological latency differences have been considered as a general signature of the phonological status of acoustic speech features (Winkler et al. 1999). Thus, the observed latency differences between signers and non-signers might be related to phonological processing mechanisms regarding information-bearing elements of sign language. Baker, S. A., W. J. Idsardi, M. Golinkoff, and L. A. Petitto (2005): The perception of handshapes in American Sign Language. Memory and Cognition 33(5), 887–904. Campbell, R., B. Woll, P. Benson, and S. Wallace (1999): Categorical processing of faces in Sign. Quarterly Journal of Experimental Psychology 52, 67–95. Ceponiene , R., P. Alku, M. Westerfield, M. Torki, and J. Townsend (2005): ERPs differentiate syllable and nonphonetic sound processing in children and adults. Psychophysiology 42, 391–406. Corina, D. P., S. L. McBurney, C. Dodrill, K. Hinshaw, J. Brinkley, and G. Ojemann (1999): Functional Roles of Broca's Area and SMG: Evidence from Cortical Stimulation Mapping in a Deaf Signer. NeuroImage 10, 570–581. Emmorey, K., S. McCullough, and D. Brentari (2003): Categorical perception in American Sign Language. Language and Cognitive Processes 18, 21–45. Finney, E. M., B. A. Clementz, G. Hickok, and K. R. Dobkins (2003): Visual stimuli activate auditory cortex in deaf subjects: evidence from MEG. NeuroReport 14, 1425–1427. Hertrich, I., K. Mathiak, W. Lutzenberger, and H. Ackermann (2003): Processing of dynamic aspects of speech and non-speech stimuli: a whole-head magnetoencephalography study. Cognitive Brain Research 17, 130–139. Hickok, G., U. Bellugi, and E. Klima (1996): The neurobiology of signed language and its implications for the neural basis of language. Nature 381, 699–702. Näätänen, R. (2001): The perception of speech sounds by the human brain as reflected by the mismatch negativity (MMN) and its magnetic equivalent (MMNm). Psychophysiology 38, 1–21. Winkler, I., A. Lehtokoski, A. P., M. Vainio, I. Czigler, V. Csépe, O. Aaltonen, I. Raimo, K. Alho, H. Lang, A. Iiovnen, and R. Näätänen (1999): Pre-attentive detection of vowel contrasts utilizes both phonetic and auditory memory representations. Cognitive Brain Research 7, 357–369.

67. 10:15 a.m. -11:15 a.m.
Studying the biology of co-speech gesture processing in natural settings

Andric, M. and Small, S.L. The University of Chicago

OBJECTIVE People often use their hands to communicate meaning in conversation. One class of these hand actions, "co-speech gestures", are only meaningful in context with accompanying speech (McNeill 2005). Because of analytic constraints related to the identification of the BOLD fMRI response, previous studies looking at brain responses for processing co-speech gestures have often used experimental manipulations that deviate from the typical experience of gesture in everyday conversational situations. Here, to study how the brain responds when processing co-speech gestures in a naturalistic setting, we developed an approach that permits the context while still allowing us to determine those brain areas registering a specific response to gestures that accompany speech. METHODS Two participants were shown a woman talking about how to do various activities (e.g., "Explain how you drive a car") across a series of 7 videos ranging from 57 s to 2 m 46 s. BOLD signals were recorded across the whole brain, acquired in the axial plane with a TR = 1500 ms. For each participant, nuisance sources of variance were removed from the time series before it was projected to that participant's cortical surface representation (Dale, et al. 1999; Fischl, et al. 1999). In the time series at every surface vertex (n = 392,000 per participant), we found the number and position of extrema ("turning points", either peaks or valleys in the time series; for similar application see Skipper and Zevin, 2009). Post-hoc, the videos were coded for occurrences when the woman performed co-speech gestures. We then determined which brain regions were sensitive to gesture by quantifying the number of peaks and valleys at those positions where gestures occurred ($p < .05$ corrected). RESULTS The visual system responded very similarly in both participants. This was most evident in areas presumably tracking visually perceived biological motion, e.g., extrastriate cortex (V5/MT+) and the posterior superior temporal sulcus. However, participants' responses differentiated in parietal and frontal areas. One participant exhibited left ventral supramarginal gyrus (SMG) and posterior inferior frontal gyrus (IFG), as well as right planum temporale and ventral premotor modulation, whereas the other participant showed a more spatially extensive response in

the left parietal lobe, insula, and right anterior IFG. CONCLUSIONS Our preliminary results show that we can extract brain responses to specific features of interest, such as co-speech gestures, from a continuous natural discourse. Because co-speech gestures require context to be meaningful, this is an important consideration in characterizing their biological basis. Furthermore, using a more natural setting, we are able to not only replicate findings from prior studies that used standard methods, but also highlight individual brain responses across parietal and frontal cortices. This suggests that, when it comes to processing gestures, there are potential individual differences that are not captured by analyses using more traditional methods.

68. 11:30 a.m. - 12:30 p.m.
Windows into ASL perception: Cognitive restoration of reversed signs
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Purpose: We investigate the impact of visual processing on time windows of integrating linguistic information in American Sign Language (ASL). Moreover, we compare our results with findings from the auditory processing of speech.
Background: Sign language research can offer a better understanding of the relationship between modality and linguistic representations in language processing. In speech perception, it has been proposed that time-windows that correspond to the length of segments and syllables are important for the integration of sensory input for successful processing (Poeppel et al., 2008). Moreover, these temporal integration windows may be attributed to frequencies of inherent cortical rhythms, namely the gamma and theta bands (Poeppel, 2003). The phenomenon of cognitive restoration of locally-reversed speech has provided insight into temporal integration windows and the limits of the auditory system in processing temporally distorted input (Saberi & Perrott, 1999). Intelligibility of speech falls drastically at reversals of 65 ms and greater, while being remarkably high at smaller intervals (Greenberg & Arai, 2001). Furthermore, Figueroa et al. (in progress) has shown that these time-windows are not absolute but relative to the length of the linguistic units. Our study investigates the cognitive restoration of locally reversed sentences of ASL. Experiment: 40 sentences of ASL, which were constructed to be balanced along phonological parameters of ASL and to have a relatively low degree of semantic predictability, were recorded by a native deaf signer of ASL. Frame sequences were locally reversed at windows ranging from 0 ms (the control condition) to 934 ms across 8 conditions. Participants (who are at least second generation deaf ASL users) were instructed to repeat back all signs that they were able to detect after each video, and percent accuracy was used as a measure of the intelligibility of the sentences. We calculated accuracy by dividing the number of morphemes produced by the participant by the total number of morphemes that were present in the stimuli. Results: Overall, we find native ASL participants can cognitively restore sentences with much larger time-windows of local reversals relative to speech, and that even the most degraded stimuli remain somewhat intelligible. This is in contrast to speech, where intelligibility quickly falls to 0% after a critical time-window. We found that intelligibility of ASL sentences decreases with the increasing size of the reversals, falling to roughly 50% at reversals of approximately 650 ms (as compared to 65 ms in speech). Conclusion: Sign languages are more resistant to the temporal distortion of local reversals than speech, presumably due to the differences between visual and auditory processing and the temporal differences between English and ASL linguistic units. Observing larger temporal-integration windows in ASL suggests modality specific effects on the size of integration windows for language processing.

Cognitive and executive functions

69. 10:15 a.m. -11:15 a.m.
The functional profile of the left IFG: Evidence against domain general cognitive control
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Objective: Regions in the left inferior frontal gyrus (LIFG) have long been implicated in several aspects of linguistic processing. However, activations have also been reported for a wide range of non-linguistic tasks, including working memory (e.g.,Duncan&Owen,2000) and cognitive control (e.g.,Badre&Wagner,2007) tasks. According to one influential proposal, LIFG subserves general cognitive control abilities (e.g.,Barde&Thompson-Schill,2002;Novick et al.,2005;Schnur et al.,2009). However, most fMRI studies arguing for overlap among cognitive functions in a particular brain region use group analyses, which are known to overestimate the amount of overlap in activation across tasks because of anatomical variability across subjects (e.g.,Saxe et al.,2006;Fedorenko et al.,in press). To address this concern, January et al. (2009) investigated a syntactic ambiguity contrast and a Stroop task within the same subjects and reported overlap in the LIFG. This evidence was interpreted as supporting the cognitive control account. However, in order to argue that LIFG subserves domain general cognitive control, stronger evidence from individual-subject analyses is needed examining a wider range of cognitive control tasks, because it is difficult to generalize from only the Stroop task which requires retrieval of lexical representations. This is the goal of the current study. Methods: We iden-

tified language-sensitive regions in the LIFG of each individual subject using a language localizer task (sentences > pronounceable nonwords) that has recently been shown to reliably activate high-level language-sensitive regions and then examined the response of these regions to (1) Stroop, and (2) a non-verbal cognitive control task: multi-source interference task (MSIT; Bush&Shin,2006). In the Stroop task, participants overtly named the ink color of color-name words in the interference condition, and of non-color-name words, matched for length and frequency, in the control condition. In the MSIT task participants were presented with triplets of digits and asked to press a button (1, 2 or 3) corresponding to the identity of the unique digit (two of the three digits were always the same). In the control condition the distractors were zeros and the position of the target corresponded to the spatial position of the button (100/020/003); in the interference condition the distractors were possible responses and the position of the target did not correspond to the spatial position of the button (e.g.,313/211). Results and conclusions: Overlap between language-sensitive regions and regions activated by the Stroop task was observed, similar to January et al. However, activations for the MSIT task were entirely non-overlapping with the language-sensitive regions, although highly overlapping with Stroop. These results argue against the role of the LIFG in domain general cognitive control (as well as against related accounts; e.g., Duncan,2004,in press) and instead suggest either (i) that sub-regions within LIFG support distinct aspects of cognitive control / working memory, and/or (ii) that cognitive control is not the right characterization for the tasks that activate regions in the LIFG. Additional studies directly comparing activations for a wide range of linguistic and non-linguistic tasks in individual subjects will be necessary for discovering functional sub-regions within LIFG or the right generalization for the broad function of the region.

70. 11:30 a.m. - 12:30 p.m.

Laterality of cognitive control: Does it depend on language laterality?

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Task-switching paradigms have been widely used to investigate the mechanisms underlying cognitive control. Previous studies have reported an enhanced activation during task-switching in the lateral prefrontal cortex (PFC) and the superior frontal gyrus (SFG), as well as the inferior parietal lobule (IPL). While these activations are suggested to be the neural basis of task preparation, the nature of task preparation is still under debate. One hypothesis is that the updating of general task representations mainly consists of verbalizing such representations (Goschke, 2000). In the current study, we examined this hypothesis by comparing the brain networks underlying task switching in participants with typical left-hemisphere (LH) speech dominance and those with atypical right-hemisphere (RH) dominance. By means of a large-scale study combining behavioral visual half field (VHF) language tasks (Hunter & Brysbaert, 2008) and a covert word generation task in fMRI (Cai et al., 2010), we first identified 18 participants with LH-dominance and 18 with RH-dominance for language production. All participants were left-handed students because the probability of being RH language dominant is much higher for left-handers than for right-handers (Knecht et al., 2000). These participants then performed a task-switching task in fMRI using a paradigm slightly modified from the original proposed by Brass and von Cramon (2004), which allows dissociating task preparation from task execution. Our results showed a typical activation pattern in task preparation (task switching against cue switching) for the LH-dominant participants, mainly including the left lateral PFC, the left SFG, and the left IPL. For the RH-dominant participants, our results showed right-lateralized PFC, SFG and IPL activities. That is, our results showed that the laterality of cognitive control processes correlates with language lateralization, which is in line with the hypothesis that a verbalization strategy is needed in task preparation. As the IPL is assumed to provide the necessary stimulus-response associations, this correlation suggests that the frontal-parietal network underlying general cognitive processes functionally lateralizes to the same side as language laterality.

71. 10:15 a.m. -11:15 a.m.

Distinct brain regions underlying semantic processing of words and pictures: Evidence from voxel-based lesion symptom mapping

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Much recent work has focused on identifying brain regions critical for accessing and processing semantic information. A network of regions within the left temporal lobe are most often implicated, including the temporal pole, middle temporal gyrus, and portions of inferior temporal cortex. In the current study, we were interested in discerning which of these areas are most critical for processing conceptual knowledge related to pictures and words. To this end, we used voxel-based lesion symptom mapping (VLSM) in a large group of well-characterized patients who had suffered a single left hemisphere stroke. VLSM is a statistical approach that allows for the identification of voxels most critically implicated in a particular task, without having to separate patients into groups based on lesion site or performance level. In the current study, patients (n = 64) performed a semantic triad task, in which they had to decide which 2 of 3 items (either pictures or words) went together best (e.g., a lion, a tiger, and a turtle). Error rates for both conditions were calculated and entered into the VLSM analysis, along with patientsí lesions which were reconstructed into normalized space. We found that processing word triads versus picture triads resulted in a distinct anterior temporal-posterior

temporal division. Semantic processing of words was associated with significant voxels primarily in the left anterior middle gyrus and underlying white matter, while processing pictures was associated with the left posterior inferior temporal gyrus, as well as the fusiform gyrus. There was also a small degree of overlap in the middle portion of the inferior temporal gyrus in both conditions, suggesting that this region may be critical for processing conceptual knowledge more generally, regardless of domain. These findings highlight those portions of the left temporal lobe most critical for processing semantic information relating to words and pictures.

72. 11:30 a.m. - 12:30 p.m.

Linking language, cognitive control and categorization: Evidence from aphasia and transcranial direct current stimulation

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In addition to communicative functions, language has been argued to possess a variety of extra-communicative functions as assessed by its causal involvement in putatively nonlinguistic tasks. Previous work links linguistic impairments to categorization impairments. Here, we argue based on data from aphasia and healthy subjects undergoing transcranial direct current stimulation (tDCS) that impaired language may be both a cause and consequence of impairments of cognitive control. Specifically, linguistic impairments appear to impact categorization that requires focusing attention and isolating specific conceptual features–a task that requires a large degree of cognitive control. Participants and Methods We tested 12 diagnosed aphasic patients; their primary symptom was anomia with mild to moderate semantic impairments. We also administered the categorization task to young adults (U. Penn undergraduates) undergoing tDCS directed to roughly Broca's area. This region was selected because of its strong links to both naming and cognitive control. Participants were randomly assigned to anodal stimulation, shown to increase cortical excitability, and cathodal stimulation, shown to decrease cortical excitability (N=10/group). We used 260 color drawings of common objects as targets and distractors. These stimuli were used to construct 34 types of categorization trials, with about four different pictures designated as targets for each trial type. On each trial, the participant was instructed to select the targets from among about 16 distractor pictures. In the low-dimensional condition the targets were defined on one or a more dimensions (typically perceptual, e.g., red things, round things, things with handles, animals with stripes). On the remaining trials (high-dimensional condition), the targets were defined along multiple broad dimensions (e.g., vegetables, objects found in a laundry room, animals that live in water). We predicted that individuals with aphasia would have particular difficulties with categorization trials requiring analytical isolation of single conceptual features (low-dimensional trials) compared to trials on which the categorization task could be accomplished based on general association strength and a global comparison of features (high-dimensional trials). Results Both patients and age and education-matched controls had reliably poorer performance on low-dimensional than high-dimensional trials. Relative to controls, patients were specifically poorer on low-dimensional trials. Patients were equivalent to controls on high-dimensional trials. Multiple regression analyses revealed that performance on low-dimensional, but not high-dimensional trials was reliably predicted by their performance on the Philadelphia naming test (as well as by years of education). In contrast, semantic impairments, as assessed by the Camels-and-Cactus test, were marginally associated with performance on high-dimensional trials, but not on low-dimensional trials. As evident in the figure (and borne out by statistical analyses by subjects and items), cathodal stimulation to Broca's area resulted in a categorization profile similar to that observed in aphasic patients —a specific impairment on low-dimensional trials. Therefore, direct current stimulation of an area known to be critically involved in cognitive control affected performance on the same trials impaired in aphasic patients. Significance of Results Links between aphasia and categorization impairments have been noted previously (e.g., Goldstein, 1948; Cohen et al., 1980; Roberson, Davidoff & Braisby, 1999), but causal directions between language, categorization, and cognitive control have remained elusive. Our data support a model in which language contributes to successful categorization on tasks that require attending to and selecting specific dimensions (and ignoring task-irrelevant dimensions). In short, language appears to reify cognitive control.

73. 10:15 a.m. -11:15 a.m.

Logical quantifier comprehension in frontotemporal degeneration

Morgan, B.,(1), Boller, A., (1), Camp, E., (1), Moore, P., (1), Gross, R., (1), McMillan, C., (1), Clark, R., (2), and Grossman, M., (1). 1. University of Pennsylvania Department of Neurology. 2. University of Pennsylvania Department of Linguistics. Also, Bolley, A. should be Boller, A.

Logical quantifiers like "some" are common, but we know little about the neural basis for their meaning. Quantifier meaning has a lower-bound component that depends on number knowledge (e.g. the truth-value for "some" is that at least one of the category is present – for a statement like "Some of the marbles are blue," at least one marble must be blue). Quantifier meaning also has an upper-bound component that depends on a pragmatic aspect of communication involving implicature (e.g. if 100% of the marbles are blue, it is logically true that "some of the marbles are blue" but

more informative to say that "all of the marbles are blue"). Pragmatic implicature is a crucial social component of conversation aligned with Theory of Mind and awareness of a conversational interlocutor. We showed previously that patients with behavioral variant frontotemporal degeneration (bvFTD) have a deficit understanding logical quantifiers. These patients have a disorder of social comportment due to frontal disease, but no evidence for aphasia or number difficulty. In this study, we tested the hypothesis that the deficit understanding logical quantifiers like "some" in bvFTD is due to impaired processing of pragmatic implicature. bvFTD patients (n=13) and elderly controls (NC, n=9) judged whether simple statements containing quantifiers (e.g. "Some of the marbles are blue") correctly describe pictures of familiar objects containing quantities of discrete items (e.g. marbles) or continuous material (e.g. water). Two types of quantifiers were assessed: logical (i.e. "some" and "most"); and majority—dependent on quantity and working memory more than implicature (i.e. "at least half" or "at least one-third"). We presented quantities of 0%, 20%, 40%, 50%, 60%, 80% and 100% to assess the component of quantifier meaning that depends on upper-bound pragmatics (100% n=20) or lower-bound quantity (0-80% n=80). These were equally divided over logical and majority quantifiers. A repeated-measures ANOVA of yes-responses with a group X quantifier (logical, majority) X quantity (0-80%, 100%) design showed a three way interaction effect (p=0.036). T-tests showed that bvFTD patients have a deficit judging the upper-bound component of logical quantifiers relative to NC (p=0.024). All other contrasts were not significant. These findings confirm that non-aphasic bvFTD patients have difficulty understanding logical quantifiers, and that this deficit is related to an impairment processing the upper-bound component of quantifier meaning. This pragmatic deficit is consistent with the disorder of social comportment in bvFTD, and emphasizes some consequences of a social disorder for language.

74. 11:30 a.m. - 12:30 p.m.

Level of cognitive control is related to use of semantic and structural information during reading

Steckley, R. (1), Ledoux, K. (2), and Swaab, T.Y. (1). 1. The University of California, Department of Psychology, Davis, CA, USA. 2. Johns Hopkins University, Department of Cognitive Neurology/Neuropsychology, Baltimore, MD, USA.

This study used ERPs to examine if semantic effects of implicit causality and structural effects of discourse prominence differentially influenced reading as a function of individual differences in cognitive control. Cognitive control refers to executive processing, including the maintenance of task-relevant goals and context, and the inhibition of contextually irrelevant information (Miller & Cohen, 2001). Implicit causality is a feature of verbs by which information about the cause of events described is conveyed implicitly as part of the verbís meaning. Violations of a verbís implicit causality result in processing difficulty. Discourse Prominence affects coreferential processing such that repeated names that corefer with a prominent antecedent are more difficult to process than names that corefer with a non-prominent antecedent, a structural effect (Ledoux, et al., 2007; Swaab, et al., 2004). Students from UC Davis were the participants in this study; all were right-handed monolingual speakers of American English, had normal or corrected to normal vision, and did not suffer from neurological or psychiatric disorders. The subjects read sentences in which implicit causality and discourse prominence were manipulated as in the following example: Example of stimuli: 1. Prominent Antecedent a. Yesterday evening Ronald amused Alison because Ronald had told a very funny joke. b. At the museum Amy thanked Joe because Amy was trying to practice good manners. 2. Non-prominent Antecedent a. At the museum Amy thanked Joe because Joe had explained the paintings so patiently. b. Yesterday evening Ronald amused Alison because Alison needed cheering up. In this example, the implicit causality of the verb is violated in 1b and 2b. Prominent antecedents were the first mentioned names in the sentence (1), non-prominent names were the second mentioned antecedents (2). Each subject also performed a cognitive control task: The AX-Continuous Performance Task (AX-CPT; Braver & Barch, 2002). This task requires context maintenance similar to that required during language processing. Reaction times were measured to relevant trials. High and low control subjects were divided using a median split of the reaction times (high control mean RT = 363ms; low control mean RT = 644ms; $t(32) = -3.87$, $p < .001$). ERPs were measured to coreferentially repeated names that were consistent (Ronald in (1a); Joe in (2a)) or inconsistent (Alison in (1b); Amy in (2b)) with the verb's bias, and that coreferred with a prominent (name in 1st NP) or non-prominent (name in 2nd NP) antecedent. Low control subjects showed costs of violation of bias regardless of whether or not names corefered with a prominent antecedent; inconsistent names elicited a greater N400 than consistent names. High Control subjects showed an interaction of consistency and prominence; processing costs were higher for consistent names that coreferred with a prominent antecedent, but for inconsistent names that coreferred with a non-prominent antecedent (greater P2 and P600). Thus, initial processing of the critical names was only influenced by semantic factors in low control subjects, but by both semantic and structural factors in high control subjects.

75. 10:15 a.m. -11:15 a.m.

Hierarchical organization of scripts and the performance of patients with ALS

Camp, E., Morgan, B., Boller, A., Gross, R., Moore P., and Grossman, M. The University of Pennsylvania, Department of Neurology, Philadelphia, PA, USA.

Objective: To examine hierarchical organization in patients with Amyotrophic lateral sclerosis (ALS).
Background: A script is a familiar, learned sequence of events, such as making a sandwich or doing the laundry. There are two basics ways of thinking about a script. One way is to think about a script in a linear manner. However, recent research suggests scripts may be organized in a hierarchical manner. This study investigates the difference in hierarchy organization for subjects with ALS compared to controls. Method: The study examined the organization of complex familiar activities, known as "scripts". A pilot study done with 10 healthy adults allowed us to quantify the associative strength of 6 events within 22 narrative scripts. Using the pilot data we could see what events in each script were associated with one another. We organized event pairs in three different ways: adjacent events in the same cluster (WC), adjacent events in different clusters (DC), and nonadjacent events (NA). ALS patients (n=10) and elderly controls (n=15) read a narrative title and then two events on a computer screen. Then they were asked if the events were in the correct order in the narrative. Results: Controls were more accurate and faster for WC events then DC events (WC mean control = 0.994, DC mean control = 0.906)(accuracy Sig. = 0.014, latency Sig. = 0.024). This supports our pilot data, and confirms the within cluster benefit. ALS patients did not distinguish between WC event pairs and DC event pairs in both accuracy and latency (WC mean ALS = 0.927, DC mean ALS = 0.927). Discussion: ALS patients were not impaired on the test overall. However, ALS patients had no difference in the accuracy for WC events than DC events while controls appreciate the hierarchical organization of the narratives. One reason for the difficulty processing hierarchical relationships is the frontal dysfunction associated with ALS.
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76. 11:30 a.m. - 12:30 p.m.

Executive resources and pronoun resolution in behavioral-variant frontotemporal dementia (bvFTD)

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Pronouns are a special category of words in language that have no independent meaning, but instead rely on the meaning of a referent in a discourse. For example, in the discourse "The king chased the woman. She laughed", the pronoun "she" refers to woman. Behavioral investigations have demonstrated that a pronoun's meaning is determined in part by lexical semantic and grammatical information. In this paper we investigate the hypothesis that language-specific processes are insufficient to determine a pronoun's meaning. Patients with behavioral-variant frontotemporal dementia (bvFTD) have executive limitations with relatively preserved language. In a behavioral task we asked 11 bvFTD patients and 15 healthy seniors (WNL) to decide the referent of a pronoun in 200 mini-discourses, as above, with either unambiguous referents (e.g., king, woman) or ambiguous referents (e.g., client, visitor). Both groups, bvFTD (96%) and WNL (99%), were highly accurate at determining a pronoun's meaning in unambiguous discourses, indicating that bvFTD do not have a language deficit. In ambiguous discourses with two gender-neutral nouns (e.g., client, visitor) both groups demonstrated a preference for the object-position noun: bvFTD (66%) and WNL (78%). This suggests that when lexical semantic information is not informative, both groups rely on grammatical information of the verb (e.g., the woman is the chasee). However, in ambiguous discourses with a gender-biased noun in the subject-position and a neutral noun in the object-position (e.g., king, visitor), WNL are significantly more likely to choose the subject noun than bvFTD. This suggests that WNL are able to use both grammatical and lexical semantic information to determine a pronoun's meaning, while bvFTD have difficulty coordinating the use of both sources of information. Furthermore, bvFTD's difficulty using lexical semantic information to shift from object-position to subject-position correlates with letter fluency, a measure of executive resources that involves mental flexibility. An analysis of grey matter volume using high-resolution volumetric MRI in a subset of bvFTD patients (n=6) relative to healthy seniors revealed significant disease in bilateral frontal regions including dorsolateral prefrontal cortex, a region known to support executive functioning. Together, these observations suggest that executive resources and language-specific processes both contribute to determining a pronoun's referent.

77. 10:15 a.m. -11:15 a.m.

Recognizing speech in a novel accent: The motor theory of speech perception reframed

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The motor theory of speech perception holds that we perceive the speech of another in terms of a motor representation of that speech. We offer a novel computational model of how a listener comes to understand the speech of someone speaking the listener's native language with a foreign accent. The core tenet of the model is that the listener uses hypotheses about the word the speaker is currently uttering to update probabilities linking the sound produced by the speaker to phonemes in the native language repertoire of the listener thus, on average, speeding the recognition of later words. This task seems to fly in the face of the motor theory. We thus proceed to assess claims for and against the motor theory of speech perception and the relevance of mirror neurons in terms of the present model of recognizing

speech in a novel accent, earlier models of the adaptive formation of mirror neurons for grasping, and work emphasizing that the mirror system is only one part of a larger system for neurolinguistics processing.

78. 11:30 a.m. - 12:30 p.m.

Template construction grammar for generating descriptions of visual scenes

Lee, J. and Arbib, M. Computer Science Department and USC Brain Project, University of Southern California.

In the present study we address issues of how linguistic processes relate to mechanisms which integrate action and perception within a broader context. As the first step, we proposed a computational model of the production of descriptions of visual scenes (Arbib & Lee, 2008). We developed a new kind of semantic representation, SemRep, which is an abstract form of visual information with an emphasis on the spatial linkage of entities, attributes and actions. SemRep provides a graph-like hierarchical structure with enough formal semantics for verbal description of a scene. As a result, it reduces the relatively complex task of semantic processing to a graph matching task. Moreover, we adopted Construction Grammar as an appropriate framework for a schema-based linguistics. The present paper reports on the implementation and operation of our system called Template Construction Grammar (TCG). Constructions, represented as schema instances in our approach, compete and cooperate to cover the SemRep to produce a description of the visual scene at hand. The present language model is built atop a particular working memory (WM) structure, which is based on Cowanís (1999) WM model. This blends the focus of attention with the WM capacity, meaning that what is being attended is what is in the WM. In this model, the vision system interprets a part of the scene under attention and then creates or updates the corresponding SemRep while the language system applies constructions on that part according to the TCG rule. The order of selecting locations of attentional focus is hypothesized to be the main driving force of the resultant sentential structure being produced, and the attention deployment is made in a highly dynamic way by taking a number of factors into account. These factors include the saliency level of the constituents (e.g. a highly prominent object captures attention), the currently activated construction instances (e.g. the passive sentence requires the patient to be assessed first), and the event or world knowledge (e.g. the discovery of the agent and the transitive action leads to searching for the patient). Moreover, the production of the system is also affected by tuning a threshold value for readout of constructions being assembled in WM ñ a lower threshold value would result in fragmented phrases whereas a higher value would yield more complete sentences.

79. 10:15 a.m. -11:15 a.m.

Eye movements and the unfolding of the SemRep semantic representation in scene description

Lee, J., Yang, B., and Arbib, M. Computer Science Department and USC Brain Project, University of Southern California.

Arbib & Lee (2008) proposed a graph-like semantic structure, SemRep, as a spatially anchored semantic representation retrieved from the perceived visual scene so structured that it converts production of a verbal description to a type of a graph matching task. The present study presents time-locked eye movement and verbal data on the temporal unfolding of descriptions of visual scenes which test hypotheses on how SemRep is built from the perceived visual information and how it influences the choice of constructions for the produced utterances. A total of 24 native English speakers participated in the experiment with various procedures that are modifications of basically two types of tasks: to describe a scene while watching (the on-line case) and to describe the scene after it disappears (the post-scene case). Natural scenes with various event settings (e.g. identical events shot from different perspectives, multiple events happening in a single setting, or events with unexpected details which tend to be overlooked at first) were used in order to induce diverse responses from subjects. A preliminary analysis of the results of the eye-tracking data was conducted to investigate the correlations between the organization of event components and the produced sentential structures. Hence we report a number of observations, which leads to the proposal of (1) the presence of a critical threshold for readout of assembled constructions which distinguishes the description style that tends to be fragmentary from the style that is more grammatically correct and complete and (2) a dynamic version of ëmacro-to-microí or ëmicro-to-macroí strategy which integrates the two seemingly incompatible data under a single unified mechanism. In a couple of recent studies, Griffin & Bock (2000) proposed that the preparation of the sentential structure is followed by the preparation of each constituent whereas Gleitman and her colleagues (2007) claimed that the earlier apprehension and preparation of constituents strongly influences the later sentential structure. We propose an alternate interpretation in which a single system addresses both of the above data as the system supports the dynamic strategy of forming sentential structures under various tasks with threshold values set accordingly. Arbib, MA; Lee, J (2008) Describing visual scenes: towards a neurolinguistics based on Construction Grammar, BRAIN RESEARCH 1225:146-162 Griffin, ZM; Bock, JK (2000) What the eyes say about speaking, PSYCHOLOGICAL SCIENCE 11 (4):274-279 Gleitman, LR; January, D; Nappa, R; Trueswell, JC (2007) On the give and take between event apprehension and utterance formulation, JOURNAL OF MEMORY AND LANGUAGE 57 (4):544-569.

80. 11:30 a.m. - 12:30 p.m.

Laminar cortical circuits for learning speech recognition categories: From temporal sequences of acoustic inputs to attended language units

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How do the laminar circuits of neocortex learn categories that can support conscious percepts of speech and language? How do learned speech categories become selectively tuned to different temporal sequences of speech items that are stored in short-term working memory in real time? How does the brain use resonant feedback between working memories and learned categories to restore information that is occluded by noise using the context of a word or sentence? How is the meaning of a word or sentence linked to such a restoration process? A model is developed to simulate how multiple laminar cortical processing stages interact to support a conscious speech percept. In particular, acoustic features are unitized into acoustic items. These items activate representations in an item-and-order, or competitive queuing, sequential short-term working memory. The sequence of stored working memory items interacts reciprocally with unitized representations of item sequences, or list chunks, in a multiple-scale categorization network that is capable of weighing the evidence for context-sensitive groupings of items as they flicker across the working memory through time, and learning to activate the list chunks that represent the most predictive item groupings at any time. These bottom-up and top-down interactions between auditory features, working memory, and list chunks generate a resonant wave of activation whose attended features embody consciously heard percepts, notably the completed percepts that can form even when acoustic information may be missing or occluded by noise, as occurs in the auditory illusion known as phonemic restoration. Phonemic restoration can occur, for example, when broadband noise replaces a deleted phoneme from a speech stream, but is perceptually restored by a listener despite being absent from the acoustic signal (Warren 1970; Warren & Warren 1970). Moreover, the phoneme to be restored can depend on subsequent context (Warren & Sherman, 1974). Model simulations clarify why the presence of noise is necessary for restoration to occur, and why in the absence of noise a silence gap is perceived. These resonant completion properties are traced by the model to the brainís ability to rapidly and stably learn language, even when the resonating groupings are a subset or superset of previously learned recognition codes.

Reading and writing

81. 10:15 a.m. -11:15 a.m.

Grapheme-to-phoneme regularity modulates the cerebral activity of phonological processing in French. A functional MRI study

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Introduction: Print-to-sound or grapheme-to-phoneme conversion (GPC) concerns the translation of elementary units (letters or graphemes) of written words into their corresponding sound forms (phonemes)(Coltheart et al. 1993) . While transparent languages such as Spanish or Italian have Regular (R) GPC, the non-transparent languages such as French, have Irregular (IR) GPC. The IR GPC means that one phoneme corresponds to various graphemes and not to a unique one as is the case for R GPC (Yvon et al. 1998). In French for instance, the phoneme /o/ corresponds to one (“o”), two (“au”) or three (“eau”) letters. The degree of GPC regularity has significant effect on word recognition processing (Simon et al. 2006). This fMRI study assesses the effect of GPC regularity on the cerebral correlates of language during a phoneme detection task. Material and Methods: Twenty two (11 male), right handed, adult (mean of age 27.45 y), French native speakers participated to the experiment. They performed a detection task of the phoneme /o/ in pseudo-words (Language condition). The stimuli have been built according to the R (grapheme “o”) or IR (graphemes “au”) form of the GPC. A visuo-attentional task (Control condition) has been included. A pseudo-randomized event-related fMRI paradigm has been used and the stimulus presentation onset has been optimized. The MR acquisition used a whole-body 3T MR scanner (Bruker MedSpec S300). Data analysis was performed by using the general linear model (Friston et al., 1994) implemented in SPM5 (www.fil.ion.ucl.ac.uk/spm). After spatial pre-processing, statistical analysis calculated first at individual level, the contrast Language vs. Control (L vs. C) and subsequently, a random-effect group analysis (one-sample t-test) has been performed. Several Regions of Interest (ROI) were defined and for each of them, the MR signal intensity variation (% MR) has been calculated. The %MR values were analyzed by means of ANOVA with GPC as within-subject factor with two conditions (R, IR) Results and Discussion: Behavioural data analysis showed more accurate responses (%CR) for R than for IR condition (Fig.1, Panel A). Phoneme detection induced predominant left hemisphere activation in several regions: inferior frontal gyrus (IFG, Broca’s area, BA 44, 45), supplementary motor area (SMA, BA 6), superior temporal gyrus (STG, Wernicke’s area, BA 22), inferior temporal gyrus (ITG, BA37) and lingual gyrus (LG, BA 18) gyrus. The GPC had significant effect on two of these regions (Fig 1, Panel B): the activation of

STG was modulated by R while that of ITG was modulated by IR condition. This result is in agreement with behavioural (Cousin et al. 2009) and neuroimaging (Paulesu et al. 2000; Dehaene et al. 2002; Price & Devlin, 2003) evidence suggesting that transparent (with predominant R GPC) and non-transparent (with predominant IR GPC) languages may differ on the engaged processes, increased phonological representations and decoding for transparent and increased visual processing for non-transparent languages.

82. 11:30 a.m. - 12:30 p.m.

The neurotopography of the long-term and working memory components of spelling

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Objectives: While extensive research has been directed at understanding the neural substrates of reading and spoken language, relatively little research has been concerned with identifying the neural substrates of written language production (spelling). The primary source of information has been deficit/lesion correlation studies. Traditionally, these have focused largely on the superior parietal cortex and the superior premotor region (i.e., Exnerís area). More recent work has added other regions including the left inferior frontal gyrus and the left mid fusiform gyrus, which may subserve orthographic processes recruited by both spelling and reading (Rapp & Lipka, in press). While these various regions have been implicated in the spelling process, their specific roles are not well understood. The objective of this study was to identify the neural substrates that support specific and well-described functional components of written language production. Specifically we sought to identify neural regions that are sensitive to the factors of lexical frequency and word length. Frequency effects are typically associated with long-term memory lexical processes, while length effects are assumed to index orthographic working memory (graphemic buffering). Methods: Nine, right-handed native English speakers underwent fMRI scanning (Philips 3T scanner) while performing spelling and reading tasks. The spelling tasks consisted of the experimental task of Writing to Dictation and two control tasks: Alphabet Writing and Circle Drawing (modeled after Beeson, et al., 2003). Word stimuli included both high and low frequency words, half of which were long (7 letters) and half were short (4 letters). A first set of analyses involved identifying a general written spelling circuit. A second set of analyses included Volume of Interest (VOI) analyses involving the regions indentified in Analysis 1. These included comparisons of neural responsiveness to low vs. high frequency words and long vs. short words. Results: Analyses reveal a highly differentiated pattern of sensitivity to the factors of length and lexical frequency. Sensitivity to frequency but not length was observed in left hemisphere mid-fusiform and inferior frontal regions, while the reverse pattern of sensitivity to length but not frequency was observed in left hemisphere superior parietal cortex as well as the superior frontal sulcus. Conclusions: These findings constitute the first fMRI evidence regarding the substrates of specific functional components of the spelling process. The fact that lexical and working memory components are considerably differentiated is significant not only for our understanding of written language production, but also contributes importantly to the broader debate regarding the independence of long-term and working memory processes in language (Miyake & Shah, 1999). References: Beeson, P. M., Rapcsak, S. Z., Plante, E., Chargualaf, J.,Chung, A., Johnson, S., et al. (2003). The neural substratesof writing: A functional magnetic resonance imaging study. Aphasiology, 17, 647ñ665. Miyake, A., & Shah, P. (Eds.). (1999). Models of working memory: Mechanisms of active maintenance and executive control. New York: Cambridge University Press. Rapp, B. & Lipka, K. (in press). The literate brain: The relationship between spelling and reading Journal of Cognitive Neuroscience.

83. 10:15 a.m. -11:15 a.m.

The neural substrates of morphological processing and representation in reading

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Most theories of word processing posit multiple levels of representation and processing of the morphological structure of words. In word reading, morphological decomposition has been claimed by many investigators to occur at both orthographic (modality-specific) and lexical-semantic (modality-independent) levels (e.g., Giraudo & Grainger, 2000; Rastle, & Davis, 2008). However, the neural bases of morphology-sensitive processes have been examined in only a handful of functional neuroimaging studies. The objective of this study was to investigate the neural substrates of the multiple levels of morphological processing that are recruited in word reading. This was accomplished through the analysis of fMRI data collected during visual masked-priming, a task widely used in prior behavioral investigations of morphology. Twelve native English speakers participated in two behavioral tasks during fMRI scanning. The two tasks were: (1) masked-priming with lexical decision and (2) silent reading/passive viewing of words, consonant strings and checkerboards. The silent reading task served as a functional localizer of reading sensitive cortex (Cohen et al., 2002), while the masked-priming task served as the primary experimental task used to identify morphology-sensitive neural substrates (e.g., Devlin et al., 2004). The masked-priming task included a number of conditions that manipulated the relationship between a briefly presented prime word and a target word (or nonword). The three morphological prime-target conditions were: Inflected (turned-TURN), Derived (sender-SEND), Pseudo-derived (corner-CORN); and the three control conditions were: Orthographic (dragon-DRAG), Semantic (paste-GLUE) and Unrelated (stamp-

IRON). Morphology-sensitive substrates were identified as those areas that exhibited activation differences between one of the morphological conditions and the unrelated condition. Furthermore, these activation differences could not be attributed to the orthographic or semantic similarity between prime and target. Whole-brain and region of interest analyses were carried out. Results of the silent reading task served to localize orthography-sensitive regions within the left fusiform gyrus. The masked priming task revealed, among other things: (1) morphology-sensitive areas in the left middle frontal gyrus, the left angular gyrus and fusiform/inferior temporal gyri, and (2) distinctions between areas sensitive to derivational and inflectional morphology in the left fusiform/temporal region. The findings of this investigation are significant in that they allow us to identify brain areas involved in different aspects of morphological processing: modality-specific processes likely involved in the decomposition of the orthographic forms, and regions within traditional language processing areas of the left frontal lobe probably involved in lexical-semantic processing. The differences in responsiveness to the various types of morphological relationships allow us to begin to identify the organization of the neural network implicated in morphological processing. Cohen, L., Dehaene, S., Naccache, L., Lehericy, S., Dehaene Lambertz, G., et al., 2000. The visual word form area: spatial and temporal characterization of an initial stage of reading in normal subjects and posterior split-brain patients. Brain 123, 291ñ307. 452ñ466. Devlin, J. T., Jamison, H. L, Matthews, P. M., & Gonnerman, L. M. (2004). Morphology and the internal structure of words. Proceedings of the National Academy of Sciences USA, 101, 14984-14988. Giraudo, H., & Grainger, J. (2000). Effects of prime word frequency and cumulative root frequency in masked morphological priming. Language and Cognitive Processes, 15, 421-444. Rastle, K., & Davis, M. H. (2008). Morphological decomposition on the analysis of orthography. Language and Cognitive Processes, 23, 942-971.

84. 11:30 a.m. - 12:30 p.m.

Facilitating orthographic memory by reducing neural repetition suppression in the left fusiform cortex

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The specific role of the left midfusiform in reading is under continuing debate. Contrary to the hypothesis that the left midfusiform is specialized in processing familiar words (e.g., Cohen and Dehaene 2004), strong midfusiform activation was observed when readers processed novel writings (Xue, et al. 2006a; Xue and Poldrack 2007). Orthographic training led to increased proficiency in identifying novel orthography, accompanied by decreased neural activation in the left midfusiform cortex (Xue, et al. 2006a; Xue and Poldrack 2007). More importantly, it has been shown that the leftward lateralization of midfusiform activation during initial learning strongly predicted the outcome and long-term (six-month) retention of a two-week orthographic training regimen (Chen, et al. 2007; Dong, et al. 2008; Xue, et al. 2006b). These results suggest that the left midfusiform plays an important role in learning new orthographies. In the present study, we examined three hypotheses on the association between midfusiform activation and orthographic learning. First, by monitoring the brain activities during the whole learning process with functional MRI, we examined whether repeated presentations of novel scripts were associated with reduced or increased neural activity in the left midfusiform cortex. Second, we investigated whether activation of the left fusiform during learning was also associated with long-term orthographic memory, both within subjects (using a subsequent memory design) and across subjects (using correlational analysis). Third, the present study examined whether we could improve orthographic memory of learnt novel writings by using manipulations (e.g., the spaced learning paradigm) that are known to increase the fusiformís activity during orthographic learning. Nineteen native Chinese readers were scanned while memorizing the visual form of 120 Korean characters that were novel to them. Each character was repeated four times during learning. Repetition suppression was manipulated by using two different repetition schedules: massed learning and spaced learning, which were pseudo-randomly mixed within the same scanning sessions. Under the massed learning condition, the four repetitions were consecutive (with jittered inter-repetition-interval to improve the design efficiency); whereas under the spaced learning condition, the four repetitions were interleaved with a minimal inter-repetition lag of 6 stimuli. A recognition memory test was administered 1 hour after the scan to assess participantsí orthographic memory. Results suggest that subjects recognized more items presented under spaced condition than those under massed condition. A comparison of the first presentation with subsequent repetitions revealed a strong repetition suppression effect in the left midfusiform cortex. Stronger left fusiform and inferior temporal gyrus activity during learning was associated with better orthographic memory, both within- and cross-subjects. Compared to massed learning, spaced learning significantly reduced neural repetition suppression and increased the overall activity in this region, and led to better orthographic memory.

In summary, our study shows that better orthographic memory can be achieved by increasing neural activation of the left midfusiform during learning. These results are incompatible with the VWFA hypothesis, and may have implications for language learning and education.

85. 10:15 a.m. -11:15 a.m.

Shared neural representations for word reading and spelling in the VWFA

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Numerous studies have found that a region in the left occipitotemporal cortex, termed the Visual Word Form Area (VWFA), plays a key role in orthographic processing for reading (Gaillard et al. 2006; Glezer et al. 2009). Recent studies that have examined the average fMRI signal in response to reading and spelling have shown that both tasks activate the VWFA, suggesting that this area may contribute to both orthographic input and output processes (Purcell et al. 2009; Rapp and Lipka 2010). Based on these findings, we hypothesize that the same neurons used to spell a word are used to read a word in the VWFA. Critically, because previous combined reading/spelling fMRI studies have relied on examining average signal changes, it is unclear if the same populations of neurons within the VWFA are used to read and spell the same word or if these tasks rely on dissociable populations of neurons with equatable average signal responses (Price and Devlin 2003). In recent years the fMRI-Adaptation (fMRI-A) technique has been developed to determine if populations of neurons within the same region process common features across different stimuli or tasks (e.g. Grill-Spector et al. 2006) and here we use this methodological approach to test whether the same neurons used to read a word are used to spell that word. We employed event-related fMRI-A in 16 right-handed, monolingual subjects with normal reading/spelling skills in an design that combined both spelling (hear a word, then type it on a keyboard) and reading. Adaptation effects were examined by detecting greater activation for conditions involving trial pairs of different words as compared to those of the same word. Effects for within-conditions (i.e. reading or spelling only) and cross-conditions (i.e. reading/spelling and spelling/reading) were investigated. This allowed us to test the hypothesis that spelling a word would lead to an adapted fMRI response when the same word was then read. In order to ensure that adaptation effects in the reading-spelling experiment were not due to semantic/phonological processing we also included a control experiment involving repetition (hear a word, then repeat it into a microphone) and reading. In each subject we first identified the VWFA via an independent reading localizer (adapted from Cohen et al. 2002) and then extracted the signal from these subject-specific regions of interest for both the experimental and control experiments. Our results confirm the hypothesis that there is cross spelling/reading adaptation but not cross repeating/reading adaptation in the VWFA. These finding indicate that some of the same neurons used to read a word in the VWFA are also called upon to spell that same word.

86. 11:30 a.m. - 12:30 p.m.

Neural bases of addressed and assembled phonologies: The role of native language experience

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A key component of reading is phonological access, i. e., the association of visual words with their sounds. Two distinct routes of phonological access, the addressed phonology and assembled phonology, have been identified. Nevertheless, questions remain regarding how the two phonological access routes are instantiated in the brain and how they are modulated by factors such as culture and prior language experience. Here, we adopted an innovative artificial language training paradigm to reveal the neural bases of addressed and assembled phonologies, and to examine the impact of native language on phonological access of second language. Forty-four native Chinese speakers and 37 native English speakers were recruited to learn an artificial language (based on Korean Hangul) that can be read either through the addressed or assembled pathway on hour per day for eight days. Both native Chinese and English speakers were divided into two matched groups to receive the two types of training, respectively. For the addressed group, subjects were asked to memorize the characters as a whole. For the assembled group, subjects were first taught the pronunciation of the letters and then to assemble the phonology of the characters from their letters. After training, subjects were scanned while performing a naming task with Chinese words, English words, trained AL words, and untrained AL words. Behavioral results showed that training significantly improved naming accuracy and reduced reaction times for both native Chinese and English speakers, suggesting that our training was effective. More importantly, we found that native English speakers learned the assembled phonology faster than native Chinese speakers. Imaging data showed that regardless of subjects' native language, addressed phonology relied more on the ventral pathway (i.e., the bilateral middle temporal gyrus), whereas assembled phonology depended more on the dorsal pathway (i.e., the left precentral gyrus and supramarginal gyrus). To further investigate the impact of native language experience on phonological access of second language, we compared the neural bases of assembled and addressed phonologies across the two groups. Results showed that native English speakers showed more activations in the left supramarginal gyrus (a key region for assembled phonology) than native Chinese speakers in assembled phonology. Taken together, using a cross-cultural artificial language training paradigm, the present study clearly indentified two neural pathways of phonological access that

are significantly modulated by prior language experience, and have differential effects on phonological learning efficiency.

87. 10:15 a.m. -11:15 a.m.

Chronometric TMS shows hemispheric asymmetries in the time course of ventral occipito-temporal processing consistent for both visual words and objects

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Visual object recognition engages ventral occipito-temporal cortex (vOTC) bilaterally whereas visual word recognition is believed to be primarily left lateralized. Here we used non-invasive cortical stimulation of left and right vOTC to map out the temporal flow of information during visual object and word processing. On each trial, a pair of TMS pulses separated by 40msec was delivered to either left or right vOTC or to a control site (vertex) while participants decided whether a stimulus (a word or picture) represented a living thing (e.g. ""cat""). Pulses were delivered at different time points (0/40, 40/80, 80/120, 120/160, or 160/200msec post-stimulus onset). Stimulation of either left or right vOTC slowed responses to both picture and words while stimulation of the vertex had no significant effects on response times. For both words and pictures, this slowdown first occurred in the 80/120msec time window in the left hemisphere but at 120/160msec in the right. Statistical testing confirmed that the effects of TMS occurred later in the right than left hemisphere for both words and objects. Indeed, there were no significant differences between words and objects either anatomically (left vs. right) or temporally (across the five time windows). These findings are consistent with neurophysiological recordings in awake monkeys showing that action potentials from the ascending ventral visual stream are seen in posterior inferotemporal cortex between 60-120msec post-stimulus onset. Here, we further demonstrate that the time course of processing in vOTC differs in the left and right hemisphere and this is replicated with remarkable consistency for both objects and words. Additional work will be necessary to investigate the basis of the temporal differences in left and right vOTC but the similarity of the timing for words and pictures suggests that vOTC is commonly involved in both visual word and object recognition.

88. 11:30 a.m. - 12:30 p.m.

Character transpositions in letter, number, and symbol strings: behavioral and electrophysiological evidence

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The present study examined whether strings of letters, numbers or meaningful symbols are processed and encoded in a different manner. To this end, ERPs were recorded while participants made perceptual matching judgments on two visually presented strings that were either identical or different. Strings were different when two internal characters were transposed or replaced. Behavioural data showed that participants took longer to respond to transposition changes than replacement changes. Critically, transpositions within letter strings were more costly than transpositions within symbol and number strings, both in the reaction time data and in the accuracy data. In line with the behavioural data, the ERP data showed an early negative-going difference only for letter replacements as compared to letter transpositions between 200 and 300 ms. On the other hand, character replacements produced a significant positive-going deflection as compared to character transpositions between 300 and 600 ms for all types of strings. Together these findings suggest that the segmentation and encoding of strings of characters occurs in a stimulus-specific manner, and that letter strings are more sensitive to position manipulations than number and symbol strings. These results are of critical relevance for adjudicating between different models of orthographic encoding, especially between those that propose similar coding processes for all types of characters and those that propose that letter position coding is fundamentally different.

89. 10:15 a.m. -11:15 a.m.

Distributed neural activity during reading words with high and low phonological consistency

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The dual route cascade model of reading postulates two distinct, but interactive routes for recognizing and reading aloud words. The indirect route involves mapping a visual word to its auditory counterpart before accessing its meaning. Words that have consistent spelling to sound mappings (or high phonological consistency, e.g. "mint") tend to be read using the indirect route. In the direct route, the visual form is linked to its meaning directly. Words with inconsistent spelling to sound mappings (or low phonological consistency, e.g. "pint") are difficult to sound out and thus elicit more direct route involvement. Neuroimaging research has related parts of this theoretical framework to human neuroanatomy, postulating different neural pathways for the two routes. In particular, the visual word form area (VWFA) is

argued to be active in direct route processing. However, it is unclear how these pathways interact, especially when processing words with varying phonological consistency. We investigated the dual route model by comparing words with high and low phonological consistency using a multivariate method that emphasizes the interdependencies among neural regions (partial least squares; PLS). In the fMRI scanner, 16 subjects were instructed to read covertly words presented in an event-related design. Subjects were asked to indicate whether an occasional picture or auditory word matched the previous stimulus. PLS was used to analyze which overall brain activity patterns differentiated high and low consistency words, and rest. Activity was thresholded based on a bootstrap estimated 99% confidence interval. Several clusters were found to relate reliably to high consistency compared to low consistency words and rest including: left sup. temp. gyrus, inf. occip. gyrus and sulcus, mid. occip. gyrus, and fusiform gyrus, including the visual word form area (VWFA). Our finding suggests that involvement of the VWFA is not unique to direct route processing. When examined in the context of neural activity in the rest of the brain, VWFA shows some sensitivity to phonological processing.

90. 11:30 a.m. - 12:30 p.m.

Exploring spatial frequency sensitivity in word and face preferential areas of the fusiform gyrus

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Introduction: The posterior fusiform gyrus is preferentially activated by words in the left hemisphere (Cohen et al., 2000) and by faces in the right hemisphere (Kanwisher et al., 1997). We investigated whether this lateralization may be driven, at least in part, by differential sensitivity of the hemispheres to high or low spatial frequencies. Written words are high spatial frequency stimuli, whereas faces have both high and low spatial frequency information. Previous fMRI (Iidaka et al., 2004) and ERP (Mercure et al., 2008) studies using high- or low-pass spatial frequency filtered images have shown a left hemisphere bias for high spatial frequency images. We investigated whether high-order regions in occipitotemporal cortex are sensitive to spatial frequency, using sine-wave gratings rather than filtered images to avoid category effects that might influence lateralization. We determined whether spatial frequency sensitive areas overlapped with areas that showed selectivity for words and faces. Methods: Functional magnetic resonance imaging data was acquired on a Siemens Avanto 1.5 Tesla MRI scanner with 32 channel head coil. Spatial frequency sensitivity was tested by presenting sine-wave gratings with ascending or descending spatial frequency over a 64 second period (see Sasaki et al., 2001). This procedure was repeated 16 times per participant, split into two scanning runs. In addition, a block-design functional localizer scan was used to identify cortical areas that were activated preferentially for faces and for words. Scrambled faces and word stimuli (matched for spatial frequency) were used as alternative baseline conditions. Results: As predicted, the functional localizer task detected left lateralized occipitotemporal activation for the contrast of words and right lateralized occipitotemporal activation for faces. The whole-brain analysis compared activation in response to high and low spatial frequencies, demonstrating a left hemispheric bias for higher spatial frequencies, and a right hemispheric bias for lower spatial frequencies. A region of interest analysis confirmed stronger activation for higher spatial frequencies in the left occipitotemporal cortex, and stronger activation for lower spatial frequencies in the right occipitotemporal cortex. Conclusions: This study has demonstrated that putative word and face processing areas in occipitotemporal cortex are differentially activated by low-level high and low spatial frequency stimuli. Whilst this finding is compatible with the hypothesis that lateralization of word and face processing is driven by sensitivity to high and low spatial frequencies, it does not preclude the opposite causal relationship: that pre-existing cortical specialization for words and faces causes the hemispheric asymmetry in spatial frequency processing. These findings have potential implications for the understanding and treatment of conditions such as pure alexia and prosopagnosia, where damage to the posterior fusiform gyrus causes a selective impairment in recognition of words or faces respectively.

91. 10:15 a.m. -11:15 a.m.

Sublexical ambiguity effects in reading Chinese disyllabic compounds

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For Chinese compounds, neighbors can share either both orthographic forms and meanings, or orthographic forms only. In this study, central presentation and visual half-field (VF) presentation methods were used in conjunction with ERP measures to investigate how readers solve the sublexical semantic ambiguity of the first constituent character in reading a disyllabic compound. The sublexical ambiguity of the first character was manipulated while the orthographic neighborhood size of the first character (NS1) was controlled (Figure 1). Subjective rating of number of meanings corresponding to a character was used as an index of sublexical ambiguity. Results showed that low sublexical ambiguity words elicited a more negative N400 than high sublexical ambiguity words when words were centrally presented. Similar patterns were found when words were presented only to the left VF (right hemisphere) in the second experiment.

Interestingly, different patterns were observed for pseudowords. With left VF presentation, high sublexical ambiguity psudowords showed a more negative N400 than low sublexical ambiguity pseudowords. In contrast, with right VF (left hemisphere) presentation, low sublexical ambiguity pseudowords showed a more negative N400 than high sublexical ambiguity pseudowords. We suggested that more morphemes corresponding to the initial character implies smaller numbers of words within a meaning when the neighborhood size was controlled (Figure 1). Furthermore, the whole word presentation of a Chinese word provides top-down information, and we showed different sublexical ambiguity patterns of words and pseudowords in two hemispheres. These findings indicate that a level of morphological representation between form and meaning needs to be established and refined in Chinese. In addition, hemispheric asymmetries in the use of word information in ambiguity resolution should be taken into account, even at sublexical level.

92. 11:30 a.m. - 12:30 p.m.

The time course of letter position assignment for low-and high-frequency words: An ERP study

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One critical process in the recognition of visually presented words involves the mapping of an abstract letter representation onto a whole-word representation. In alphabetic languages, this implies that the identity and the position of the letters need to be assigned ñ if not, one would not be able to distinguish trial and trail. Furthermore, transposed-letter nonwords like jugde are perceptually highly similar to their base word (i.e., letter position seems to take long to encode; e.g., Perea & Lupker, 2004). The goal of the present study was to analyze the impact of lexical frequency on letter position assignment by examining potential differences in the onset of the transposed-letter effects on words of different lexical frequency. To this aim, Event Related Potentials (ERPs) were recorded while participants read 6 or 7-letter length words and nonwords in a semantic categorization task. For each word, two different nonwords were created: transposed-letter (TL) nonwords resulted from transposing the internal 4th and 5th letters; the replaced-letter (RL) nonwords resulted from substituting the 4th or 5th letter with a different one. This manipulation occurred for Low Frequency words (e.g., modular, modluar, mogular) and High frequency words (e.g., article, artcile, artacle). Transposed-letter effects were found in high frequency words: larger negativities starting as early as 200 ms were observed for RL compared to TL nonwords (the two conditions showing larger negativities than the corresponding base words). However, this pattern of results did not occur for low frequency words: RL nonwords differed from words, while no early ERP differences were observed between TL and RL nonwords. The implications of the present experiment are quite clear. First, the assignment of letter position is more error-prone flexible than that of letter identity. Second, assignment of letter positions in words is less susceptible to perceptual uncertainty in very familiar patterns (i.e., high-frequency words) than in less frequency patterns (low-frequency words). The present results are determinant for the choice of a different letter-position-coding scheme in visual word recognition models which accommodates letter-position assignment uncertainty.

93. 10:15 a.m. -11:15 a.m.

Neural bases of addressed and assembled phonologies: The role of native language experience

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A key component of reading is phonological access, i. e., the association of visual words with their sounds. Two distinct routes of phonological access, the addressed phonology and assembled phonology, have been identified. Nevertheless, questions remain regarding how the two phonological access routes are instantiated in the brain and how they are modulated by factors such as culture and prior language experience. Here, we adopted an innovative artificial language training paradigm to reveal the neural bases of addressed and assembled phonologies, and to examine the impact of native language on phonological access of second language. Forty-four native Chinese speakers and 37 native English speakers were recruited to learn an artificial language (based on Korean Hangul) that can be read either through the addressed or assembled pathway on hour per day for eight days. Both native Chinese and English speakers were divided into two matched groups to receive the two types of training, respectively. For the addressed group, subjects were asked to memorize the characters as a whole. For the assembled group, subjects were first taught the pronunciation of the letters and then to assemble the phonology of the characters from their letters. After training, subjects were scanned while performing a naming task with Chinese words, English words, trained AL words, and untrained AL words. Behavioral results showed that training significantly improved naming accuracy and reduced reaction times for both native Chinese and English speakers, suggesting that our training was effective. More importantly, we found that native English speakers learned the assembled phonology faster than native Chinese speakers. Imaging data showed that re-

gardless of subjectsí native language, addressed phonology relied more on the ventral pathway (i.e., the bilateral middle temporal gyrus), whereas assembled phonology depended more on the dorsal pathway (i.e., the left precentral gyrus and supramarginal gyrus). To further investigate the impact of native language experience on phonological access of second language, we compared the neural bases of assembled and addressed phonologies across the two groups. Results showed that native English speakers showed more activations in the left supramarginal gyrus (a key region for assembled phonology) than native Chinese speakers in assembled phonology. Taken together, using a cross-cultural artificial language training paradigm, the present study clearly indentified two neural pathways of phonological access that are significantly modulated by prior language experience, and have differential effects on phonological learning efficiency.

94. 11:30 a.m. - 12:30 p.m.

Top-down influences on ventral occipito-temporal activation during reading

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Functional neuroimaging studies in skilled readers as well as acquired and developmental dyslexics have shown that the left ventral occipito-temporal cortex (vOTC) is involved in visual word recognition. While the representational properties of this region have been proposed and investigated, its processing dynamics have received less attention. One theory suggests that visual word recognition follows serial feed-forward steps from physical feature detection in early visual cortices through to visual word form detectors in vOTC. An alternative account suggests that vOTC interactively links bottom-up visual form information necessary for (but not specific to) reading with top-down phonological and semantic information. Here we investigated this question in two separate lexical decision tasks using functional magnetic resonance imaging (fMRI). In the orthographic lexical decision task, participants decided whether letter strings formed real words (e.g., "brain") or not (they were pseudohomophones, e.g., "brane,"), forcing participants to focus solely on the visual form, rather than the sound or meaning, of the stimuli. The second task used phonological lexical decisions between pseudohomophones and pseudowords (e.g., "brane" vs. "brate"), forcing participants to focus solely on non-visual properties of the stimuli (since none of the visual patterns comprised English words. If processing in vOTC is feed-forward then activation may reflect the difference between words and pseudohomophones present in the orthographic task but not between pseudohomophones and pseudowords in the phonological task, as neither has any type of stored representation. Furthermore, the activation in vOTC should not be different for pseudohomophones across two tasks. In contrast, if vOTC processing is interactive, then activation would be expected to be sensitive to both the nature of the task and the stimuli. That is, within-task differences between conditions would result from top-down feedback from both phonology and meaning while the two different tasks would be expected to modulate pseudohomophones differently. We found that the pattern of vOTC activation differed significantly across conditions and could not be predicted by differences in response times. Participants responded more quickly to words than pseudohomophones in the orthographic task and faster to pseudohomophones than pseudowords in the phonological task (Figure 1a). In contrast, pseudohomophones produced greater vOTC activation than either words (orthographic task) or pseudowords (phonological task; Figure 1b). In addition, there was a significant activation difference between pseudohomophones across the two tasks indicating that vOTC activation is influenced by task demands. These differences could not be attributed to purely visual characteristics of the stimuli as these were closely matched across conditions. This same pattern of activation was also observed in pars opercularis (POp), suggesting a possible functional linkage between these two regions during reading. Our results demonstrate that reading-related activation in vOTC cannot be strictly feed-forward but must also be influenced by top-down, non-visual aspects of the task and/or stimuli, consistent with the hypothesis that vOTC acts as an interface linking visual form information with nonvisual properties of the stimuli.

95. 10:15 a.m. -11:15 a.m.

Get a grip: Motor contributions to handwritten word recognition

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Recent experiments employing both EMG and fMRI have shown that muscles in the right hand demonstrate increased activation during lexical access and that these effects are augmented when reading handwritten words. An embodied explanation for these increases is that handwritten words are perceived through a motor simulation of the strokes used to generate the items (in a similar fashion to the motor theory of speech perception). In the current study, we extended the previous research on motor activation during lexical access by employing three different methodologies designed to measure motor contributions to the processing and articulation of high- and low-frequency printed and cursive words. To date, few studies have examined overt motor activities during lexical access, and no studies have examined the motor consequences of a lexical variable such as word frequency. In Experiment 1, we measured deviations in grip force during a standard word naming task. We observed increases in both maximum grip force and

squeeze duration for the right hand during the processing and articulation of low-frequency, cursive words, suggesting that lexical access has an influence on overt motor activation in the hand even in instances where the words contain no semantic relationship to grasping. Experiment 2 employed a fatigue methodology. We predicted that if hand motor areas are recruited to aid in the recognition of handwritten words, fatiguing muscle groups in the hand should have a detrimental effect on word recognition. Indeed, in a sample of strongly right-handed participants, we found that hand fatigue produced prolonged response times in a naming task, with the largest effects following fatigue of the right hand. This was taken as more evidence that motor areas of the brain play a role in visual word recognition, but it remains unclear whether the effect is due to language processing in general or word articulation, specifically. The final experiment was designed to examine hand motor activation in a context where articulation was unnecessary. Participants made lexical decisions for printed and cursive letter strings by squeezing hand dynamometers, measuring grip force. In this experiment, the effects reversed, with high-frequency words eliciting stronger grasps than low-frequency words. This reversal could be due to the absence of articulation or could be analogous to the findings of Abrams and Balota (1991) who observed more forceful lexical decisions for high-frequency words when responses were made by moving a lever.

96. 11:30 a.m. - 12:30 p.m.

An event-related potential study of awareness of form-sound correspondence in Chinese children with reading disorders: Preliminary data

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Introduction: Children with developmental dyslexia are usually characterized as having difficulties learning grapheme-meñphoneme correspondence and applying the mappings. While Chinese characters do not contain components representing phonemes, over 80% of characters are phonetic compound characters containing a radical often serving as a phonetic cue (e.g. phonetic radical 將 zoeng1 in 漿 zoeng1 ëpasteí). The form-sound mapping can be described by (i) regularity ñ whether a phonetic compound character has the same pronunciation as its phonetic radical, and (ii) consistency ñ the degree of reliability of a phonetic radical as a phonetic cue for characters containing it. In light of the observations from normal Chinese adult readers of phonological consistency effects in P200 (180-230 ms) and N400 (300-500 ms) (Lee et al., 2006, 2007), this paper reports preliminary results of a study examining the sensitivity of Chinese reading-impaired children to form-sound correspondence in terms of effects of regularity and consistency using the event-related potentials (ERPs) technique. Methods: The participants included two right-handed Cantonese-speaking Primary 4 male students, one with reading impairment and one with normal reading performance. The third participant was a left-handed male student of the same grade who was formerly diagnosed as dyslexic and underwent reading remediation in the summer of 2009. His reading score at the time of study was within the normal range. The participants carried out a character recognition task in which they pressed separate buttons to indicate whether or not they had learned the character presented in each trial. Unlearned items were pseudocharacters created by rearranging the radicals from real characters. Learned characters were those taught by Primary 2. They were selected in terms of regularity (regular vs. irregular) and consistency (consistent = 0.88 vs. inconsistent = 0.21; values based at Primary 4). Cumulative frequency and visual complexity (i.e. number of strokes) were matched across experimental conditions. Results and Discussion: Behavioral results show that the dyslexic participant had the poorest accuracy in identifying real characters (66%), with comparable accuracy from the control (86%) and former dyslexic child (84%). An effect of lexicality at the N400 was found for the control participant, where pseudocharacters elicited a greater negativity (Hauk et al., 2006), see Figure 1. This was not seen in the other children. Moreover, the former dyslexic child showed the opposite pattern where real character evoked greater negativity. Similarly, regularity and consistency effects were found at the P200 only for the control, with regular and consistent characters eliciting greater positivity (see also Lee et al., 2006, 2007). The dyslexic participant showed no clear difference for regularity, and the opposite pattern of polarity for consistency. While no notable effects of regularity and consistency were observed for the former dyslexic child, his overall ERP waveform pattern was similar to the control. In short, the preliminary ERP findings of lexicality, consistency and regularity effects observed only in the control participant suggest that dyslexic children, remediated or not, may have weaker orthographic representations, and may be less sensitive to the internal structure of characters and its relationship with sounds. Figure 1. Preliminary ERP waveforms of lexicality, regularity and consistency effects at the N400 (top) and P200 (bottom) for the control, dyslexic and former dyslexic participants.

97. 10:15 a.m. -11:15 a.m.

Neural correlates of alphanumeric and non alphanumeric multi element string processing in healthy skilled readers

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Visual word recognition involves several cognitive processes of both phonological and visual nature. Developmental dyslexia, a specific reading acquisition impairment, can occur if one or more of these processes are disrupted. Recent evidence has identified a multi-element visual-processing disorder in some dyslexic readers. In order to better understand this deficit, the early visuo-attentional mechanisms involved in processing multi-element strings need to be specified. Previous studies have suggested an involvement of parietal areas including the superior parietal lobule (SPL) in letter string processing. The objective of this study is to isolate this putative parietal network in skilled readers. In order to disambiguate its stimuli-type specificity, we used novel character string processing tasks that can be carried out with both alphanumeric and non-alphanumeric strings. Twelve French skilled readers performed these visual processing tasks on character strings. The first task, a categorization task (CAT), involved identifying a distracter character within a 5 character string while the second task, a counting task (COU), involved evaluating how many characters of a target character type were present in a 5 character string. Finally, a control task (CON) involved identifying the character category of a single character flanked by 2 pound signs on each side. All of these tasks were performed in two conditions: alphanumeric and non alphanumeric. Functional MR imaging was performed on a Bruker 3T MR imager, equipped with echo-planar (EPI) acquisition. Each task was designed in an event-related mode. Data analyses were performed by using SPM5 (Wellcome Department of Imaging Neuroscience, London, UK). Both multiple element tasks (CAT and COU) activated a common network including the right superior parietal lobule (BA7) and the left fusiform gyrus (BA 37). The left superior parietal lobule was activated only in the non-alphanumeric condition. These results suggest an involvement of a common right sided visuo-attentional network in character string processing regardless of the linguistic nature of the characters. Furthermore, contrasts between the COU task and the control (CON) condition revealed stronger superior parietal lobule activations for the multi-element processing task than for the central element processing task. This stronger activation was bilateral for nonalphanumeric characters and right sided for alphanumeric characters. These results suggest that string processing involves attention-modulated brain mechanisms that are not specific to alphanumeric stimuli. These findings provide novel insight in the early visual mechanisms that are involved in string processing regardless of reading experience with the stringís characters. Furthermore, as parietal dysfunction has been documented in dyslexic readers, these tasks could be used to further assess this impairment. The counting task, which benefits from the most favorable signal to noise ratio, seems to be the best candidate to evaluate this dysfunction and its specificity to alphanumeric stimuli or lack thereof.

98. 11:30 a.m. - 12:30 p.m.

Affix frequency versus positional letter string frequency in visual recognition of morphologically complex words

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Objective: Recent MEG studies of visual complex word recognition find that activation in the fusiform (FF) region ~150ms post-stimulus onset is correlated with properties of morphological form, but not with lexical properties such as meaning entropy (Solomyak & Marantz, 2009a, 2009b). The FF response is also modulated by morphological properties of pseudo-affixed words like ìbrother,î of which the base ìbrothî is unrelated to the whole form (Lewis, Solomyak, & Marantz, in press). Because affixes are considerably more frequent than non-affixes, the role of positional letter string frequency in decomposition cannot be dismissed. The present MEG study compares responses to non-affixed words like ìscoundrelî that end in a frequent letter string to responses to unique-root words like ìsporadicî (ìsporadî occurs only in this word) that end in an affix. We examined cuneus, FF, and superior temporal (ST) region of interest (ROI) responses associated with orthographic, morphological, and lexical recognition stages, respectively. Focus was on effects of the wordsí orthographic affix frequency (OAF; the frequency of an affix as a letter string ending), residual morphological affix frequency (rMAF; the frequency of an affix as a morpheme after regressing out the effect of OAF), and word-class (WC; unique-root vs. non-affixed items) on cuneus and FF responses. Predictions were for FF correlations with rMAF and with WC. Methods: MEG recordings from 10 subjects were acquired during a lexical decision task. Target stimuli were 106 unique-root words and 106 non-affixed words. Each unique-root item ended in one of four affixes that were of similar frequency and equal in length to the individual letter string endings of the non-affixed items. Structural MRIs were used to calculate cortically constrained minimum-norm solutions for each subject. Grand average activation was computed over trials and subjects by morphing each subjectís brain to a standard brain. ROIs were identified in peaks in grand average activity within the cuneus, FF, and ST regions. Vertices of the ROIs were labeled and morphed back to individual subjects. Trial-by-trial ROI activity was employed in correlational analyses. Results: Cuneus activation was significantly correlated with unique-root and non-affixed OAF, but not with WC or unique-root rMAF. The FF analysis revealed significant positive effects of rMAF and significant negative effects of pseudo-affixed OAF at a later time-window. The FF activation was also significantly correlated with WC, with weaker activation for unique-root items suggesting a facilitative effect for decomposition for these words. Conclusions: The OAF effects from both classes on cuneus activation resemble the findings for complex words in Solomyak & Marantz (2009b). The rMAF FF effect for unique-root words taken with the FF WC effect support the position that decomposition ~150ms in the FF is modu-

lated by morphemic word forms rather than by frequent letter strings. Discussion of Significance: This study provides evidence that decomposition is accomplished in the FF ~150ms post-stimulus and that decomposition effects cannot be reduced to effects of positional letter frequencies.

99. 10:15 a.m. -11:15 a.m.

Cortical asymmetries in the precuneus and fusiform gyri are associated with visual field asymmetries in word processing: A voxel based analysis

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Introduction: A right visual field/left hemisphere (RVF/LH) advantage is routinely obtained in verbal tasks where words are briefly presented to one or the other visual field (Chiarello, 2009). In this study we asked whether individual differences in the strength of this advantage were associated with gray or white matter cortical asymmetries.

Method: Subjects were native English speakers (100M, 100F, ages 18 - 34). Asymmetry scores across seven divided visual field tasks were calculated separately for accuracy and reaction time: lexical decision, masked word recognition, word naming, nonword naming, semantic (manmade vs natural) decision, verb and category generation. Composite asymmetries were calculated by averaging the individual z-scored task asymmetries. Two volumetric (1.5T GE) T1 scans from each individual were co-registered, normalized, bias field corrected, segmented and modulated using SPM8 with DARTEL (diffeomorphic anatomical registration through exponentiated algebra (Ashburner 2007)). Normalized and segmented images were averaged to produce sample specific a priori templates. Each template was flipped and averaged with the unflipped template to create symmetrical gray matter, white matter, and CSF templates. Segmentation with DARTEL was performed with the symmetrical templates before the normalized, segmented, and modulated images were smoothed using an 8 mm kernel. Gray and white matter asymmetry images were then created by subtracting the flipped scans (Watkins (2001)). Results: Four separate regression analyses examined the relation between composite reaction time (CRTA) and accuracy asymmetries (CAA) and gray and white matter asymmetries. T values for voxel clusters described below exceed $p = 0.001$, uncorrected. Three gray matter R > L asymmetry clusters were associated with CRTA (see fig): a 65 voxel cluster in the posterior fusiform gyrus, a 65 voxel cluster in the precuneus and a 44 voxel cluster in the inferior temporal gyrus. CRTA was also associated with L > R fusiform and precuneus clusters in the white matter asymmetry images. Three gray matter clusters were associated with CAA: a 62 voxel R > L anterior fusiform cluster, a 44 voxel L > R cluster in the superior colliculus, and a 39 R > L voxel cluster in the precuneus. Discussion: In contrast to our expectation that individual differences in visual field asymmetry would be associated with individual differences in perisylvian regions that show robust population asymmetries, neither manual nor automated analyses identified any significant associations with perisylvian asymmetry. Instead, reaction time asymmetry was associated with reciprocal gray and white matter asymmetries in fusiform and precuneus gyri. Although there is little evidence for robust anatomical asymmetries in these areas, there is substantial functional evidence that both the fusiform and precuneus gyri participate in word identification and reading. Left hemisphere fusiform damage is associated with naming deficits and activation during word reading has led to its designation as the ìvisual word form areaî (Cohen 2004), while activation in the precuneus occurs during reading aloud (Graves 2009). Decreased activation in these two areas is also associated with dyslexia (Maisog, 2008). The current results suggest that increased myelination of fiber tracts underlying the fusiform and precuneus gyri in the left hemisphere may be responsible for the RVF/LH advantage in processing words. Ashburner J. A fast diffeomorphic image registration algorithm. Neuroimage 2007; 38: 95-113. Chiarello C, Welcome SE, Halderman LK, Leonard CM. Does degree of asymmetry relate to performance? An investigation of word recognition and reading in consistent and mixed handers. Brain Cogn 2009; 69: 521-30. Cohen L, Jobert A, Le Bihan D, Dehaene S. Distinct unimodal and multimodal regions for word processing in the left temporal cortex. Neuroimage 2004; 23: 1256-70. Graves WW, Desai R, Humphries C, Seidenberg MS, Binder JR. Neural systems for reading aloud: A multiparametric approach. Cereb Cortex 2009; Nov 17. [Epub ahead of print] Maisog JM, Einbinder ER, Flowers DL, Turkeltaub PE, Eden GF. A meta-analysis of functional neuroimaging studies of dyslexia. Ann N Y Acad Sci 2008; 1145: 237-59. Watkins KE, Paus T, Lerch JP, Zijdenbos A, Collins DL, Neelin P, et al. Structural asymmetries in the human brain: a voxel-based statistical analysis of 142 MRI scans. Cereb Cortex 2001; 11: 868-77.

100. 11:30 a.m. - 12:30 p.m.

From letter strings to connected text: Using fMRI to investigate reading fluency

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Fluent readers process written language rapidly and accurately, and comprehend what they read (National Reading Panel, 2000; Wolf & Katzir-Cohen, 2001). They achieve competency in numerous reading subskills, including 'phonological and orthographic. processes' (Katzir et al., 2006, p54). FMRI has clarified the structures supporting these skills (Schlaggar & McCandliss, 2007), but not their relative engagement as reading fluency varies. We hypothesized that manipulating the fluent reading network through altering reading speed would increase cognitive demands and decrease activation

in higher-order network components. To this end we assessed 13 right-handed adults (12 female; mean age 24.05 [4.48] yrs) with a novel fMRI design. Participants completed two reading tasks at individually determined slow, comfortable and fast speeds. In the fluent sentence reading task, words constituting a sentence accrued sequentially on a screen and subjects were asked to select an image that best illustrated the meaning of the sentence from distracters. In the letter reading task, matched groups of identical letters and a single target were similarly presented, and subjects were asked to identify the target. Letter stimuli were matched to the sentences in overall number and letter grouping. Null periods were presented between trials. Accuracy for fluent sentence reading and letter reading tasks exceeded 95%. The three fluent sentence reading contrasts (each speed > null) were associated with bilateral occipito-fusiform, left middle temporal and left inferior frontal gyral activation (bilateral in the slow condition). As speed increased, so did activity in the occipital cortex and the visual word-form area (fusiform gyrus; left > right) (contrast: fast > slow fluent sentence reading). In contrast, letter reading tasks (tasks > null) engaged lateral occipital cortex bilaterally, along with fronto-parietal, subcortical and frontal regions at all three speeds. Conversely, in letter reading increasing presentation speed elevated superior parietal and supramarginal activation. These data suggest that when reading speed is increased, components of the fluent reading network respond differently from both one another, and from speed-related changes in a more basic letter reading task. Notably, in healthy participants lower-order reading regions (e.g., fusiform gyrus) may increase their activity while higher order areas (e.g., the IFG) do not. These results have important implications when examining neurofunctional changes in dyslexia, which we are investigating in a follow-up study.

101. 10:15 a.m. -11:15 a.m.

Exploring alternate routes to literacy in profoundly deaf native signers

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Phonological awareness, or knowledge of the sound structure of a language, is consistently the best predictor of reading in hearing individuals. For this reason, the bulk of deaf education and reading research has focused on phonological skills[1]. Yet, we would argue that learning to read presents different challenges to each population. In hearing children, word-to-sound mapping benefits reading thanks to the spoken language the child already mastered. For deaf children, learning to read may rather rely on learning to map new forms to meaning and how these forms should combine to express more complex meaning through the syntax of English. To address this issue, the current study examines how English phonological skills, speech-reading, long-term memory, short-term memory, and language proficiency in both English and American Sign Language (ASL) contribute to reading performance. Deaf native signers of ASL were compared to hearing controls with a similar range of reading competency. As expected, measures of English phonological skills were the best predictors of reading in hearing controls. In contrast, a measure of long-term memory best predicted reading in deaf native signers. These results unveil a different route to literacy in the deaf population. Neural underpinnings of reading were also examined at the single word and sentence level. Hearing participants confirmed robust patterns of left-lateralized activation for single words (defined by processing alphabetic stimuli vs. checkerboards) including inferior frontal and dorsal lateral prefrontal cortices and the visual word form area (VWFA)[2]. While the same network was engaged in the deaf, its overall activation level was significantly weaker. Crucially, the VWFA in the deaf showed significantly less recruitment than in hearing. A strikingly different pattern emerged when looking at sentence processing (defined by reading sentences for comprehension vs. processing 'false-font' sentences). Hearing and deaf displayed similarly robust activation in the peri-sylvian neural network typically associated with language processing, including bilateral temporal, inferior and middle frontal, and parietal cortices. While overall quite similar, the hearing group engaged left structures to a greater degree, including left parietal, precentral, cerebellum, and the VWFA, while the deaf group engaged right structures to a greater degree including the right superior temporal, supplementary motor area and the putamen. A notable exception was the left auditory cortex, including primary auditory cortex, which showed greater activity during sentence reading in the deaf group. Crucially, this activation positively correlated with standardized reading comprehension scores. This is the first evidence of cross-modal plasticity in auditory cortex during a language task in deaf individuals, a result which parallels reports of visual cortex recruitment in congenitally blind individuals during verbal memory and text comprehension[3]. These results also raise key issues concerning what should be the focus of instruction when teaching deaf individuals to read. The present work reinforces the view that deaf and hearing come to master reading through alternate routes. While both of these routes have been documented before during language use, English speakers predominantly rely on the phonological route when reading, whereas deaf signers may make greater use of the conceptual route. [1] Hanson, V.L., & Fowler, C.A. (1987). Phonological coding in word reading: Evidence from hearing and deaf readers. Memory & Cognition. 15(3): 199-207. [2] Cohen, L., Lehéricy, S., Chochon, F., Lemer, C., Rivaud, S., & Dehaene, S. (2002). Language-specific tuning of visual cortex? Functional properties of the Visual Word Form Area. Brain. 125(5): 1054-1069. [3] Amedi, A., Raz, N., Pianka, P., Malach, R., & Zohary, E. (2003). Early 'visual' cortex activation correlates with superior verbal memory performance in the blind. Nature Neuroscience. 6: 758-766.

Syntax

102. 11:30 a.m. - 12:30 p.m.
"Chomsky illusion"? ERP evidence for the influence of information structure on syntactic processing

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Information structure (IS) can be used to facilitate communication between interlocutors by highlighting relevant information. We used Event-related Potentials (ERPs) to investigate the influence of IS on the depth of syntactic processing. IS was marked by question contexts in question-answer pairs, so that particular words in the answers were in focus or out of focus (non-focus). In addition, two types of syntactic violation were created in focus and non-focus position, one of which was subtle (a number agreement violation) and the other was salient (a phrase structure violation). We considered the depth of syntactic processing to be reflected in the amplitude of the P600 effect. For the number agreement violation, we found a P600 effect for the focus condition, but not for the non-focus condition. For the phrase structure violation, both focused and non-focused information elicited P600 effects. Thus, it seems that IS modulates the depth of syntactic processing: subtle syntactic violations did not lead to a P600 effect when in non-focus position, but this P600 modulation did not occur for very salient syntactic violations. We hypothesize that IS serves to allocate more cognitive resources to focused information (facilitating, amongst others, syntactic processing), whereas non-focused information receives less resources, resulting in a ìgood enoughî syntactic representation (Ferreira, Bailey, & Ferraro, 2002). However, when there is a very salient incongruence between the current information and the context (in the case of phrase structure violations), the influence of IS will be overridden.

103. 10:15 a.m. -11:15 a.m.
The influence of context on word order processing: An fMRI study

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A number of behavioral studies prove that object-initial clauses are harder to process than subject-initial clauses (Finnish: Hyönä and Hujanen 1997; German: Bader and Meng 1999; English: Ferreira 2003). In accordance with these behavioral results, existing neuroimaging studies show more activation in left Inferior Frontal Gyrus (IFG) for object-initial clauses than for their subject-initial counterparts (Ben-Shachar, Palti et al. 2004; Bornkessel, Zysset et al. 2005; Kim, Koizumi et al. 2009). The increased activation in left IFG has both been explained in terms of syntactic transformation demands (Ben-Shachar, Palti et al. 2004), increased linearization demands (Bornkessel, Zysset et al. 2005) and increased load on working memory (C.J. Fiebach 2005). However, it has not been investigated whether the context can decrease the activity in left IFG. Within linguistic theories, it is well-established (MacWhinney 1977; Kaiser and Trueswell 2004) that object-initial sentences can only occur in certain contexts (e.g. when the object-initial sentence serves as a contrast ""I donít drink wine and shots, but beer I like""), but all existing neuroimaging studies of object-initial clauses present the target sentences in isolation, thereby providing sub-optimal prerequisites for successful processing of the object-initial sentences. In the present fMRI study we investigated the effects of introducing object-initial sentences with or a without a preceding textual context. Our target sentences were Danish transitive main clauses. In Danish both subjects and objects can occur sentence-initially (although subject-initial sentences are more frequent) and substantives bear no case. Given that the subject-initial sentence structure is the most frequent, we predicted that a preceding linguistic context would have greater facilitating impact on the syntactic and semantic unification in BA44/BA45/BA47 of object-initials, thus resulting in a relatively decreased activity for object-initial sentences. Methods: 21 participants (12 female) read 120 items, balanced over four conditions: Subject-initial sentences with a preceding context (Con-Sub), object-initial sentences with a preceding context (Con-Obj), subject-initial sentences with no linguistic context (ÿ-Sub) and object-initial sentences with no linguistic context (ÿ-Obj). After each item, the participant answered a comprehension question by pressing a button. Functional MR images were acquired on a General Electrics 3 Tesla system at Aarhus University Hospital. Results: The behavioral measurements showed faster reaction times to comprehension questions for sentences with a preceding context ($p < 0.01$), and lower accuracy for object-initial items ($p < 0.001$). We reduplicated previous findings that activity in BA44 and BA45 is higher for object-initial than for subject-initial sentences. A Region of Interest analysis of BA44/BA45/BA47 showed reduced activity in BA45 for both object-initial and subject-initial sentences when they occurred in a context, whereas the activity in BA44 was not reduced for sentences with

context in this study. Sentences with no preceding context showed enhanced activity in BA47, an area relating to pragmatic processing difficulties (Hagoort, Hald et al. 2004). No interaction was found between context and word order. Discussion: The reduced activity in BA45 and BA47 suggests less semantic and pragmatic processing difficulties for target sentences that occurred in a context. We did not find the expected interaction effect of context and word order, possibly due to a long Inter-Stimulus Interval (500-5500 ms) between the context sentences and the target sentences, which may have made it hard for subjects to make use of the context information.

104. 11:30 a.m. - 12:30 p.m.

Left hemisphere knows more about verbs than right hemisphere does

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Both brain hemispheres contribute to language processing in different ways. In comprehension, the left hemisphere appears to be more engaged than the right in predicting upcoming words based on meaning (Federmeier, 2007). Some words also provide structural constraints that predict what kinds of words should follow. This is particularly true of verbs, whose argument structures determine the types of words that can follow them. Many verbs can appear in different structures, but one is usually the most likely (called ìverb biasî). We created temporarily ambiguous sentences whose structures were either consistent or inconsistent with the bias of the main verb and compared the responses in each hemisphere when verb-based expectations were violated, as a test of whether verb-based predictions were made. Sentences like The anxious applicant expected the rejection would arrive in the mail were presented visually word-by-word while event-related brain potentials (ERPs) were recorded. Words were presented centrally except for the critical disambiguating word (would), which appeared in the left or right visual field. In the example, the main verb (expected) is biased toward simple direct object structures but is instead followed by a whole clause. This violation of expectation has been found to cause readers to garden-path at the disambiguating word (would), reflected in increased reading times (Garnsey et al., 1997) and increased P600 amplitude in ERPs (Osterhout et al., 1994). Sentences with verbs biased toward being followed by a whole clause were also included, as were ones that were rendered unambiguous by the inclusion of the complementizer that (e.g., The anxious applicant expected that the rejection would arrive in the mail.). We hypothesized that only the left hemisphere would make verb-based structural predictions, so there should be a P600 amplitude difference between bias-inconsistent and bias-consistent critical words presented to the left (LH) but not the right hemisphere (RH). The P600 verb bias effect was indeed reliable only when the critical word was presented to the LH. There was also a reliably larger P600 ambiguity effect (comparing temporarily ambiguous and unambiguous sentences) for critical words presented to the LH. Individual differences in working memory, inhibitory control, and familial handedness were also found to influence processing. Among other things, verb bias and ambiguity effects were less lateralized in right-handers with left-handed relatives. The overall pattern of results shows that the left hemisphere uses wordsí structural properties to predict upcoming words, especially in those with no left-handed relatives.

105. 10:15 a.m. -11:15 a.m.

Grammatical processing in patients with progressive non-fluent aphasia

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Patients with the non-fluent/agrammatic variant of primary progressive aphasia, also known as progressive non-fluent aphasia (PNFA), have sentence comprehension difficulty. Previous work from our lab and elsewhere has shown that both linguistic and executive deficits contribute to this impairment, but this has been difficult to demonstrate because of confounds in the sentence materials being used and the nature of the task. In this study we examined grammatical and executive resource aspects of oral sentence comprehension in PNFA using a sentence-picture matching task that minimizes confounding task-related resource demands such as manually sentence construction or speaking. Nine PNFA patients and 25 control subjects, matched for age and education, were administered a 72-item, forced-choice sentence-picture matching task designed to examine the effect of increasingly complex syntactic structures, number of propositions, and sentence lengths on sentence comprehension. The core of each sentence consisted of a transitive verb with a distinct agent and recipient. We used a fully penetrated, 3-factor design to develop materials, including items drawn from each of 3 syntactic structures (simple active declarative, subject-relative, object-relative), 2 proposition amounts (cleft, center-embedded) and 2 working memory lengths (9 words ìshort,î 12 words ìlongî), resulting in 6 stimuli per category. Patients heard each item twice at a natural cadence with a normal stress pattern, and were asked to match each sentence to one of two pictures. Pictures illustrated the action named in the sentence, and alternate choices showed the correct or reversed agent-recipient relationship. Performance on this task was then correlated with neuropsychological tests measuring dementia severity, executive control, lexical retrieval, and semantic knowledge. PNFA were significantly more impaired than controls across all conditions ($p<0.01$). An interaction effect was found ($p<0.01$)

for number of propositions and grammatical complexity. Within-group analyses showed that PNFA have marked difficulty with the processing of grammatical features (object-relative < subject-relative, p<0.03) and number of propositions (3 propositions < 2 propositions, p.0.05) of the sentences. There was no effect found for length. As length was not a factor contributing to impairment in comprehension, it was not included in the correlation analysis. Impairment in processing the number of propositions and grammatical features correlated with measures of executive control (Trails B, r = -0.954, Stroop, r = -0.951.) In this novel test of sentence comprehension, PNFA were significantly more impaired than controls across all conditions. Moreover, PNFA exhibited marked difficulty processing sentences featuring a larger number of propositions and more complex grammatical structures, and this correlated with measures of executive control. These results confirm the role of grammatical difficulty on a task that involves minimal resource demands and is suitable for clinical use, and help specify the source of limited resources in PNFA patientsí sentence processing deficits.

106. 11:30 a.m. - 12:30 p.m.

The impact of familial left handedness on cortical organization for information integration in language and vision

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Sixty years ago, Luria noted that right handers with familial left handedness (RHFLH) recover from left-hemisphere aphasia relatively fast, and show crossed aphasia (right hemisphere) more often than people with only right-handed family members (RHFRH). Fifty years of subsequent behavioral research supports the hypothesis that normal right-handers with familial left handedness (RHFLH) have a distinct pattern of language behavior, which reflects differences in neurological organization of the lexicon. Behaviorally, RHFLH people organize their language processing with relative emphasis on individual words, while RHFRH people are more reliant on syntactic patterns. This difference appears in a wide range of experimental situations, as well as in patterns of learning a first or second language. Two non-linguistic tasks further clarify the functional changes in RHFLH subjects. In a visual category learning task with category structures previously shown to recruit distinct cortico-striatal-thalamic networks during learning, RHFLH people are superior at learning subcortically-associated categories, while RHFRH subjects are superior at a frontally mediated XOR task. These results suggest a genetic factor of left-handed background, linked to atypical organization of cortico-striatal-thalamic loops relevant for a range of cognitive processes in addition to language. This hypothesis may be further supported by observed changes in cortico-striatal-thalamic loops in numerous heritable disorders associated with individual and familial left-handedness, Recent neuroimaging studies sharpen the importance of familial handedness and offer initial support for these hypotheses, by giving some understanding of the neurobehavioral differences between the two groups of people. An event-related functional magnetic resonance imaging (fMRI) study shows that RHFLH people have reduced or partially reversed cortical and subcortical functional asymmetries for lexical access compared to the typical RHFRH pattern: this supports the idea that RHFLH people may access words more easily than RHFRH people because their lexicon is more bilaterally represented. A syntactic/constituent ordering tasks revealed left inferior frontal gyrus (IFG) activation for both RHFLH and RHFRH subjects; corresponding lexical/semantic ordering tasks elicit left hemisphere activation in RHFRH people, but bilateral representation in RHFLH people. An independent components analysis of lexical task related activity shows a single difference between RHFRH and RHFLH subjects: increased, correlated activity in the right IFG and right thalamus for RHFLH subjects ($p < .01$; Figure 1). In addition, time course analysis shows that the lexical/conceptual task activates the right IFG sooner than the syntactic task for RHFLH subjects, while the RHFRH subjects show no difference in activation between the two tasks. These results have implications for clinical work and re-interpretation of many clinical and neurolinguistics studies that fail to differentiate subjects' familial handedness ñ since almost half the population is RHFLH. The results are also suggestive about the language-specific neurological basis for syntax, amidst a more general feature-integrative basis for the lexicon

107. 10:15 a.m. -11:15 a.m.

Left inferior frontal cortex and syntax: analysis of structure, function and behaviour in LH damaged patients

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Abstract: For the past 150 years, neurobiological models of language have debated the role of key brain regions in language function. One hotly debated set of issues concern the role of sub-regions (Brocaís area) of the left inferior frontal gyrus in syntactic processing. Here we combine measures of functional activity, grey matter integrity and performance in left-hemisphere damaged patients and healthy participants to ask whether sub-regions of left inferior frontal gyrus are essential for syntactic processing. In a functional neuroimaging study, participants listened to spoken sentences which either contained a syntactically ambiguous phrase or matched unambiguous phrase. Behavioural data on all par-

ticipants were subsequently collected. Healthy controls activated a left-hemisphere network including Brodmann area (BA) 45 and left posterior middle temporal gyrus during syntactic processing. Exploiting the variability in lesion location and performance in the patients, we carried out whole brain correlations of tissue integrity and neural activity with performance on tests of syntactic comprehension. We found that the degree of syntactic preservation correlated with increasing tissue integrity and increasing neural activity primarily in BA 45 and left posterior middle temporal gyrus. We used a second task to measure sentence processing based on sentential semantics / pragmatics over and above syntax. Activity in right middle temporal gyrus correlated with preserved performance, even when areas essential for syntax in LIFG were damaged. Conversely, activity in right hemisphere did not correlate with performance on syntax. These results argue for the essential contribution of regions of left inferior frontal gyrus in syntactic analysis and highlight the functional relationship between LBA45 and left posterior middle temporal gyrus, suggesting that when this relationship breaks down, either through damage to left inferior frontal gyrus or left posterior middle temporal gyrus which impairs their communication, syntactic processing is impaired. On this view, the left inferior temporal gyrus is not specialised for syntactic processing, but plays an essential role in the neural network which carries out syntactic computations. Figure: Correlations between performance, activity and tissue integrity in patients. (A): activity in LIFG and R insula / STG and LMTG correlates with performance on the acceptability task (difference in error rate between ambiguous and unambiguous sentences). Plot: performance over cluster mean tissue integrity for each region. (B): tissue integrity in LIFG, LMTG and L post-central gyrus correlates with performance on the acceptability task (as in A). Plot: performance over cluster mean tissue integrity for each region. All effects shown voxel-level $p < 0.01$, cluster-level $p < 0.05$ uncorrected (A) and corrected (B). Rins/STG = insula/superior temporal gyrus. LpCG = post-central gyrus. IFG = inferior frontal gyrus. STS = superior temporal sulcus. MTG = middle temporal gyrus.

108. 11:30 a.m. - 12:30 p.m.

Shared syntactic processing in language comprehension and language production

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Introduction: Syntactic processing deals with constructing syntactic representations in production (syntactic encoding) and parsing of incoming information in comprehension (syntactic decoding). As syntactic processing entails different aspects of the same task in speaking and listening, it has been a longstanding issue whether we have two separate or one common syntactic processor [1-3]. We investigated this by comparing fMRI adaptation effects (a phenomenon whereby the BOLD-response in areas sensitive to a stimulus property is reduced when this stimulus property is repeated) of syntactic repetition within one language modality and across modalities. Comparable within-modality and cross-modality syntactic fMRI adaptation effects would imply that we have one common syntactic processor in speaking and listening. Method: On production trials subjects described pictures which were color-coded to elicit either active or passive transitives. On comprehension trials subjects listened to active and passive transitive descriptions of black and white pictures. The syntactic structure of the produced/heard sentence was repeated or novel between two successive sentences. Also, the language modality of two successive sentences could be repeated (two production or two comprehension sentences) or novel (a switch from comprehension to production or vice versa). Results: At whole-brain level ($p<.05$ cluster-level corrected) syntactic repetition reduced activation in left inferior frontal gyrus (LIFG; BA 45/47), left middle temporal gyrus (LMTG; BA 21) and left supplementary motor area (BA 6/32). These regions have been implicated in unifying and storing syntactic information and articulatory processes respectively. No clusters showed an interaction between syntactic repetition and whether there was a switch in language modality. ROI analyses in LIFG and LMTG (coordinates of syntactic repetition effect by [4]) also showed a main effect of syntactic repetition but no interaction of syntactic repetition with modality switch. Conclusions: Syntactic repetition effects were the same whether the language modality was repeated or switched from comprehension to production or vice versa. This suggests that syntactic encoding and decoding rely on the same neuronal infrastructure, and more importantly, provides crucial evidence for shared syntactic representations and processing mechanisms within these regions for production and comprehension. [1] Clark, H. H., & Malt, B. C. (1984). Psychological constraints on language: a commentary on Bresnan and Kaplan and on Givo¥n. In W. Kintsch, J. R. Miller, & P. G. Polson (Eds.), Method and tactics in cognitive science (pp. 191ñ214). Hillsdale, NJ: Erlbaum. [2] Grodzinsky, Y. (2000). The neurology of syntax: Language use without Brocaís area. Behavioral and Brain Sciences, 23(1), 1-21. [3] Kempen, G. (2000). Could grammatical encoding and grammatical decoding be subserved by the same processing module? Behavioral and Brain Sciences, 23(1), 38-39. [4] Menenti, L. et al. Semantics, words, syntax: fMRI adaptation in sentence comprehension and production. Program No. 217.8. 2009 Neuroscience Meeting Planner. Chicago, IL: Society for Neuroscience, 2009. Online.

109. 10:15 a.m. - 11:15 a.m.

Segregating nouns and verbs in the neural language system: Evidence from Arabic

Boudelaa, S., Woolgar, A., and Marslen-Wilson, W. MRC Cognition & Brain Sciences Unit

An important question in understanding language in its neural context is whether linguistically salient distinctions such as grammatical category (whether a form is a noun or a verb) correspond to distinctions in the underlying neural systems. Prior research has focused on Indo-European languages (chiefly English), using univariate methods to ask whether verbs and nouns differ in the amounts of brain activation they elicit in different brain regions. The present research departs from this tradition in two respects. First it focuses on the noun-verb contrast in Modern Standard Arabic, where a categorically non-specific consonantal root combines, in a non-concatenative manner, with either nominal or verbal word-patterns to generate noun or verb surface forms, and where both nouns and verbs are inflected for number, gender, and case. Second, besides using standard univariate analyses, this study uses multivariate pattern classifier techniques to ask whether Arabic nouns and verbs (generated by the underlying combination of roots and word patterns) are represented by differential patterns of neural activation (in a set of anatomically pre-specified regions of interest), and whether these differ as function of the presence of a concatenated inflectional suffix (e.g. [firaar] escape), vs. [naqaluu] they moved) One hundred and sixty words were used, made up of 80 nouns and 80 verbs, half with an inflectional suffix and half without. Words were contrasted with a matched complex auditory baseline that does not trigger a speech percept. The univariate analysis showed no differences between verbs and nouns in either condition at corrected levels, although at the uncorrected threshold of .001, nouns without suffixes show more activation than verbs without suffixes in the left middle BA21 and superior temporal gyri BA22, and at the right temporal pole. Similarly, nouns with suffixes show more activation than verbs with suffixes in the middle temporal gyrus, BA21. No advantage for verbs over nouns was observed. The multivariate results were statistically more robust, showing differential patterns of activation in a series of ROIs, including the middle temporal gyrus BA21 bilaterally, the left pars opercularis, BA44, and pars triangularis, BA45 for nouns and verbs without a suffix. Additionally, for nouns and verbs with a suffix, the results show different patterns of activity in the left middle temporal gyrus, BA21, and the right superior temporal gyrus BA22. These findings demonstrate that nouns and verbs in Arabic reliably engage differential patterns of activations across the brain. This is consistent with, though in a very different linguistic context, earlier claims that noun-verb differences only emerge when the stems are grammatically complex. In Arabic, this injection of grammatical complexity is inherent to the word-formation process, where the derivational and inflectional properties of the word pattern result in a complex surface form that is unambiguously nominal or verbal in character, and where this is reflected in its accompanying patterns of neural activity.

110. 11:30 a.m. - 12:30 p.m.

Inflectional and phrasal interactions with lexical processes: An MEG/EEG study

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The comprehension of spoken language requires the rapid access and integration of lexical information in order to create dynamic interpretations of the incoming utterance. An issue in psycholinguistic research has been the role of grammatical category information in these processes, with a lexical account specifying that different word types (nouns and verbs) are represented separately and have different neural substrates. Current fMRI evidence, in contrast (e.g. Tyler et al., 2008), supports a process-driven account where noun-verb differences only emerge in the appropriate combinatorial/grammatical context, with a triggering role both for inflectional (intra-lexical) and phrasal (extra-lexical) markers, and where each may engage different aspects (anterior/posterior) of the LH peri-sylvian language system.

In this study, using spoken rather than written language, and with no word-by-word response task, we develop and test a process-driven approach by combining magneto-encephalography (MEG) and event-related brain potentials (ERPs) to track the spatiotemporal dynamics of potentially different combinatorial processes. First we contrasted inflectional markers (e.g., play vs played) and phrasal markers (as in play vs we play). Second, we manipulate the categorical properties of the stimuli, using three sets of words (N=40 each) varying in their degree of verb dominance (based on large-scale corpus analyses): 1) Unique verbs (e.g. argue) that never occur as nouns; 2) Highly verb dominant forms (e.g., poke) that are nonetheless category ambiguous and can occur as nouns; 3) Less verb dominant forms (e.g., visit) that are also category ambiguous. Participants listened to spoken words that were either single stems (play), inflected stems (played) or phrasal sequences (we play, we played), and occasionally performed a 1-back memory task.

Preliminary univariate analyses suggest that isolated stems do not differ strongly between simple and inflected forms. By contrast, the presence of a phrasal context induced robust topographical differences in both EEG and MEG (magnetometers and gradiometers) compared with the simple stem. Scalp distributions for the stem (in phrasal vs. simple context) are modulated as early as 100 ms for the EEG in the posterior left part of the scalp and at 160 ms for the magnetometers and gradiometers in temporal regions. The verb dominance dimension (consistent with earlier work) affects responses only in the presence of a phrasal context (we play or we played), with largest amplitude for unique as opposed to less dominant verbs. In current analyses we are investigating in more detail these suggestive spatiotemporal differences between intra- and extra-lexical combinatorial processes.

Tyler, L. K., Randall, B., & Stamatakis, E. A. (2008). Cortical differentiation for nouns and verbs depends on grammatical markers. Journal of Cognitive Neuroscience 20(8), 1381-1389.

111. 10:15 a.m. -11:15 a.m.

Processing of null argument sentences in English, the OSP and the N400

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The present study examines whether different event-related potential (ERP) components are associated with processing of null arguments (the omission of direct object arguments in sentences – a syntactic disruption in English) and repeated lexical items (in place of pronouns – an anaphoric violation in English). Two event-related potential (ERP) components are of particular interest; the Omitted Stimulus Potential (OSP) and the N400. The OSP is a positive deflection in the waveform that occurs approximately 300-400 ms after omission of an anticipated stimulus (e.g. tones or flashes of light) (Decker and Weber, 1976; Penny, 2004). While the OSP has been elicited by perceptual stimuli, its role in the linguistic domain is less clear. In one example, however, (Besson, Faita, Czternasty, Kutas, 1997) an OSP (referred to as an Emitted Potential) was elicited to violations of prosodic timing (i.e., delayed words in proverbial phrases). In another, (Tate & Nakano, 2009) an OSP was elicited to object omissions in conversational/contextual speech, but not to appropriate pronouns in identical sentences. In the current study, in order to validate the pattern of the OSP to omitted arguments in linguistic material, and to investigate the processing of anaphoric violations, English monolingual participants ($n = 8$) listened to 66 pairs of context sentences, e.g., "The apples on the tree are ripe now", followed by response sentences with or without violations. Response sentences contained either a pronoun, e.g., "Maybe we should pick them" (Control condition), the repeated lexical item, e.g., "Maybe we should pick the apples" (Lexical condition), or an omitted argument, e.g., "Maybe we should pick [ø]" (Null condition). ERPs measured at the onset of object arguments showed greater positivity, peaking at ~450 ms (time window: 200-800 ms) in the Null condition, compared to both the Control and Lexical conditions ($p < 0.05$). This null argument OSP was elicited early and prolonged as observed by Tate and Nakano (2009). For the Lexcial condition, a marginally significant N400 (time window: 300-600 ms) occurred relative to the Control condition, indicating a potential processing difference in the way repeated lexical items are treated with respect to pronouns. ERPs measured at the onset of verbs showed no differences among the three conditions, thus the ERP differences at the object arguments can be attributed to the omitted as well as repeated argument violations. While the pattern of OSPs in previous studies, which resembled the P300, reflected a distruption of temporal and/or prosodic sequence by omitting an expected stimulus (e.g. tones, lights, delayed words in proverbs), the OSP presented here, early and prolonged (200 – 800 ms) may reflect both a disruption of syntactic sequence as well as structural reanalysis: possibly a combination of the P300 and P600. The possible N400 effect elicited by the repeated lexical items may reflect semantic reanalysis of once resolved referent in an expected pronoun upon encountering the repeated lexical item.

112. 11:30 a.m. - 12:30 p.m.

An event-related potential (ERP) investigation of processing of agreement: An examination of gender and number in Spanish

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Recent ERP studies have investigated how syntactic agreement is processed online, examining whether the parser is sensitive to the structural distance between agreeing elements (Münte et al., 1997) and whether different agreement categories (number, gender) are processed similarly (Barber & Carreiras, 2005). Barber & Carreiras (2005) compared ERP effects for number and gender agreement violations in Spanish in two sentential contexts, one where agreement was established within the same phrase (*la piano… "the-FEMININE piano-MASCULINE…") and one where agreement was computed across a phrase (*el faro es alta… "the lighthouse-MASC is high-FEM…"). Relative to their grammatical counterpart, both number and gender agreement violations elicited a P600, an ERP response assumed to reflect the repair of morphosyntactic anomalies, including agreement mismatches (Osterhout & Mobley, 1995). Furthermore, results showed that the late portion of the P600 was greater for gender than for number agreement violations, which Barber & Carreiras interpret as evidence that gender is costlier to repair than number. Finally, across-phrase violations elicited a greater P600 than within-phrase violations, which Barber & Carreiras interpret as evidence that agreement mismatches are costlier to repair when the agreeing elements are situated across a phrase. However, their stimuli were not controlled for linear distance: within-phrase agreement was established between two adjacent words, while across-phrase agreement was established between elements separated by one word. Moreover, Barber & Carreiras did not control for the syntactic category of the word where the violation was realized: within-phrase violations were noticeable on nouns, while across-phrase violations were realized on adjectives. This is not an ideal comparison, as gender and number are analyzed as interpretable on the noun but uninterpretable on the adjective (Carstens, 2000). The present ERP study addresses these issues and investigates the processing of number and gender agreement in sentential contexts where agreement is established within and across a phrase boundary, controlling for linear distance. Sample

stimuli are provided in (1) and (2). In both conditions, the agreeing elements are separated by one word, and mismatches are realized on adjectives. Therefore, the two conditions only differ in the number of phrase boundaries between the agreeing elements. Participants read sentences while EEG (Electroencephalogram) was recorded from 29 scalp electrodes using a Neuroscan SynAmps2 system. (1) Within-phrase El banco es un edificio muy seguro the bank is a building-masc-sg very safe-masc-sg y el juzgado también. and the courthouse also. "The bank is a very safe building and the courthouse too." (2) Across-phrase El cuento es anónimo the tale-masc-sg is anonymous-masc-sg y el manuscrito también. and the manuscript also "The tale is anonymous and the manuscript too." Preliminary results, summarized in Figure 1, show that both gender and number violations yielded robust P600s in both the within and across-phrase conditions, consistent with Barber & Carreiras. Furthermore, no increased P600 amplitude was observed for gender versus number agreement violations, or for across-phrase versus within-phrase agreement violations. These results suggest that agreement is computed in a homogenous way regardless of the agreement category involved and of the syntactic distance between the agreeing elements.

113. 10:15 a.m. -11:15 a.m.
A comparison of the syntactic processing of noun phrases and verb phrases using event-related potentials

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Developmentally, noun phrase (NP) and verb phrase (VP) morphology are not acquired in the same manner and time course. For example, childrenís grammaticality judgments regarding NP structures reach adult levels by age 11 but they continue to have poorer accuracy than adults with VP structures (MacDonald, 2008). Children with specific language impairment also have marked and persistent difficulties with VP structures (Leonard, 1998). Given the differences in the syntactic functions of NPs and VPs, and the differences between these syntactic categories in acquisition and disorders, it is important to understand whether there are processing differences between nouns and verbs in typical adult language. The purpose of the present study is to compare event-related potentials (ERPs) to NPs and VPs in adults in order to determine whether there are differences in the presence, amplitude, latency or distribution of the P600 response to these syntactic categories. Twenty-nine right-handed English-speakers completed an EEG task in which they listened to sentences that were presented as natural speech. They judged each as grammatical or ungrammatical. Ungrammatical sentences contained developmental omission errors. The stimulus conditions were: 1) NP grammatical (NPG); 2) NP ungrammatical (NPU), in which an article (a/the) was omitted; 3) VP grammatical (VPG); 4) VP ungrammatical (VPU) in which the auxiliary verb (is) was omitted. Data were analyzed using 3-way area (frontocentral, centroparietal) X grammaticality (grammatical, ungrammatical) X syntactic category (NP,VP) repeated measures ANOVAs. There was a significant 3-way interaction, $F(1, 28) = 7.76$, $p = .01$ between 725 and 850 ms. Post hoc tests revealed that NPUs exhibited a significant P600 effect in the frontocentral area, while VPUs did not and there was a main effect of grammaticality in the centroparietal area. There was a 2-way, area X location interaction $F(1,28) = 5.324$, $p = .0286$ between 850 and 975 ms. Post hoc tests revealed the effect of grammaticality as significant in the centroparietal but not the frontocentral area. Another potential 2-way interaction in this time period was suggested for syntactic category by grammaticality $F(1, 28) = 4.158$, $p = .051$. Post hoc tests suggested that in this time period NPUs, but not VPUs, exhibit a significant difference, implying that the duration of the P600 effect is shorter for VPs than for NPs. Overall, this study revealed differences in the processing of similar errors, i.e., omission of unbound grammatical morphemes, in NPs as compared to VPs. NPs appear to have a broader distribution, extending into the frontocentral area as compared to VPs whose distribution is limited to centroparietal areas. It also suggests that the P600 elicited by NP errors is of greater duration. These results are important on two levels. First, methodologically, many P600 studies use errors that are not subtle, developmental omission errors as those used here. This study demonstrates that such errors can elicit the P600 response. Secondly, evidence of differential processing across syntactic categories in adults provides a frame of reference for examining the development of syntactic processing in children as well as in language disordered populations.

114. 11:30 a.m. - 12:30 p.m.
Syntax and LH brain damage: Examining LH fronto-temporal connectivity

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Neuroimaging and neuropsychological evidence suggests that two left hemisphere (LH) regions are involved in syntactic processing – the Inferior Frontal (LIFG) and Middle Temporal Gyrus (LMTG). Here we test the hypothesis that interaction between these two regions is essential for successful syntactic analysis (Tyler & Marslen-Wilson, 2008). We carried out an fMRI study in which we manipulated syntactic processing requirements by varying syntactic ambiguity and dominance in a group of LH brain damaged patients with language deficits, and healthy controls. We avoided in-

creased memory load and cognitive control by having people passively listen to spoken sentences in the scanner and obtaining behavioural data in a separate session. Combining behavioural data with evidence from functional imaging and examining syntactic processing in both intact and damaged systems allowed us to make stronger inferences about the neural network which is essential for preserved function. Subtractive fMRI analysis revealed that in both groups the LIFG and LMTG supported syntactic processing. We then used functional connectivity analysis (psycho-physiological interactions, PPI; Friston et al., 1997) to examine the connectivity of these two regions in the context of syntactic processing. We expected left fronto-temporal (LFT) connectivity to be modulated by syntactic processing demands in the controls, while in patients it will be disrupted. We also investigated whether the LIFG * LMTG interaction predicted activity elsewhere (Stamatakis et al., 2005). We expected that in healthy controls, the LFT network alone would support syntactic processing. To the extent that LFT connectivity is disrupted in patients, additional regions may need to be recruited to facilitate syntactic processing. We found that in controls LFT connectivity was modulated by syntactic integration demands and LIFG * LMTG interaction did not predict activity anywhere else in the brain, suggesting that the LFT network is sufficient for syntactic processing. For patients, although the LIFG * LMTG interaction was not significant, it predicted activity in a region of posterior LMTG. Connectivity within this network correlated strongly with preserved syntactic processing as measured in the behavioural task. These results highlight the importance of intact Left fronto-temporal connectivity in syntactic processing and suggest that when this is disrupted, additional neighbouring areas may be recruited, possibly to compensate for damage to the original LFT network.

115. 10:15 a.m. -11:15 a.m.

Neural correlates of linguistic distinctions: Different syntactic movements yield different activation

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Introduction: Word order variation is one of the most important aspects of sentence comprehension in both linguistics and cognitive science. In Hebrew, the basic word order is, like in English, Subject-Verb-Object (SVO), but other orders are also possible, such as OSV or VSO. According to syntactic theory, such non-canonical orders are derived from the canonical (base-generated) order by syntactic movement. Crucially, different elements and different positions within the syntactic tree are involved in the derivation of different non-canonical orders. To generate the OSV order, Wh-movement is applied and the noun phrase in the object position moves from its post-verbal position to a pre-verbal position (spec-CP [Complementizer Phrase]). By contrast, the VSO order is created by a head movement in which the verb moves from its original position within the verb phrase to the C position within the CP, after a phrase (such as ìyesterdayî). Methods: This experiment assessed the differences between Wh-movement and verb movement using minimally different sentences. We compared sentences with verb movement (AVSO - where A stands for an adjunct- a temporal adverb) and sentences with the same words in a canonical order (ASVO). The adverb is required because, in Hebrew, verb movement is acceptable only with a trigger at the first position. We also compared OSVA sentences, in which the object moves to the beginning of the sentence with canonical SVOA sentences. The temporal adverb was used to allow better control for a comparison between the two movement types. 24 Hebrew speakers performed a semantic decision task on auditorily presented sentences. Results: In the comparison between OSVA and SVOA sentences (for assessing Wh-movement), we found activations in the left inferior frontal gyrus (IFG), in Brodmann areas (BA) 44/45 and BA 46, as well as activation in the right middle temporal gyrus (MTG). Activation in the right MTG was also identified in the comparison between AVSO and ASVO sentences (for assessing verb movement). However, the activations in the right MTG did not overlap. Because the left IFG is strongly associated with the processing of Wh-movement as implicated by the behavior of individuals with agrammatic aphasia and from neuroimaging studies, we assessed the activations in this area (BA 44/45) with regard to all the conditions. We found that the activation in response to OSVA sentences was significantly higher than the activation in response to the other conditions, including AVSO. Conclusion: This experiment showed that the different syntactic structures that linguistic theory assumes for different word order are reflected in differential brain activations, thus lending support for the linguistic theory of syntactic movement and for syntactic distinctions between verb and phrasal movement.

116. 11:30 a.m. - 12:30 p.m.

Neural mechanisms for the processing of movement and scrambling constructions

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Languages feature sentences that implement rather similar meanings through varied word orders. As the resulting representations are related, syntactic theory assumed the existence of a basic word-order, from which others are derived. Movement, an operation of central syntactic significance is assumed in order to capture such regularities. Typically, the

moved element (""filler"") precedes the position from which it is extracted in the base (""gap""). In addition to standard linguistic evidence, there exists behavioral and neurological evidence for the filler-gap link - a relation of central importance to sentence processing. Cross-linguistic differences complicate the picture. Languages like German, Japanese, and Hindi seem to allow more possible word-orders than English, for which an operation called Scrambling is invoked. It is similar to Movement in that it maintains filler-gap relations, but is potentially different as it is language specific, and subject to different constraints. To elucidate whether or how the brain mechanisms differ between the processing of sentences made by movement and scrambling, the present functional magnetic resonance imaging study examined neural correlates for the processing of sentences constructed by both operations. We tested in German that has both movement and scrambling relations. Secondly, we contrasted the parametric effect of filler-gap distance, thereby overcoming the problem in the direct comparison of two different surface structures. We designed a within subject 2 x 3 factorial design with factors TYPE (scrambling/movement) and DISTANCE (3 levels of distance between filler and gap) using 240 sentences systematically derived from base order sentences. The base sentences are constructed with ditransitive verbs that take two human objects (e.g., show, recommend). Movement operations on the base sentence yield a topicalized construction, while the scrambling permutes the linear order of three argument noun phrases. Crucially, the manipulation of DISTANCE with each TYPE is identical. Twenty-two young, right-handed, native German speakers were scanned with a Siemens TRIO 3.0 Tesla magnetic resonance imaging (MRI) scanner while they read the sentences presented visually word-by-word. The MRI data were analyzed with a within subject analysis of variance (ANOVA) in SPM8. Crucially, a significant interaction (as F contrast) was not detected, which suggest that the neural basis for movement and scrambling is overlapping, at the very least. The main effect of DISTANCE (as a t contrast for linear increase in activation with distance) involves the left inferior frontal gyrus (IFG) that extends to the inferior frontal sulcus and the left middle superior temporal sulcus, as well as the left globus pallidus, the right pars opercularis and the bilateral intraparietal sulci. The activation cluster in the left IFG mainly covers the pars opercularis and the posterior portion of pars triangularis. The main effect of TYPE (as t contrast) was found only in the bilateral occipital regions as higher activation in the movement conditions relative to in the scrambling conditions. These results suggest that neural mechanisms for the processing of movement and scrambling are both supported by the left IFG. In our presentation, we will discuss the neurocognitive implications of this generalization.

117. 10:15 a.m. -11:15 a.m.

Parameterization of successive-cyclic movement reveals structural constraints on Broca's area in sentence processing

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We investigated the effect of successive-cyclic movement on the fMRI signal. Previous studies have explored the neural reflections of the number of NPs displaced by syntactic movement (Friederici et al., 2006) or the number of NPs crossed by a single moved NP (Santi and Grodzinsky, 2008; Makuuchi et al., in preparation). The results led to a neurocognitive generalization: Brocaís area is sensitive to the number of interveners that moved NPs cross. To better identify whether additional movement-related factors recruit this region, our parametric study explored whether the number of iterations of a movement operation is functionally or anatomically differentiated from that observed for number of intervening NPs. Movement (b) maps a single Noun (girl) to two dependent positions that provide distinct interpretations (interrogative and thematic). Only one position is pronounced (a,b); if there is a copy it is <bracketed> and silent. a. The boy likes the girl. b. Which girl does the boy like <which girl>? c. I know which girl the teacher thinks <which girl> the boy likes <which girl> Furthermore, movement proceeds successive-cyclically (c). As wh-phrases move from a thematic (ie, doer or doee) to a pronounced position, they move through the left edge of each intervening clause (CP) and leave behind a silent copy (for (psycho)linguistic evidence see McCloskey 2000; Gibson and Warren, 2005). For each successive-cyclic movement, a CP is crossed. The number of crossings was the parameter, which employed two intervener types, NP or CP. Our comprehension study had an NP condition, where an embedded clause containing a ditransitive verb had either no movement (0), a movement of the direct object over the subject (1), or movement of the indirect object over both the direct object and the subject (2); and a CP condition: two embedded clauses with either no movement (0), a movement of the object to the front of the second embedded clause (1), or a movement of the second embedded object to the front of the first embedded clause (2). A comprehension question followed 50% of the trials. Comprehension accuracy and fMRI data were analyzed with a 2(NP/CP)x3(Distance) ANOVA. Accuracy showed a significant linear effect of Distance $F(1, 20)=37.6$, $p<.001$ and a main effect of Distance $F(2, 40)=15$, $p<.001$. Compared to 0 interveners, 1 or 2 interveners (CPs/NPs) reduced comprehension accuracy. There was no significant interaction. The fMRI results paralleled the behavioral ones with the distance linear effect across type coded (-1 0 1; -1 0 1) in SPM{T} producing a significant ($p<.001$ voxel; $p<.05$ cluster) cluster straddling left BA44 and BA45. The interaction effect was not significant. Given that the parameterization of successive-cyclic movement did not modulate the linear effect of crossed NPs, severe constraints must be imposed on the involvement of Broca's area in processing syntactic movement. Appeals to complexity or size of the intervening material are inconsistent with such a

result. Rather, the results are best captured by structural properties of the movement relation, specifically the structural similarity between the intervening element and the moved element (ie, Noun).

118. 11:30 a.m. - 12:30 p.m.

Effects of task and narrative context on syntactic processing: An ERP-fMRI study

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Many neuroimaging studies of syntactic processing use violation paradigms in which unrelated sentences are presented in isolation, and many of these paradigms also require participants to make grammaticality judgments after each sentence. While some event-related potential (ERP) studies of syntactic processing have specifically manipulated task requirements (e.g., Osterhout & Mobley, 1995; Gunter & Friederici, 1999; Hahne & Friederici, 2002), to date no study has compared the neural response to syntactic violations presented in unrelated sentences with a grammaticality judgment task with the neural response to the same type of violations when presented in a more ecologically valid context featuring narrative context and no task. Here we examine this question using data gathered from the same participants in two different task conditions in two complementary methodologies: ERPs and functional magnetic resonance imaging (fMRI). The neural response to auditorily presented phrase structure violations across task conditions and methodologies was compared in monolingual native English speakers. In the Grammaticality Judgment Condition (GJC), participants made grammaticality judgments after each sentence in a series of unrelated sentences; in the Narrative Context Condition (NCC), sentences accompanied an animated video with coherent narrative context, and no task was required. In the ERP paradigm, syntactic violations in both conditions elicited both an early anterior negativity and a posterior positivity (P600), though the P600 in the NCC was significantly reduced, consistent with some previous results (Gunter & Friederici, 1999; Hahne & Friederici, 2002). In the fMRI paradigm, syntactic violations in both conditions elicited robust activation in left perisylvian language areas including left inferior frontal gyrus. In the GJC activation was more left-lateralized and included more activation in parietal and basal ganglia regions previously identified as likely generators of the P600 (Pakulak, Dow, & Neville, 2009). In the NCC activation was more bilateral in anterior and posterior superior temporal regions and also greater in posterior medial regions including posterior cingulate cortex and precuneous, consistent with previous neuroimaging evidence on coherent text comprehension (for review, see Ferstl et al., 2008). The results suggest that the processing of syntactic violations recruits a core network of neural regions independent of task requirements, but that additional regions are recruited under different task and context conditions.

119. 10:15 a.m. -11:15 a.m.

Task-related fMRI networks involved in syntactic ambiguity processing

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The study of brain networks has recently benefited from the use of sophisticated network analysis tools that examine characteristics such as small-world properties and modularity. However, their use to study brain function has been primarily restricted to resting-state fMRI. Here we implement such network analyses on data collected from an fMRI study which includes manipulations focussed on the processing of syntactically ambiguous sentences. We asked participants to attentively listen to spoken sentences without performing an explicit task thus minimising working memory demands (Tyler et al. 2009). We adopted a novel method to construct and study functional brain networks from task-related fMRI data using Statistical Parametric Mapping (SPM8) software. SPM uses the general linear model to fit parameters (beta values) for each regressor corresponding to an experimental condition. We first extracted mean beta values (for each experimental condition) for all brain regions delineated in a predefined template and perform pair-wise regional correlations across subjects for each condition. In this manner we investigate network differences between experimental conditions at a whole-brain level. Second, we extracted mean beta values for each cluster that survived a prespecified statistical threshold ($p<.001$ voxel uncorrected, $p<.05$ cluster corrected for multiple comparisons) for each experimental condition from the SPM analysis. We used all clusters obtained for all contrasts, having applied a restriction criterion on overlapping clusters, to define a network relevant to syntactic processes. We computed pair-wise regional correlations across subjects, as described in the first approach. The two complementary approaches allowed us to study (a) the overall network involved in this key language function (syntax) in the context of whole brain interactions, and (b) interactions only within the network of areas displaying functional specialization for syntax. Our results show that syntactic ambiguity leads to an overall decrease in correlations at the whole-brain level. We believe this may signify the emergence of a specialized network, with fewer overall - but stronger - correlations between syntax specific areas, thus increasing the differentiation between areas involved in syntax, and areas not relevant for this cognitive process. Tyler LK, Shafto MA, Randall B, Wright P, Marslen-Wilson WD, Stamatakis EA, 2009. Preserving syntactic processing across the adult lifespan: The modulation of the fronto-temporal language system in the context of age-related atrophy. Cereb Cortex 20:352-364.

120. 11:30 a.m. - 12:30 p.m.

Network modulation during complex syntactic processing

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Introduction: An fMRI subtraction paradigm, together with directed partial correlation (dPC; Mader et al., 2008), was used to map the functional connectivity between areas in a network underlying complex syntactic processing. Dynamic Causal Modeling (DCM; Friston et al., 2003) was then used to investigate which of the directional network connections is crucially modulated by the processing of complex syntactic structures and to test whether the driving input enters the network through the inferior frontal gyrus (IFG) or the posterior superior temporal cortex (pSTG). Methods: Twelve right-handed participants (7 F; age 32-79)) performed an auditory verification task, in which they were presented with auditory sentences and concomitant visual scenes. Sentence types were (English) object clefts (OC) and subject clefts (SC). OC constructions have a 'noncanonical' word order and are syntactically more complex than SC structures. For the extraction of the dPC analysis time series, we identified participant-specific activation peaks, based on the contrast of OC>SC sentence processing, within a 9 mm radius from group peaks. The result of the dPC analysis constrained the models tested with DCM. All models had bidirectional connectivity, with one driving input and one unidirectional condition modulation per model. We tested two sets of models: those with a driving input in the pSTG, i.e. closest to primary auditory input regions, and those with a driving input in IFG, i.e. the core region associated with some forms of syntactic computation. Modulations were modeled by the OC condition. The optimal model was determined through variational Bayesian Model Selection (Stephan et al., 2009). Mean estimates for all the parameters in the winning model were tested for difference from zero with one-sample t-tests. Results: The contrast of OC>SC ($p < .05$, FDR; $k > 15$) revealed differential activation in the triangular part of IFG, superior temporal sulcus (STS), premotor cortex (PM) and the anterior middle temporal gyrus (aMTG). The reverse contrast, of SC>OC, yielded no significant differential activation. Subsequent dPC analysis revealed significant connectivity between aMTG-pSTS, pSTS-triIFG and triIFG-PM. Based on these results, 12 DCMs were built. From these, the model that fit the data best had driving input to triIFG and modulation by OC processing of the connection from triIFG to pSTS (see fig. 1). Comparison between the two groups of models with different driving inputs showed that the models with driving input on triIFG generally fit better to the data, with a group exceedance probability of 86.7% and a posterior model probability of 64%. In the winning model, parameter values that differed significantly from zero were for the connections from pSTS to aMTG and from pSTS to triIFG. Conclusion: The network revealed by the OC>SC contrast replicates results from earlier studies examining the neural correlates of syntactic processing. The current results add insight into the nature of the neural system involved. These findings suggest that computation of hierarchical dependencies is supported primarily by inferior frontal cortex, in an interactive relation with posterior superior temporal cortex.

121. 10:15 a.m. -11:15 a.m.

Associating the precise shape and size of lesions with complex syntactic abilities in aphasia

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Objective: The idea to associate properties of lesions with language impairment has long been with us. We propose a novel method to implement it, motivated by recent developments in computational neuroanatomy and (psycho)linguistics. We take seriously the notion that examining individual participant data will eventually yield important insights into brain-behavior relations. To this end, our team has developed a behavioral test battery that contains a rich array of on- and off-line syntactic and cognitive probes, which we have been administering to individuals with aphasia who have suffered stroke. In parallel, the same patients receive a high-density MRI scan through a fixed protocol, which is subsequently subjected to a host of computational analyses, carried out relative to cytoarchitectonic probabilistic maps. Our goal is to discover correlations between anatomical properties of lesions and behavioral profiles in order to express more precisely the relation between complex linguistic ability and its anatomical substrate. Methods: Our behavioral methods include off- and on-line measurement of patients' performance on a variety of complex syntactic structures, including ellipsis. In this presentation, we focus on the performance of our patients on VP-Ellipsis (VPE), a complex, biclausal, sentence type in which the Verb-Phrase of the first clause has a silent copy in the second, elided, clause (marked). Off-line tests assessed patients' comprehension abilities in VPE sentences like (I), whereas on-line tests (Cross-Modal-Lexical-Priming) measured antecedent reactivations in points (1,2,3) in VPE sentences such as the one in (II). Both tests connect to previous results [a,b], and their administration is aimed to enrich the empirical picture on aphasic deficit in a principled way: (I) The boy kicked the tiger and the girl did , too. (II) The locksmith photographed the babysitter and the friendly 1 neighbor did 2, too, according 3 to the clumsy plumber. The anatomical analysis consisted of the demarcation of the lesions in each patient's MR scan, and the estimation of the lesion fraction of several regions (e.g., BA44, 45, 22,

and adjacent regions) that were defined by cytoarchitectonic probabilistic maps [e.g., c]. These maps were warped onto each patient's brain by a non-linear registration of an atlas brain to the patient's brain. Transformations were governed by the non-lesioned part of the patient's brains [d]. Results and Conclusions: So far we have tested 10 patients, 5 diagnosed as anomic aphasics and 5 as Broca's aphasics. Table 1 presents sample data from 6 of our participants. The table shows that both groups did very well on VPE constructions in off-line comprehension, yet individuals from both groups evinced considerable variability in our on-line cross-modal priming experiment. Fairly large variability in lesion properties was also observed, making future correlations to behavior possible. We will report on additional patients, behavioral scores, and additional anatomical regions as well. We suggest that the combination of carefully constructed behavioral tests on the one hand, and brain morphometry in stereotaxic space based on cytoarchitectonics on the other, opens new perspectives to quantify the correlation between aberrant performance and lesion properties. References: [a] Poirier et al. (2009) J Psycholing Res 38: 237-254. [b] Grodzinsky, Y. (2000). Behav Br Sci, 23: 1-20 [c] Amunts K et al. (1999) J Comp Neurol 412: 319-341.

122. 11:30 a.m. - 12:30 p.m.

The role of language in human thought: neural basis of arithmetic versus linguistic inference

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A signal characteristic of human cognition is the capacity to compose indefinitely numerous, possibly novel, combinations of ideas from a finite set of primitive concepts and operations. This ability is most clearly evident in language, but also characterizes many other aspects of human thought. Whether the mechanisms underlying this capacity in language also subserve the capacity in other kinds of thought has been studied in various ways by anthropologists, linguists, psychologists, and neuroscientists. In the present study, we attempted to clarify whether the neural substrate of natural language manipulation, including syntactic and semantic transformations, underlies manipulation of symbols (i.e. variables) according to the sequencing rules of arithmetic. In an event-related, 3T fMRI experiment, twenty-one healthy adults were presented with pairs of ""linguistic"" and ""arithmetic"" sentences (i.e., arguments) and required to perform two tasks. In the inference task, volunteers evaluated whether the two sentences of each argument were equivalent. In the grammar task, participants judged whether there was any grammatical defect in the sentences. The equivalence judgment in ""linguistic"" pairs depended upon the transformation of di-transitive verbs (e.g., give, take, say). For example, the statement 'X gave Y to Z' is equivalent to the sentence 'Z was given Y by X'. In ""arithmetic"" pairs, the equivalence judgment was based on the syntax of elementary algebraic operators (i.e., '+','-','*',' /','='). For instance, the statement 'X plus Y equals Z' is equivalent to the statement 'Z minus Y equals X'. We compared the BOLD signal for inference trials and grammar trials, for each type of argument. Linguistic judgments uncovered activity in left inferior frontal (BA 45), bilateral angular gyrus (BA39), bilateral precuneus (BA 7), bilateral middle frontal (BA 6), left middle frontal (BA9), and right superior temporal (BA 22) cortices. For mathematical judgments, we observed activity in bilateral precuneus (BA 7), bilateral middle/superior frontal (BA 6, 8) gyri, bilateral superior parietal lobule (BA 7), and right inferior parietal lobule (BA 40). Direct comparison of the two tasks revealed extensive activation in left inferior frontal (BA 45, 47) and posterior temporal (BA 21, 22) for the linguistic minus arithmetic equivalence contrast, and bilateral inferior parietal lobule (BA40), precuneus (BA 7) and right middle and superior frontal gyri (BA 8, 6) for the reverse. These findings suggest that while both tasks hinge on common neural substrate, related to general cognitive processing (e.g. WM, attention), the manipulation of arithmetic symbols does not depend on the neural basis of natural language syntax and semantics. With respect to the issue of language and thought, these findings thus support the idea that structure-dependence in non-linguistic domains of human cognition is not derived from the properties of natural language processing (at least in the mature cognitive architecture).

Poster Session B

Friday, November 12 4:45. – 7:00 p.m.

Acquisition

1. 4:45 p.m. - 5:45 p.m.

Processing of case marking information in the developing brain

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Childrens' language skills develop rapidly with age. Previous studies indicate that children use language and age-specific strategies to understand complex sentences. German sentence structure allows one to express transitive structure in two different ways: through subject-first or an object-first construction. Behavioral studies with German children demonstrate the reliable processing of morphological information at the age of 7 (Dittmar et al., 2008). Studies using functional magnetic resonance imaging (fMRI) showed a higher involvement of the bilateral perisylvian language areas during the syntactic processing of auditory sentences in 6-year-olds compared to adults, primarily in the Brocaís area in the inferior frontal gyrus (IFG) and its right hemisphere homologue (Brauer and Friederici, 2007). So far, there are no fMRI studies that deal with the processing of case marking information in syntactically complex sentences in pre-school children. The present study investigates the acquisition of the case marking cue for argument interpretation in the developing brain of children aged 5 to 6 years using fMRI. We presented acoustically short sentences with a transitive verb and two arguments: correct sentences with subject-first vs. object-first word order and syntactically incorrect sentences with two subjects vs. with two objects. Behavioral results suggest that children are able to process case-marking information even in object-first sentences, however their responses are less accurate in object-first sentences (65%) as compared to subject-first constructions (96%). FMRI results show increased activation within the frontal cortex and superior temporal gyrus and sulcus (STG/STS) in incorrect and object-first sentences compared to sentences with subject-first order. Additionally, object-first in contrast to subject-first sentences reveal increased activation within the IFG. The processing of more grammatically complex sentences showed stronger activation within IFG and left STG/STS. Thus, children at this age are able to differentiate syntactically incorrect from correct sentences as well as subject-first from object-first sentences, even if they are rather unfamiliar with such constructions. However, increased activation within the IFG for even simple object-first constructions indicates higher processing demands in preschool children during these operations.

2. 6:00 p.m. - 7:00 p.m.

Implicit acquisition of grammars with crossed and nested non-adjacent dependencies: Need for double letter control

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A hallmark of syntactic complexity in human language is the ability to process complex non-adjacent dependencies, which require extensive memory resources. One suggestion is that dependent concrete material is maintained of over intervening words in a sentence by an external memory device in the form of a limited push down stack. This model predicts a processing bias for so-called nested compared to crossed non-adjacent dependencies. Interestingly, there is cross-linguistic evidence for a bias for nested structures in natural language processing, since nested structures are more common than the rare crossed structures across known human languages. In order to study the preference of nested and crossed sequences in a within-subject paradigm, we used an artificial grammar learning paradigm. The study contained a nine-day acquisition phase where the subject was presented with a sample of letter sequences generated from a formal grammar. This grammar is ambiguous in the sense that it is possible to read all non-adjacent dependencies in the grammar as derived from either a crossed or nested structure. The acquisition task was presented as a short-term memory task and subject were not told that there was an underlying generative structure for the sequences. Before and after acquisition, preferences were tested by asking subjects whether they liked or disliked grammatical sequences (immediate guessing based on ìgut feelingî), which were either nested or crossed. Initial analysis of the results showed a significant preference for nested over crossed sequences, both before and after acquisition. However, further analysis showed that there was a highly significant preference for sequences with at least one double letter bigram (e.g., XX) compared to those without, independent of if the sequence was nested or crossed. The frequency of double letter bigrams was thus a confounding variable in the model since nested sequences had more double letter bigrams than the crossed sequences. When we analyzed the results with a 2x2 factorial ANOVA with the factors DOUBLE BIGRAMS

(absence/presence) and GRAMMAR (nested/crossed), there was no preference for nested sequences. This finding suggests that controlling for double letters in artificial grammar learning is necessary when subtle preferences are investigated. Further investigation of the push-down stack model in a laboratory setting is needed.

3. 4:45 p.m. - 5:45 p.m.
Improved second language acquisition is predicted by structural laterality of brain pathways in healthy adults
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Healthy adults display differing abilities in learning second languages (L2). The present study investigated whether inter-individual variability in the structural laterality of language pathways relates to variability in the language aptitude of adults for learning L2 in real life. We tested a group of German college students before and after they took a 5/6-week intensive Dutch course. In addition, we acquired a Diffusion Tensor Imaging (DTI) scan for each participant before they started the course. From the DTI measurements, we devised a structural connectivity laterality index. We discovered a significant correlation between L2 improvements and the structural laterality of the frontal (BA 44)-temporal pathways. The more left-lateralized the pathways are, the more the subject improved in Dutch learning. It suggests, for the first time, that adults with more left-lateralized frontal-temporal pathways have more advantages in learning L2 in adulthood.

4. 6:00 p.m. - 7:00 p.m.
Neural basis of auditory-verbal sequence learning
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We used fMRI to study how short term memory interacts with longer term learning of phonological sequences. We used the Hebb repetition learning paradigm (1) where serial recall of a list of items is seen to improve over successive unannounced repetitions of the same list. This Hebb learning paradigm has been suggested as a model of the process underlying the acquisitions of new phonological sequences in word learning (2). However, we know little about the neural basis of order learning in the auditory-verbal domain. Subjects had to verbally recall a list of eight auditorily presented letters in the correct order immediately after presentation. Each trial consisted of an ordered sequence chosen without replacement from the same set of 8 letters. However, a given sequence might be presented only once (unique), or be repeated 12 times (Hebb). A new Hebb list was introduced after the previous list had been repeated 6 times. We used repetition number and positional (order) recall performance as parametric modulators to identify order repetition and learning effects. Recall of repeated Hebb lists relative to unique lists improved over the experiment: all participants showed a positive learning slope in the scanner ($F=4.78$, $p<.001$). During encoding left inferior frontal gyrus (IFG), right striatum and bilateral superior temporal cortex (STG) became less active in response to order repetition. This effect was also displayed by left inferior parietal and frontal lobes when interference from new lists was accounted for. Improved recall performance for repeated Hebb lists was correlated with increase in activation in posterior and central hippocampus during the encoding period. The relative de-activation of prefrontal and striatal brain areas supports the view that these regions participate in auditory-verbal order coding (3). Additionally, these areas are sensitive to interference from the introduction of new repeating order (Hebb) combinations, while auditory areas are not. This suggests that auditory cortex does not participate in order processing itself, but that its activity reflects subjects' decreased attention to input items when the sequence of items in the list has been identified as familiar. Activation in the posterior and central hippocampus correlated with recall improvement due to learning of order. The role of the hippocampus in learning associational and order information has been previously well documented (4). These results provide evidence for a frontal-striatal-hippocampal network that may support initial learning of phonological sequences in both the Hebb effect and word form learning (2). 1) Hebb, D. O. (1961). Brain mechanisms and learning. In J. F. Delafresnaye (Ed.), Distinctive features of learning in the higher animal (pp. 37ñ46). New York. 2) Page, M. P. A., & Norris, D. (2009). Is there a common mechanism underlying word-form learning and the Hebb repetition effect? In A. Thorn & M. P. A. Page (Eds.), (pp. 136-156). 3) Marshuetz, C., & Smith, E. (2006). Working memory for order information: multiple cognitive and neural mechanisms. Neuroscience, 139(1), 195-200. 4) Kumaran, D., & Maguire, E. (2006). The dynamics of hippocampal activation during encoding of overlapping sequences. Neuron, 49(4), 617-29.

5. 4:45 p.m. - 5:45 p.m.
Language learning across hemispheres
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The human brain is exquisitely sensitive to the probability of innumerable environmental contingencies. In sentence comprehension, this translates into fine-grained expectations about upcoming words and syntactic features that reflect the sculpting of underlying probability distributions by linguistic input. The present work asks if the updating of these distributions is reflected in ERP measures of brain activity, and whether the left and right cerebral hemispheres (LH and RH) might respond differently to changes in linguistic probability distributions. Previous work has demonstrated whole-brain sensitivity to the probability with which grammatical and ungrammatical sentences occur in the input (Coulson, King, & Kutas, 1998). And in ERP studies using the visual half-field manipulation, both hemispheres have been shown to respond to ungrammaticality, although potentially in different ways (Kemmer, 2009; Lee & Federmeier, 2010). Here, we factorially crossed visual field (VF), probability, and grammaticality manipulations in the same experiment. Participants read two blocks containing sentences that were grammatical and ungrammatical at the pronoun (e.g., "Kelly promised me/*I a trip to Hawaii"). The blocks instantiated different probability distributions, containing 20% and 80% ungrammatical sentences, respectively, and block order was counterbalanced across participants. Pronouns were evenly distributed to either the right or left VF across blocks and across the different levels of grammaticality, thereby biasing initial processing to the LH or RH. We hypothesized that the difference between grammatical and ungrammatical ERPs at the pronoun would differ by block, reflecting sensitivity to the changing probability of encountering ungrammaticality. Whether the two hemispheres would show the same level of sensitivity was an open question. In a version of the experiment (n = 12) in which all words were centrally presented, the results showed a standard grammaticality effect in the 20% block—i.e., larger P600 amplitudes to ungrammatical than grammatical pronouns. This effect was significantly attenuated, however, in the 80% block, reflecting sensitivity to the change in probabilities from block to block. In the lateralized experiment (n = 16) there was a fatigue effect that dampened the difference between grammatical and ungrammatical pronouns in the second block. This was presumably brought on by the greater task demands associated with constantly maintaining central fixation during the presentation of lateralized stimuli. Since, however, block order was controlled through counterbalancing, it was still possible to see unconfounded probability effects. These mirrored what was found in the centralized version of the experiment: for both the LH and RH, P600 amplitudes were larger for ungrammatical than grammatical pronouns in the 20% block, but were not different in the 80% block. This result is significant because it illustrates the malleable nature of the brain's electrophysiological response to changes in the linguistic environment, even when considered on a hemisphere-by-hemisphere basis. This malleability indexes quick adaptation to novel linguistic formulations (i.e., learning), which is important because new morphosyntactic constructions are constantly being introduced into languages. Sensitivity to changing probability distributions thus plays a potentially crucial role in explaining how and why new constructions are often rapidly adopted by native speakers.

6. 6:00 p.m. - 7:00 p.m.

Emerging categorical perception of non-native speech sounds: Behavioral and neural effects of categorization training

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Listeners typically show greater sensitivity to distinctions between two phonetic categories than distinctions within phonetic categories. This phenomenon, known as categorical perception, is a hallmark of native language phonetic categories. Of interest is how this discontinuous perception arises, and to what extent the existing category structure can be adjusted to accommodate the acquisition of a new phonetic contrast. Previous work has suggested that training participants to categorize non-speech sounds may result in changes in the cortical representation of those sounds in the left superior temporal gyrus (Guenther, et al, 2004). However, it is less clear whether categorization training of items from a novel acoustic-phonetic continuum will produce a similar shift in cortical representation, and whether participants will exhibit differential patterns of activity corresponding to a gain or loss in sensitivity. In the current study, categorization training was used to induce changes in behavioral and neural sensitivity to non-native contrasts along a three-category acoustic phonetic continuum (dental ñ retroflex ñ velar voiced stops). Two groups of participants (n=28) were trained to partition the nine points on the three-category continuum at two different boundaries. Via a perceptual fading technique, participants categorized consonant-vowel syllables from this continuum such that one group learned to place a boundary between dental and retroflex sounds, while the other group learned a boundary between retroflex and velar sounds. Perceptual sensitivity to these contrasts was assessed behaviorally before and after training using an AX discrimination task. As predicted, categorization training resulted in increased behavioral sensitivity to between-category contrasts (shown in Figure 1A), especially for the dental/retroflex contrast, which was easier for participants to learn. Neural sensitivity to sounds from this continuum was then assessed using an adaptation paradigm in fMRI. Participants heard trains of five syllables, four identical followed by a fifth that was either the same or different from the previous four. Two regions in left and right middle frontal gyrus (MFG) showed a significant interaction between group and contrast type (shown in Figure 1B). In these clusters, greater activation was apparent for each sound contrast when the contrasting sounds had been trained as members of the same category than when they had been trained as members of different categories. No such interaction was observed in either right or left temporal cortex,

suggesting that the change in behavioral sensitivity to phonetic contrasts was mediated by executive rather than perceptual mechanisms. Nonetheless, activation in right temporal areas was negatively correlated with improvements in discrimination accuracy irrespective of how participants had been trained to categorize the sounds. Taken together, these results support the notion that temporal areas respond to fine-grained aspects of the acoustic signal, whereas frontal areas play a greater role in mapping incoming sounds onto emerging category structure.

7. 4:45 p.m. - 5:45 p.m.

The formation of the perceptual vowel space in monolinguals and simultaneous bilinguals: Insights from a model

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In order to describe the architecture of bilingual language organization, several experiments have investigated the abilities of second language users (L2). Traditionally, these studies often draw conclusions based on comparisons between L2 users and the native monolingual users of the same langauge. Although this approach has added significantly to our understanding of age effects in bilingualism, it remains unclear whether the differences between the monolingual and L2 users can be attributed to disparities in the age of acquisition alone, or to different language processing abilities of the bilingual individual. The effects of age of exposure can only be separated from dual language exposure if native (or simultaneous) bilinguals - learners exposed to both of their languages from birth, are tested in comparable experimental paradigms. In the field of bilingual speech perception, recent behavioral and electrophysiological data on simultaneous bilinguals suggest that they do not always exhibit abilities similar to those of the native monolinguals of the same languages (i.e., Guion, 2003; Molnar et al, 2009a,b; Sundara and Polka, 2008) despite the fact that simultaneous bilinguals are native users of both of their languages as well. Specifically, as opposed to the second language users, who often assimilate the acoustically similar non-native phonetic categories to their native ones, simultaneous bilinguals rather tend to dissimilate the phonetically similar sounds that occur across both languages. Importantly, the categories developed for the same speech sounds by native bilinguals do not completely overlap with those developed by the native monolinguals. In order to understand the mechanism underlying the phonemic category formation of simultaneous bilingual language users at the perceptual level across their two languages, we modeled the unsupervised formation of the phonetic perceptual space of English-French bilinguals by training self-organizing maps (SOMs) with vowels from both languages at the same time. Similarly, we modeled the formation of phonetic categories in monolinguals by training SOMs with vowels from either French or English alone. Differences in the perception of speech segments in the bilingual SOMs with respect to the monolingual SOMs are discussed, and compared to experimental findings. The overall findings suggest that native bilingual and monolingual users of the same language rely on different perceptual systems of the same phoneme inventory.

8. 6:00 p.m. - 7:00 p.m.

A NIRS study on children's processing of word order variations in Japanese

Ayano, S. (1), Nishimura, Y. (1), Sugisaki, K. (1), Komachi, M. (2), Hattori, N. (1), Inokuchi, Y. (1), Nishimura, Y. (3), Ostu, Y. (4), Ogawa, M. (1), Okada, M. (1), Umeda, S. (4), Tamari, K. (1), Yoshida, E. (1), and Yamamoto, T. (1). 1. Mie University, Tsu, Japan. 2. Shizuoka University, Shizuoka, Japan. 3. Suzuka University of Medical Science, Suzuka, Japa. 4. Keio University, Tokyo, Japan.

It is widely known that Japanese is a free word-order language. In Japanese, both Subject-Object-Verb (SOV) and Object-Subject-Verb (OSV) orders are possible, and an adverb like naze ëwhyí can freely appear before or after the subject. Theoretical studies on Japanese syntax argue that (i) the OSV order is derived from the SOV order via movement of the Object to the sentence-initial position (e.g. Saito 1985), and that (ii) the Subject-why-Object-Verb (SwhyOV) order is derived from the why-Subject-Object-Verb (whySOV) order via movement of the Subject to the sentence-initial position (e.g. Ko 2005). Our previous experiments with Japanese-speaking adults using near-infrared spectroscopy (NIRS) evaluated these theoretical proposals, and found that, while OSV sentences induce more activation in the left prefrontal cortex than SOV sentences, such effects was not observed between SwhyOV and whySOV sentences. These results were taken to suggest that, while the OSV order is derived from the SOV order as the theory claims, both SwhyOV and whySOV orders should be considered as basic in Japanese. In order to deepen our understanding of the relationship between various word orders in Japanese, this study extends our previous studies and addresses the question of whether Japanese-speaking children exhibit the same pattern of brain activation when interpreting sentences with the SOV, OSV, whySOV, and SwhyOV orders. Eighteen monolingual Japanese-speaking children (between 4 and 6 years of age) participated in our experiment. In this experiment, each child was presented a series of short stories that were accompanied by a set of pictures, and at the end of each story, the child was asked two questions by the computer. There were eight questions in total, which were varied with respect to their word orders. The task for the child was to answer these questions. By using NIRS (ETG-7000, Hitachi Medical Co.), the oxygenated hemoglobin concentration changes (oxyHb) in childrenís prefrontal cortex were recorded throughout the entire experiment. Analysis was conducted only on the oxyHb data obtained during the period around the presentation of the test sentences. Children in our study responded correctly to almost all the questions. The results revealed that oxyHb

changes were significantly larger when interpreting whySOV sentences than when interpreting SwhyOV sentences, in the left lateral prefrontal cortex in the interval from 7-9 s after the start of the sentence presentation (CH15, 16, 20, t=2.325-3.036, p=0.009-0.036). In light of the theoretical proposal in Japanese syntax that the SwhyOV order is derived from the whySOV order, our new finding that the latter induced more brain activation is quite surprising, since it would suggest that SwhyOV is actually the basic order in Japanese and that whySOV is derived from SwhyOV by moving why to the position in front of the subject. Compared with the results in our previous studies, the results in this study also suggest that the prefrontal activity involved in the processing of sentences with various word orders may be quite different between adults and children, and that it may undergo developmental change.

9. 4:45 p.m. - 5:45 p.m.

Event-related potential correlates of artificial grammar learning in preschool children with specific language impairment and controls

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Objective: The current study of children with specific language impairment (SLI) and controls aimed to assess the neural correlates of the ongoing learning of an artificial grammar as well as the final outcome of this learning. Methods: Participants were 14 preschool children with SLI and 14 controls matched on gender, age and nonverbal IQ. The experiment consisted of a training session and a test session. In the training session 40 strings from a simple phrase structure grammar were presented 4 times each. The strings consisted of 2-4 nonsense words. In the test session the trained strings were interspersed with with ungrammatical strings which were composed of the same lexical items, but violated the grammatical rules. Results: Training phase. Visual inspection of grand averages showed a fronto-central negative-going ERP component in the 400-600 ms interval differing between the first presentation and subsequent repetitions of the first word in the strings. A repeated measures ANOVA for the fronto-central region in this time interval with repetition (1, 2, 3, 4) as within-subjects factor and group (SLI, control) as between subjects factor showed that there was a significant effect of repetition ($F(3, 78) = 2.79$, $p = 0.046$), but no interaction between repetition and group ($F < 1$). Test phase. Visual inspection of grand averages for the control group showed a P600-like positive deflection in the 700-800 ms interval for grammatical violations compared to grammatical words. For the SLI group, on the other hand, there was a tendency that ungrammatical words elicited more negative ERPs than grammatical words. A global repeated measures ANOVA for the 700-800 ms interval with grammaticality (grammatical, ungrammatical) and electrode (14) as within-subjects factors and group (SLI, control) as between-subjects factor, showed no significant effect of grammaticality, but a significant grammaticality * group interaction ($F(1, 26) = 9.25$, $p = 0.005$). To follow up the interaction separate ANOVAs were run for the two groups. For the control group, there was a significant main effect of grammaticality ($F(1, 13) = 5.88$, $p = 0.031$), where ERPs to ungrammatical words were more positive than ERPs to grammatical words. For the SLI group, there was a trend towards an effect of grammaticality ($F(1, 13) = 3.39$, $p = 0.089$), but in the opposite direction, i.e. ERPs to ungrammatical words were more negative than ERPs to grammatical words. Discussion: In the present study there was no evidence for differences between children with SLI and controls in the neural correlates of encoding of novel words during the exposure to an artificial grammar. However, when the outcome of training was tested, only control children displayed a P600-like component to grammatical violations. These findings indicate that the ability to infer grammatical rules may be more impaired in SLI than the capacity to encode lexical items. The results are consistent with theories positing that SLI results from a deficiency in rule-based as opposed to declarative language processes. The findings may also have implications for intervention, suggesting a need for the training of abstraction processes.

10. 6:00 p.m. - 7:00 p.m.

The role of selective attention in implicit language learning: An ERP study

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Implicit learning of the statistical relationships between linguistic elements that characterize word boundaries [1,2], phrase structure [3-6], and verbal subcategorization [7] have been documented using artificial grammar learning paradigms. What remains unclear is the role of attention in implicit learning. Studies employing secondary tasks to vary attentional load during implicit language learning [8,9] have yielded contradictory results, while studies examining implicit learning in other domains [10-12] suggest that "selective attention" directed to the stimulus dimension encoding the to-be-learned pattern rather than "attentional load" determines whether learning takes place. We adopted the type of selective attention manipulation employed in [10-12] - but absent from the language literature – by comparing ERP responses to violations of systematic regularities that were either attended or unattended during artificial language exposure. During training, subjects read 384 sentences of an SOV split-ergative artificial language and completed a 2-alternative-forced-choice task with feedback at the main verb. This task, designed to explicitly instruct subjects on the agreement system, focused attention on co-variation between a verbal prefix and a suffix on the agreeing noun (1). (1)

Ba flerbit-OT po klamon-il iti KOG-glim boke ton ol. Training materials contained additional regularities that formed the language's verbal subcategorization system. Verbs obligatorily selected for adjacent auxiliary verbs (local pattern), and were obligatorily transitive or intransitive (global pattern). The subcategorization system was independent of the agreement system and task-irrelevant, and therefore unattended during training. After training, learning of both systems was assessed by having subjects read sentences and make end-of-sentence grammaticality judgments during EEG recording. Subjects read and judged the grammaticality of grammatical sentences and violations (agreement, local and global subcategorization), 40 per condition. The main verb was the critical position in all conditions, as it determined the sentence's grammaticality. Analysis of 20 monolingual native English speakers (aged 18-24) revealed the following results: i) Subjects successfully learned the explicitly trained-upon agreement system (2AFC training data). ii) Subjects performed above chance behaviorally only on grammatical sentences and agreement violations (testing data). iii) No significant differences were observed in the EEG data. iv) A median split based on subject's performance during training revealed the following: "Good" learners (mean training accuracy = 80%) successfully detected only trained-upon violations during testing, and showed no brain response to any of the three violations. "Poor" learners (mean training accuracy = 60%) were less accurate behaviorally during testing, but showed late frontal positivities to all violation types (200-500, 500-900 msec, $p < .05$) These and other results [10-12] are consistent with the assertion that implicit learning is strongly constrained by selective attention, as we have potentially demonstrated that variability in attentional resource allocation during training maps onto variation in both behavior and brain responses during testing. These data also reveal interesting (proficiency-dependent) brain-behavior dissociations (see also [13-15]), and raise the question of how the competence grammar should be assessed: should it be defined at the neural level, the behavioral level of objective acceptability measurements, or the subjective, introspective level of global assessment?

Anatomy, brain plasticity and brain disease

11. 4:45 p.m. - 5:45 p.m.

The therapeutic potential of botanical Norepinephrine Transporter Inhibitor on depression

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In central nervous system (CNS), norepinephrine (NE) was found to regulate mood, sleep and expression behaviors. The norepinephrine transporter (NET) is located in the plasma membrane of noradrenergic neuron for uptaking NE, which is released from the synapse terminal. There are many evidences supported that NE is involved in depression and the NET is the target for anti-depressant medicine development due to the lower side effects and higher efficiency. Reboxetine and Viloxazin, selected NET inhibitors, are used to treat depression patients. The molecular mechanism had been discovered that reuptake activity of NE was blocked and the concentration in synapse terminal space had increased. In this study, we identified PDC-1421, a botanical selective NET inhibitor from a Chinese traditional medicine, which was used as a sedative for insomnia, anxiety, depression and heart palpitation. The IC50 is 1.27 ± 0.46 mg/ml in NET, while 60 and 200 folds to dopamine and serotonin transporter by in vitro radioligand binding assay. PDC-1421 inhibits the reuptake of NE and the IC50 is 0.704 ± 0.191 mg/ml in HEK293 cell line but the concentration is more than 100 mg/ml for inhibition of dopamine and serotonin reuptake. Besides, PDC-1421 demonstrated a great response in depression correlated animal models, including tetrabenazine-induced hypothermia, despair swimming and tail suspension. In conclusion, PDC-1421 is a potent anti-depression drug candidate and the selective NET inhibition is a novel mechanism for CNS drug development.

12. 6:00 p.m. - 7:00 p.m.

Sex differences in Foxp2 expression in the developing rat brain

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The Foxp subfamily has recently been recognized as a member of the Fox gene family. The Foxp subfamily is characterized by presence of a zinc finger domain and a leucine zipper design in addition to a forkhead domain (Shu et al., 2001). Foxp2, a member of the Foxp subfamily is the first gene to be linked to an inherited form of language and speech disorder (Lai et al., 2001). Previous reports in both the rodent and human brain reveal Foxp2 in the cortex, thalamus, amygdala, and cerebellum (Ferland et al., 2003; Lai et al., 2003; Takahashi et al., 2003). We investigated the effect of the steroid hormones estradiol and the non-aromatizable androgen dihydrotestosterone (DHT) on Foxp2 protein levels in developing male and female rats. In Experiment 1, pups were treated on the day of birth with estradiol (100 g s.c. in 0.1cc) or vehicle. Animals were euthanized two days later and Western blots performed on the cerebellum, amygdala, cortex, thalamus, hypothalamus, hippocampus, and POA. Males had higher basal levels of Foxp2 protein than females in the cerebellum, amygdala, cortex, and thalamus. There was no sex difference found in the hypothalamus

or the POA. There was no Foxp2 in the hippocampus of either sex. Estradiol treatment resulted in lower levels of Foxp2 protein in the cerebellum, amygdala, cortex, and thalamus in males. There was no effect of estradiol treatment of females in these same brain regions. In Experiment 2, pups were treated on the day of birth with DHT (100 g s.c. in 0.1cc) or vehicle and euthanized two weeks later. The sex difference observed earlier persisted, with males having higher basal levels of Foxp2 protein than females in the cerebellum, amygdala, cortex, and thalamus. There was no sex difference found in the hypothalamus or the POA. Males treated with DHT had lower levels of Foxp2 protein in the cerebellum, amygdala, cortex, and thalamus, as compared to vehicle treated males. In contrast, DHT treated females had higher levels of Foxp2 protein in these same brain regions, as compared to vehicle treated females. The increased levels of Foxp2 protein in DHT treated females were equivalent to vehicle treated males. To our knowledge, this is the first report of steroid hormones altering Foxp2 protein levels in region specific brain areas.

13. 4:45 p.m. - 5:45 p.m.

Using structural and functional MRI to predict treatment outcome in aphasia

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The primary purpose of this study was to examine functional brain changes associated with aphasia treatment outcome in patients with chronic stroke using functional MRI (fMRI). A secondary exploratory analysis was performed to detect whether frank cortical damage to one or more regions has a greater effect on treatment assisted anomia recovery compared to comparable damage to other brain regions. Methods: Twenty-six patients with chronic stroke and concomitant aphasia were included. Aphasia severity and type varied among the patients. All patients underwent aphasia treatment specifically targeting anomia, an impairment that occurs in all cases of aphasia. The treatment (cueing hierarchy) uses verbal cues of increasing cueing strength to elicit correct naming of colored pictures (Linebaugh & Lehner, 1977). Each patient received three hours of treatment per day for two weeks for a total of 30 hours. During fMRI scanning, patients completed an overt picture naming task. Naming attempts were recorded and later scored off-line. Correct naming during fMRI scanning was utilized as the outcome measure to assess changes in naming performance. Each patient completed two functional MRI (fMRI) sessions before treatment started and two after treatment was completed. All patients were scanned using a 3T Siemens Trio system. Each 20m fMRI session utilized sparse scanning (TR=10s; TA=2s). T1- and T2-MRI was collected for lesion demarcation. fMRI data were analyzed in three steps using FMRIBís Software Library version 4.1 (Smith et al., 2004): 1) Determined cortical modulation associated with correct naming attempts for each of the fMRI sessions before and after treatment; 2) Contrasted the fMRI sessions before treatment with the two fMRI sessions administered after treatment; 3) Included a regression analysis in which statistical maps created in step 2 from all participants were combined to predict change in correct naming. The exploratory analysis of structural damage as a predictor of anomia treatment outcome relied on Non-parametric Mapping (Rorden et al., 2007). As above, the dependent factor was standardized change in naming. Results: A positive relationship was revealed between treatment assisted increase in correct naming and modulation of cortical areas in the left posterior and anterior hemisphere. That is, patients whose activation increased in the areas highlighted in Figure 1 were more likely to improve with respect to correct naming compared to those with limited change. The strongest lesion predictor (i.e., the voxel with the highest Z-score) of limited improvement in correct naming was found at the junction of Brodmannís areas (BA) 37 and 39 in the posterior portion of the left middle temporal lobe (Z=2.20; uncorrected) (not pictured). Discussion: This study is the first to combine structural and functional MRI to predict anomia treatment outcome in a relatively large group of aphasic patients. The most salient findings were related to increase in a common left hemisphere network to support positive treatment outcome. As importantly, the fortuitous preservation of specific left hemisphere regions was associated with improvement in correct naming. These findings highlight functional brain changes and structural brain damage as biomarkers of positive anomia treatment outcome in patients with aphasia. References: Linebaugh C, Lehner L (1977) Cueing hierarchies and word retrieval: A therapy program. Rorden C, Karnath H, Bonilha L (2007) Improving lesion-symptom mapping. Journal of cognitive neuroscience 19:1081-1088. Smith S, Jenkinson M, Woolrich M, Beckmann C, Behrens T, Johansen-Berg H, Bannister P, De Luca M, Drobnjak I, Flitney D (2004) Advances in functional and structural MR image analysis and implementation as FSL. Neuroimage 23:208-219.

14. 6:00 p.m. - 7:00 p.m.

Recruitment of occipital cortex for speech and auditory processing in anophthalmia

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Individuals born with bilateral anophthalmia present an opportunity to investigate the reorganisation of the brain when deprived of visual input. We have previously shown that the brains of anophthalmic subjects are only subtly different from sighted subjects in their structure and connectivity (Bridge et al., Brain 2009). Here, we used functional MRI to investigate the function of the ëvisualí system in five adults with bilateral anophthalmia. We performed two experiments using a 3-T Siemens Trio with 12-channel headcoil: a low-level auditory processing experiment and a higher-order language task. In the auditory experiment, participants passively listened to 1-s trains of pure tones at different

frequencies. Data were acquired using sparse sampling so that the sounds were played during a 7-s silent period between two scan volumes, each of which was timed to capture the peak of the haemodynamic response to the preceding auditory stimulus. In the language task, data were acquired continuously while participants heard short phrases and silently retrieved the name of the object defined e.g. ìbees make itî [honey] or listened to reversed speech. For the auditory task, both control (N=6) and anophthalmic groups (N=5) showed highly significant activity in the primary and secondary auditory cortex along Heschlís gyrus. In addition, four out of five anophthalmic subjects showed activity (Z>2.3) along the calcarine sulcus, the location of primary visual cortex in sighted subjects. For the language task, while listening to speech, controls (N=11) and anophthalmic groups (N=5) activated the classic language network comprising bilateral superior temporal and predominantly left inferior frontal areas. The anophthalmic group also showed significantly more activity than controls (Z>3.1) in the lateral occipital cortex (LOC), corresponding to a functional definition in sighted subjects. While listening to reversed speech the anophthalmic group had more activity than controls in the medial dorsal occipital cortex. In sum, in anophthalmic subjects, low-level auditory processing activated medial occipital areas in the region of the calcarine sulcus, whereas the higher-order task activated more lateral occipital areas extending anteriorly and ventrally to inferior temporal cortex. This pattern parallels the hierarchy of processing of visual information in the occipital lobe in sighted subjects.

15. 4:45 p.m. - 5:45 p.m.

Meta-analysis reveals consistent activation patterns in aphasic patients

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Introduction: Aphasic patients recruit right and left hemisphere areas for language tasks, but the consistency of this activity across subjects and studies is unknown. We meta-analyzed prior functional neuroimaging studies to determine whether right hemisphere activity in aphasics mirrors left-sided activity in controls, and how activity varies with subject and task attributes. Methods: We submitted activation foci from fMRI and PET studies using the same tasks on both aphasics and controls to Activation Likelihood Estimation (ALE) analysis. We used random effects significance testing and a new algorithm that does not sum ALE values within subjects to prevent any one study from driving results. Using single-study ALE maps, we calculated the degree to which fluency, lesion location, or task determined ALE values. Results: We identified 12 studies reporting 240 activation foci from 104 aphasics, and 197 foci from 129 control subjects. A variety of tasks were used. Controls consistently activated typical language and motor areas (Figure 1). Aphasics consistently activated right hemisphere areas homotopic to the control subjectsí ALE map, and inferior frontal areas surrounding the control subjectsí ALE clusters. The right pars opercularis and right motor cortex were recruited only by nonfluent aphasics. In contrast, the left pars triangularis and right posterior MTG were recruited by fluent aphasics. Task demands altered recruitment patterns, and some areas in aphasics responded similarly to normal areas activated by control subjects. Discussion: There is considerable consistency in aphasic language activity across studies, despite variation in patients and tasks. Activity regularly occurs both in spared left hemisphere areas and in the right hemisphere, where aphasics recruit regions that are homotopic with normal left-sided language areas. The pattern of recruitment depends on lesion site and the language deficit. Recruitment of certain peri-lesional and contra-lesional sites varies with task demands, in some cases mirroring recruitment patterns of normal language areas in controls.

16. 6:00 p.m. - 7:00 p.m.

Interhemispheric functional connectivity following pre- or perinatal brain injury predicts language outcome

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The proliferation of axonal fibers during the prenatal period establishes interhemispheric connectivity, and this process is fundamentally altered by early brain injury (Moses et al., 2000). Early injury also alters the degree to which each hemisphere contributes to language processing, with certain patterns of brain activity predicting better language outcome than others (Raja Beharelle et al., in press), but to date the contributions of each hemisphere have been investigated without regard to how they interact. In the present study, we relate interhemispheric functional connectivity of frontal, parietal, and temporal brain regions to language outcome following early stroke. Method: We used functional magnetic resonance imaging (fMRI) to study 14 people with early left hemisphere (LH) stroke, 11 people with early right hemisphere (RH) stroke, and 26 typical controls during passive audiovisual story comprehension. To assess interhemispheric functional connectivity, we correlated the fMRI time series from six LH anatomical regions with their RH homologues. We then Fisherís z transformed these correlations, and used robust statistical measures (Wilcox, 2005) to relate them to a behavioral measure of story comprehension performed outside the scanner. Results: A significant correlation between interhemispheric functional connectivity (x axis in Figure 1) and story comprehension (y axis in Figure 1) was found for the posterior superior temporal gyrus for people with LH injury, but not for RH injury. For the poste-

rior superior temporal sulcus, significant correlations were found for both injury groups. In contrast, for controls, correlations ranged from r = -0.07 to 0.3 and were non-significant for all regions. These results show that stronger interhemispheric connectivity for posterior temporal regions predicts better language outcome following early stroke, in particular for people with LH injury, and that this pattern deviates from that found in typical individuals. This suggests a potential compensatory organization for language comprehension in response to early insult.

17. 4:45 p.m. - 5:45 p.m.

An fMRI study of language reorganization following early neurological disease and neurosurgery

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In this study functional MRI was used to examine the impact of epilepsy and brain surgery on cortical plasticity of language. Although the inter- and intrahemispheric transfer of language is well documented as evidence of functional plasticity, many details are still poorly understood. Our work contributes to previous research by examining a carefully selected patient population and administering a battery of distinct language tasks, to observe the aspects of language that undergo cortical reorganization and how such reorganization occurs. The relatively homogeneous patient population consisted of two groups of epilepsy patients who have all undergone left temporal lobectomy to control seizures. Two groups, right (RH, n=7) or left (LH, n=10) hemisphere speech dominant, were selected based on pre-surgical Wada tests and matched for age, gender, education and etiology. A group of similarly matched healthy volunteers (C, n=14) was also enrolled in the study. Four language tasks (verb generation-VG, passive sentence reading-PSR, definition naming-DN and semantic decision-SD) were selected in order to sample a range of language processes (semantic, syntactic), presentation (auditory, visual), and response modalities (passive encoding, active response, decision-making). Robust BOLD activity was consistently found in all groups for each task in language areas (inferior frontal gyrus-IFG and posterior temporal gyrus-PTG) or their right hemisphere homologues, with clear differences in language lateralization across the groups: the C and LH groups show strong left lateralization, while the RH group shows right dominance. Comparisons between the LH and C reveal greater right hemisphere activation in LH subjects on some tasks, reflecting partial transfer of some language function due to epilepsy and resection. Activation maps for the LH and RH groups show mirrored distributions of language networks, indicating that right hemisphere structures have assumed the language functions of their left homologues during interhemispheric transfer. Direct comparisons between the patient groups reveal no significant difference for the PSR and SD tasks, but did show significantly more activation for the RH group in the right IFG and PTG for the VG and DN tasks. These results indicate that language production is more strongly lateralized after transfer, while activation during semantic and syntactic processing is somewhat more bilaterally distributed. Altogether these findings provide enriched information about the ways in which language functions reorganize in the brain as a result of epilepsy and temporal lobectomy.

18. 6:00 p.m. - 7:00 p.m.

Low perfusion affects cortical neuroplasticity

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Introduction: In stroke patients, time-to-peak (TTP) of local hemodynamic response functions (HRFs) may be delayed, resulting in underestimation of neural activity when a canonical HRF is used to model fMRI data (Bonakdarpour et al., 2007). These delays are likely related to hypoperfusion. Reperfusion of hypoperfused tissue is correlated with improvement on language tasks in acute stroke (Hillis et al., 2006). Importantly, hypoperfusion is not often associated with chronic stroke (Love et al., 2002). As part of a study into effects of language training on improvement and associated neural plasticity in speakers with aphasia, we measured local perfusion levels and investigated correlations between perfusion, TTP and propensity for neural activation change. Methods: Six speakers with mild to moderate agrammatic aphasia (1 female; age 38ñ66 years; between 6-146 months post onset) were scanned before and after Treatment of Underlying Forms (see Thompson et al. 2003). The task used for pre-post measurement of relevant neural activation changes was auditory verification of object-cleft and subject-cleft sentences, matched and mismatched to pictures. In a separately run long-trial version of the same task, a fixed SOA of 30 seconds was used, to examine participant-specific HRFs in 16 ROIs, associated with syntactic processing: BAs 7, 9, 13, 21, 22, 39, 40, 44, 45, bilaterally. These response patterns were fed as weights to FIR-modeled stimulus-locked time bins in the statistical model for analysis of pre-post activation contrasts, using t-tests to compare the different conditions. Participants underwent perfusion imaging by arterial spin labeling. We calculated the mean flow value for the grey matter in each ROI, quantified in ml/100g/min.. Correlations between perfusion and region-specific TTP were calculated using a Pearson test. In addition, relations between region-specific upregulation of fMRI activation after treatment, perfusion and TTP were examined with independent-

samples t-tests, dividing ROIs into two groups, viz. those that showed upregulation of activation after treatment and those that did not. The same analyses were performed using regional downregulation and using ëdifferential activationí (up- or downregulation versus no change) as grouping factors. Results: Perfusion was lower in the hemisphere directly affected by the stroke, while relatively low perfusion also extended beyond the immediate perilesional areas. Lower perfusion was correlated with longer TTPs (Pearson $r(103) = -.20$, $p<.05$). In addition, regions showing post-treatment upregulation of activation showed significantly shorter TTPs ($t(101.9) = -4.793$, $p<0.001$)) and higher perfusion levels ($t(106) = 2.089$, $p<0.05$), compared to regions that did not (Figure 1). There were no differences between regions showing or not showing downregulation for either TTP or perfusion levels. Regions with ëdifferential activationí showed shorter TTPs than regions that showed no change ($t(91.0) = 3.024$, $p<0.05$), with no difference in perfusion levels. Conclusion:. The negative correlation between perfusion and TTP as well as the relation between perfusion levels and propensity for upregulation of activity after training indicate the importance of taking into account participant-specific brain response parameters in neuroimaging studies of clinical populations. Locally reduced perfusion essentially extends the lesion in patients with stroke, limiting the candidacy of affected regions for functional recovery.

19. 4:45 p.m. - 5:45 p.m.

Transcranial direct current stimulation (tDCS) applied to the left posterior cortex improves language performance in fluent aphasia

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Objective: Recent work utilizing anodal transcranial direct-current stimulation (A-tDCS) revealed improved naming accuracy in persons with aphasia (PWAs) following application to the left frontal cortex. PWAs with perilesional areas closest to the stimulation site demonstrated greatest improvement, whereas those with more posterior lesions revealed minimal benefit (1). The aim of the current study was to examine the effect of A-tDCS upon naming improvements by targeting perilesional areas in PWAs with posterior damage. The specific outcome measure was reaction time (RT) of correctly named trained nouns following A-tDCS and sham tDCS (S-tDCS). We hypothesized that multiple administrations of A-tDCS to the scalp overlying the left posterior cortices would improve RT in PWAs with posterior damage. Methods: Patients- Eight patients (five female) with chronic, stroke-induced aphasia aged 53- to 79-years participated. All patients sustained a single ischemic stroke to the left hemisphere (LH), were at least 10-months post-stroke, and had participated in an ongoing study which incorporated functional MRI (fMRI) examination. Design- Electrode positioning was followed by baseline testing, treatment, and post-treatment testing. The computerized anomia treatment, coupled with either A-tDCS or S-tDCS, was administered for five consecutive days and followed by a three-week rest period. Next, another five-day treatment period was administered, coupled with the remaining stimulation type. Electrode Positioning- Coordinates of the left posterior cortex with the highest level of activation during correct naming of nouns on a previously completed fMRI exam was located on a patient-by-patient basis using methods described previously (1). This region was stimulated by the anode electrode. tDCS- tDCS (1 mA) was delivered for 20-min per session via two electrodes (5x5 cm) and a constant-current stimulator (Phoresor® II PM850). During both stimulation phases, the anode electrode was placed over the left posterior cortex, while the reference cathode electrode was placed over the right orbitofrontal cortex. For S-tDCS, the stimulator was turned off following 45s of stimulation using an in-house computer program that allowed for double-blinding of stimulation type, which was counterbalanced among patients. Anomia Treatment- The computer anomia treatment consisted of a picture-auditory word-matching task comprised of 50 low-frequency nouns (2). This treatment occurred concurrently with the application of tDCS and lasted for 25-min per session, commencing 5-min prior to the start of stimulation. Outcome Measures- To determine whether the patients' RT improved following each treatment phase, a computerized naming test consisting of the 50 trained nouns was administered at baseline, immediately following the final session of each treatment phase, and three-weeks following the final session of each treatment phase. Results: All patients tolerated tDCS well and no adverse effects were demonstrated. A 2x2 repeated measures ANOVA (stimulation, time) was conducted; analysis of the main effect of stimulation type revealed RT of correctly named nouns was statistically faster following A-tDCS versus S-tDCS ($F(1,7)=7.44$, $p<0.0294$). Conclusions: Results suggest that A-tDCS significantly decreases RT of trained nouns in PWAs. Additionally, these improvements were maintained for at least 3-weeks post-treatment. Our findings are in agreement with previous evidence demonstrating that A-tDCS over the LH improves naming performance in PWAs (1). References: 1. Baker JM, Rorden C, & Fridriksson J. Using transcranial direct-current stimulation to treat stroke patients with aphasia. Stroke. 2010;41:1229-1236. 2. Fridriksson J, Baker JM, Whiteside J, Eoute D, Moser D, Vesselinov R, & Rorden C. Treating visual speech perception to improve speech production in non-fluent aphasia. Stroke. 2009;40:853-858.

20. 6:00 p.m. - 7:00 p.m.

What iterative parcellation of DTI data tells us about the language network

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The Dual Stream Model of speech processing (Bookheimer 2000; Hickok 2009) posits a human language network with two subsystems: 1) The dorsal ""how"" stream subserves auditory-motor integration and connects the sylvian temporoparietal region to BA 44 via the arcuate fasciculus. 2) the ventral ""what"" stream accesses lexical-semantic information and connects superior and medial temporal regions to Brodmann areas 45 and 47 via the extreme capsule. Based primarily on lesion and fMRI studies, Hickok (2009) hypothesized that whereas the dorsal stream is left-lateralized, the ventral stream is largely bilateral. Mapping the neural circuits of the Dual Stream Model emerged from laborious, invasive and indirect studies of the language system because no simple method of characterizing the connectivity presented itself. The objective of this study was to apply a novel method, iterative parcellation (IP), to the problem of characterizing the language network. If successful, IP should reveal patterns consistent with the more laborious methods of exploring the language network. In addition, we predicted that IP would appropriately characterize the location and size of the cortical endpoints connected by each tract. Methods: Using a DTI dataset (GE 3.0T, 25 directions, isotropic 2.6 mm voxels; B=1000) from 62 normal adults (30-84 yrs), we tracked the arcuate and extreme capsule tracts with FSL. We then used FSL's parcellation, iteratively, to identify the location and size of the cortical regions connected by each tract. After parcellation, we examined the cortical endpoints by location and size, comparing right versus left using paired t-tests and using Cohen's d to estimate effect sizes. Results: The iterative parcellation approach produced both confirmatory and novel findings. Tractography indicated that arcuate fasciculus and extreme capsule volumes were left-lateralized ($t>3.2$, $p=0.002$; $d>0.42$). The IP procedure confirmed that each tract connected different cortical endpoint locations, as predicted by the Dual Stream Model (all comparisons significant at $p<0.001$). Frontal endpoint volumes, for both the arcuate fasciculus and extreme capsule, were significantly larger on the left than right ($t=2.8$, $p=0.007$; $d=0.4$ dorsal; $t=7.3$, $p>0.001$, $d=1.16$ ventral). In temporoparietal regions, however, only the volume of the arcuate endpoint was left-lateralized ($t=4.9$, $p<0.001$, $d=0.82$), while the extreme capsule endpoint was right-lateralized ($t=-2.9$, $p<0.005$; $d=0.39$). Conclusion: From a methodological perspective, IP proved to be a promising easily implemented technique to measure the size and location of connected cortical regions. When used to examine the cortical endpoints of the dorsal and ventral streams, IP appeared to appropriately characterize the language network. The frontal regions associated with speech production were left-lateralized, whereas temporoparietal regions associated with auditory comprehension were left-lateralized for the arcuate, but right-lateralized for the extreme capsule. These finding are consistent with Hickok's proposal that the right ventral stream plays an important role in processing syllabic input.

21. 4:45 p.m. - 5:45 p.m.

Pure word deafness: Evidence of functional asymmetry between left and right auditory cortex using MEG recordings

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Objective: Pure word deafness (PWD) is a disorder in which comprehension of spoken language is impaired while other auditory functions remain intact. The very existence of PWD suggests that there are speech-specific mechanisms in the brain. There is a long-standing debate about the nature of the lesions that cause PWD (e.g., left or bilateral lesions in the auditory cortex) and the processing levels that are impaired (e.g., ìpre-phonemicî or phonetic levels). It has been proposed that a substantial impairment in the ability to process rapid spectro-temporal variations in speech is one of the primary causes of PWD. Patient and Methods: We report a single-case study of PWD associated with production aphasia in a 35-year-old woman. Two consecutives cerebrovasculars accidents induced lesions in the left hemisphere (superior temporal gyrus, planum temporal, occipito-parietal junction, part of the inferior frontal gyrus) and in the right hemisphere (posterior part of STG, occipito-parietal junction). Standard pure tone threshold audiometry and brainstem auditory evoked potentials (BAEPs) were normal confirming the absence of peripheral hearing loss. Perception of single tones, speech sounds, male/female voices, music, and environmental sounds were assessed in discrimination and identification tasks. Lexico-semantic and phonological performance was evaluated in the visual modality. The efficiency of the left and right auditory cortices was assessed by magnetic auditory evoked potentials (MAEPs) to pure tones and voiced and voiceless syllables (/ba/ - /pa/). A mismatch negativity (MMN paradigm) was also performed. Results: Perception of musical and non-verbal environmental sounds was preserved in the patient. In the visual modality, performance in lexico-semantic and phonological tasks (rhyme task with drawings) was unimpaired. In discrimination (d) and identification (i) tasks, a dissociation between verbal and non-verbal items was observed: discrimination and identification were preserved for pure tones (d, 87.5%; i, 100%) and male/female voices (d, 100%; i, 75%), but not for

syllables (d, 80%; i, 40%) and words (d, 55%, i, 20%). Pure tones elicited a M100 that was localized in the right auditory cortex. MAEPs to /ba/ and /pa/ were delayed by 200ms and did not exhibit the typical differential coding of stimuli on the basis of temporal cues revealing anomalies in temporal processing of speech. Interestingly, source localization again showed a specific involvement of the right auditory cortex. In the MMN paradigm, no automatic changeñdetection response was obtained for minimal word pairs (e.g., /bain/ versus /pain/) neither from the right nor the left auditory cortex. Conclusion:In the present single-case study of PWD, electrophysiological recordings highlight a functional lesion of the left auditory cortex (despite bilateral lesions of STG), which causes a substantial impairment in the ability to process temporal variations in syllables contributing to the deficit in speech sound discrimination. The dissociation between intact nonverbal but impaired verbal perception suggests that the right auditory cortex is able to process environmental sounds, music and male/female voices but not speech sounds. Interestingly, lexico-semantic and phonological processes were spared in the visual modality, which suggests an intriguing separation between visual and spoken language processes.

22. 6:00 p.m. - 7:00 p.m.

Compensatory cross-modal plasticity of speech perception and production neural networks in congenitally blind adults

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Visual cues play an important role in the development of speech perception and production. Deprived of the visual correlates of articulatory gestures, congenitally blind speakers rely only on the auditory and somatosensory modalities to perceive and produce speech. In order to test whether visual brain areas might be recruited in a compensatory cross-modal manner during speech perception and production, we here focus on the neural substrates of vowel perception and production in both congenitally blind and sighed adults. In order to minimize scanner noise and movement-related imaging artifacts, a sparse sampling acquisition technique was used where participants produced or passively listened to a vowel during a silent interval between successive image acquisitions. For vowel perception, a conjunction analysis revealed common bilateral activations for both groups in the superior temporal gyrus/sulcus extending to the ventral part of the inferior parietal cortex. In addition, a group comparison showed specific bilateral activations in the calcarine gyrus and the superior/middle occipital gyri for blind participants. For vowel production, the conjunction analysis revealed a bilateral set of brain areas classically involved in motor control: the sensorimotor cortex, the premotor cortex, the inferior frontal gyrus, the supplementary motor area and the anterior cingulate gyrus, the superior and inferior parietal lobules, the insula, the basal ganglia, the thalamus and the cerebellum. The group comparison further showed specific reduced neural responses for blind participants in the prefrontal cortex, the right superior parietal gyrus, the basal ganglia, the cerebellum and the posterior cingulate gyrus. Interestingly, no activations were observed in the visual cortex during the production task. Compared to vowel perception, reduced activity observed for both groups in the auditory cortex as well as in the visual cortex for blind participants might reflect motor-to-sensory feedback control mechanisms. Altogether, these results provide clear evidence for cross-modal plasticity due to early visual deprivation of the neural networks involved in speech perception and production.

23. 4:45 p.m. - 5:45 p.m.

Mapping receptive and expressive functional language in surgical patients: An MEG investigation

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Recent neuroimaging studies have shed light on the cortical organization for language, with findings implicating both left and right temporal lobe involvement in early language processing converging to a left-dominant pattern. These findings highlight the fact that the present state of theoretical knowledge is ahead of current clinical methods for determining language dominance, and motivate a rethinking of approaches for presurgical language mapping. While ultimately we need to provide surgeons with a hemisphere-specific location for language function, it is becoming increasingly clear that there is substantial bilateral temporal lobe activation that must be taken into account in pre-surgical planning (Gage et al., 2002; Hickok & Poeppel, 2007). We used Magnetoencephalography (MEG) and tasks tapping receptive (Word Recognition) and expressive (Verb Generation, Picture Naming) language function in patients being evaluated for surgery (n=8, 6 female, 23-60 yrs; 6 with a diagnosis of epilepsy, 1 tumor, 1 arterovenous malformation (AVM)) who are part of an ongoing prospective study (N=20). Our aim was to separately assess receptive and expressive language localizations for each patient. Participants were scanned using a 148-channel Magnes 2500 whole-head Biomagnetometer SystemTM (4D Neuroimaging, San Diego, CA). Auditory and visual evoked fields were recorded for each

task and data were analyzed using standard methods described elsewhere (Gage et al., 2006). Late (post-sensory processing, ~150-400ms post stimulus onset) language activations were assessed using automated algorithms to select those single equivalent current dipoles (SECD) that clustered in time and brain space with strong model fits. A laterality index (LI) was calculated (SECD meeting criteria [(L-R)/(L+R)]) for each patient in the late field time window with negative LI values reflecting right-dominance and LIís near zero (+0.15 to -0.15) reflecting bilateral organization. Verb Generation: all 8 patients showed left dominance, with activations in occipital and frontal sites. Picture Naming: 2 patients were not able to tolerate the task and 1 was excluded due to seizure activity during the scan. Results for n=5: 4/5 patients showed left and 1 (left-handed female) showed right dominance, again in occipital and frontal sites. Word Recognition: all patients showed Superior and Middle Temporal Gyrus activations. Of the 6 epilepsy patients, 4 patients (3 female) showed rightward, 1 female showed bilateral, and one female showed leftward dominance for receptive language. The AVM patient showed bilateral and the tumor patient showed strong left-dominance. We found strongly left-lateralized responses for the Verb Generation and Picture naming tasks, in good accord with previous findings showing that theses tasks tap expressive language processes in the dominant hemisphere. A different pattern was found for Word Recognition, with only 2/8 patients showing leftward dominance, indicating that receptive and expressive language processes may have divergent patterns of hemisphere dominance. Cumulatively our findings indicate that it is critical to use multiple tasks tapping separable aspects of language function to provide the most sensitive and specific estimate of language localization in surgical patients, especially in patient populations with early developing disease/disorder where cortical reorganizations processes may have occurred.

24. 6:00 p.m. - 7:00 p.m.

Progression in fluent primary progressive aphasia (PPA): A longitudinal multivariate approach

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This longitudinal study of primary progressive aphasia (PPA), a neurodegenerative disorder with predominant language impairment, investigated long-term development of deficits and associated changes in brain anatomy and function. Such longitudinal approach is required since, despite its progressive nature, previous studies mostly relied on cross-sectional data in order to characterise the development of PPA. Moreover, a detailed description of changes in a wide spectrum of linguistic, neuropsychological, and motor abilities is needed in order to characterise the nature of PPA and its neural basis. Three German patients diagnosed with fluent PPA were examined three to four times at intervals of six months. FMRI was recorded for visual lexical decisions. Neuropsychological testing included digit span (forward and backward), visual-spatial span (Corsi), verbal and nonverbal learning (VLT/NVLT), executive functions in word recall (RWT), IQ (LPS 50+), spatial-constructional processing (mosaic test), sustained, divided, and selective attention (TAP), and dementia screening (MMSE). Neurolinguistic tests comprised receptive and expressive language abilities (AAT), nonverbal semantic processing (BORB), and examination of limb- and buccofacial apraxia and neurogenic speech disorders (AMDNS). Syntax tests for vascular patients were adapted to the German language, covering sentence repetition, sentence completion, sentence-picture-matching, and grammaticality judgement. 59 German healthy controls were examined with these tests in order to acquire normative data for the investigation of PPA patients. Our large set of detailed tests exposed an intricate performance pattern: Worse-than-normal, though stable, performance was observed for the PPA group in the linguistic tests (sentence completion and repetition), as well as verbal learning was worse than nonverbal learning. Progressive deterioration was observed in sentence repetition, AAT subtest naming, and phonological fluency. Finally, the following tests gave mixed results: performance on certain parts of the sentence completion and the grammaticality judgement batteries was diminished but stable, whereas in other parts, there were decreasing performance trends. Non-linguistic performance deficits included alertness and divided auditory attention. Limb apraxia evolved in all cases. Interestingly, no non-linguistic semantic deficits or dementia emerged. The fMRI group analysis showed a continuously decreasing activation bilaterally in middle temporal gyri and pons over time. Increasing right frontal activation was found to overlap with cytoarchitectonic area 45 and SMA (area 6). Corresponding grey matter decreases in predominantly fronto-temporal regions were observed. This longitudinal study using a large battery of linguistic, neuropsychological, and motor tests in combination with (f)MRI revealed consistent decrease of linguistic and non-linguistic performance in fluent PPA. Deterioration of lexical access at word level corresponds to decreasing bilateral middle temporal activation. Increasing right frontal activation could reflect functional re-organisation as a compensatory mechanism, as described for vascular aphasics. Whether this frontal effect relates only to lexical or also to syntactic processing deficits remains to be investigated. Progressive deficits were not confined to linguistic abilities, but also to attention and praxis. The absence of non-linguistic semantic deficits allows the distinction of PPA from semantic dementia. Thus, the longitudinal view on PPA gave insights into the progressive nature of linguistic and non-linguistic deficits, providing better understanding of the course of PPA and hints for compensatory interventions.

25. 4:45 p.m. - 5:45 p.m.

Intact, anterior portions of corpus callosum may be critical for improvement in naming and speech, post- TMS treatment in chronic, nonfluent aphasia: A DTI study

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Introduction: Increased R frontal activation in nonfluent aphasia may be due, in part, to decreased inter-hemispheric inhibition from the left hemisphere (LH) frontal lesion. This might represent "maladaptive plasticity" and ultimately limit recovery (Belin et al., 1996; Rosen et al., 2000; Naeser et al., 2004; Martin et al., 2005; LeFaucheur, 2006). Suppression of the RH pars triangularis (PTr) with slow, 1 Hz, repetitive transcranial magnetic stimulation (rTMS) may help to shift activation for naming, back into parts of the LH, and thus improve naming and phrase length (Martin et al., 2009). Inclusion criteria for our rTMS treatments include single LH stroke, at least 1-word phrase length (Cookie Theft picture, BDAE), no stereotypies, ability to name at least 3 pictures (Boston Naming Test, BNT). We report lesion sites and diffusion tensor imaging (DTI) in a nonfluent aphasia patient (P1) who met our Inclusion criteria, but failed to show improvement post-rTMS as compared with others who did show the predicted improvement (Naeser et al., 2005). Method: Neuronavigated TMS was applied daily for 10 consecutive days at 1 Hz to R PTr. Comprehensive speech evaluation was completed before and at 2 mo. or more post-rTMS. DTI was used to visualize the callosal pathways. The white matter fiber tracts were calculated with Diffusion Toolkit (Ruopeng Wang, 2007), with a deterministic tractography algorithm based on the FACT algorithm (Mori and van Zijl 2002), and visualized with TrackVis software (Ruopeng Wang, 2007). Results: P1 was 48 Yr.M, R-handed, college-educated, worked in computer software technology; tPA was administered. He was treated with rTMS 1.5 years poststroke. Pre-rTMS and at 2 mo. post-rTMS, phrase length was 2 words; pre-rTMS, BNT was 9 and post-rTMS, 10. His LH lesion was compatible with nonfluent aphasia (Naeser et al., 1989). Additionally however, Fig. 1,P1 shows atypical lesion was present in parts of the anterior third of the corpus callosum (CC), including rostral body (affecting premotor and supplementary motor, SMA, callosal pathways), and anterior midbody (motor pathways) (Witelson, 1989). In contrast, P2 was 48 Yr.M, R-handed, college-educated, engineer treated with rTMS at 10 years poststroke (Naeser et al., 2005, Martin et al., 2009) who showed good response to rTMS. Pre-rTMS, he named 11 pictures on BNT; at 2 and 6 mo. post-rTMS, 14, 18. At 2 and 6 mo. post-rTMS his phrase length was 5 words; pre-rTMS, only 3. His LH lesion was compatible with nonfluent aphasia (Naeser et al., 1989). Fig. 1,P2 shows LH lesion did not extend into the CC. The normal control had full CC pathways (Fig. 1,NC). Conclusions: Slow, 1 Hz rTMS can be used to suppress an ROI in the undamaged hemisphere in a stroke patient to modulate the bi-hemispheric neural network. Treatment success, however, appears dependent, in part, on intact, inter-hemispheric CC pathways for areas related to the rTMS treatment. In nonfluent aphasia, important CC pathways appear to include those of premotor/SMA and motor areas, areas likely related to recovery of naming and speech in nonfluent aphasia. References Belin, P, Van Eeckhout, P, Zilbovicius, M, et al. (1996). Recovery from nonfluent aphasia after melodic intonation therapy: a PET study. Neurol, 47(6), 1504-1511. Lefaucheur, JP (2006). Stroke recovery can be enhanced by using repetitive transcranial magnetic stimulation (rTMS). Neurophysiol Clin, 36(3), 105-115. Martin, PI, Naeser, MA, Doron, KW, et al. (2005). Overt naming in aphasia studied with a functional MRI hemodynamic delay design. Neuroimage, 28(1), 194-204. Martin, PI, Naeser, MA, Ho, M, et al. (2009). Overt naming fMRI pre- and post-TMS: Two nonfluent aphasia patients, with and without improved naming post-TMS. Brain Lang, 111(1), 20-35. Mori, S, & van Zijl, PC (2002). Fiber tracking: principles and strategies - a technical review. NMR Biomed, 15(7-8), 468-480. Naeser, MA, Martin, PI, Nicholas, M, et al. (2005). Improved picture naming in chronic aphasia after TMS to part of right Broca's area: an open-protocol study. Brain Lang, 93(1), 95-105. Naeser, MA, Martin, PI, Baker, EH, et al. (2004). Overt propositional speech in chronic nonfluent aphasia studied with the dynamic susceptibility contrast fMRI method. Neuroimage, 22(1), 29-41. Naeser, MA, Palumbo, CL, Helm-Estabrooks, N, et al. (1989). Severe nonfluency in aphasia. Role of the medial subcallosal fasciculus and other white matter pathways in recovery of spontaneous speech. Brain, 112 (Pt 1), 1-38. Rosen, HJ, Petersen, SE, Linenweber, MR, et al. (2000). Neural correlates of recovery from aphasia after damage to left inferior frontal cortex. Neurol, 55(12), 1883-1894. Ruopeng Wang VJW (2007). TrackVis.org. In: Martinos Center for Biomedical Imaging, Massachusetts General Hospital. Witelson, SF (1989). Hand and sex differences in the isthmus and genu of the human corpus callosum. A postmortem morphological study. Brain, 112 (Pt 3), 799-835.

Multilingualism

26. 6:00 p.m. - 7:00 p.m.
Neural correlates of lexical processing in 6-year-old German-English bilinguals

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Introduction: The present study aimed at investigating the effects of language use on auditory word recognition in bilingual children by means of Near Infrared Spectroscopy (NIRS). An auditory repetition priming paradigm was used in which German and English words were presented first as primes and subsequently repeated as targets. Previous studies have found that adult bilinguals show asymmetrical priming effects, i.e. greater priming in a weaker language than in the stronger language. However, to date no study has investigated how language exposure or use affects repetition priming in early simultaneous bilingual children. Methods: Twenty-four right-handed participants took part in the study. All subjects were early simultaneous German-English bilingual children, aged between 6 to 7 years. All children learned both languages from birth in their families and were currently living in Germany. Even though proficiency in both languages was very high, the dominant language was German. Two sets of stimuli were created consisting of 112 German and 112 English concrete nouns. German words represented a literal translation of the English words. All stimuli were presented auditorily in alternating blocks of German and English words. Participants were asked to listen passively to these words while hemodynamic activity was monitored. An auditory repetition priming paradigm was adopted, that is each word was presented twice (prime and target) with varying lags between repetitions. Concepts were either first presented in English followed by German or in German followed by English (50%). Results: Results revealed a main effect of language and a language by repetition interaction. There were significantly greater signal changes in German than in English in the temporal brain regions. The language by condition interaction revealed greater repetition priming in frontal regions of the brain for English compared to German. Taken together these results suggest that word recognition involves the use of temporal lobe mechanisms in German whereas English word recognition may involve deeper semantic processing. Conclusions: The findings of the present study suggest that immersion in a language may modulate the magnitude of lexical processing. These results are consistent with the view that lexical-semantic processing in bilingual children, even in those who exhibit high proficiency in two simultaneously learned languages, is sensitive to factors such as language use. Furthermore the results indicate that the recording of NIRS during passive priming tasks is a feasible experimental method that can be used to explore the organization of the developing bilingual language system in childhood. Acknowledgements: This work was supported by a research fellowship from the Alexander von Humboldt foundation, by the DFG (WA2155) and by an NIH research grant (R21HD059103-02).

27. 4:45 p.m. - 5:45 p.m.
Electrophysiological correlates of form and semantic interference during translation recognition in bilinguals with varying degrees of second language proficiency

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Past studies have investigated how lexical access changes as a result of proficiency level in a second language (L2), but there is little evidence across studies for a consistent developmental trajectory. Early research suggested that, to activate the meaning of L2 words, less proficient learners rely on lexical links with translation equivalents in their first language (L1), but more proficient learners access concepts more directly from L2 words (e.g., Kroll & Stewart, 1994). Using a translation-recognition task in which participants determined whether two words were translations of each other, Talamas et al. (1999) found that relatively skilled English-Spanish bilinguals were more sensitive to interference from L1 distractors related in meaning than in form to the L2 words, whereas the opposite was true for less skilled learners. For example, more skilled Spanish learners were slower and less accurate to reject incorrect pairs such as ìpechoî ñ ìribî (semantically related to the correct translation, ìchestî) than pairs such as ìpechoî ñ ìchessî (related in form to the correct translation), while less skilled participants showed greater interference for the form-related distractors. More recently Sunderman and Kroll (2006) reported form interference only for less proficient L2 learners while semantic interference was seen in both less and more proficient groups. However, Guasch et al. (2008) found form interference regardless of proficiency, but no semantic interference for beginning L2 learners. The current study takes another look at the effects of proficiency on L2 lexical access by examining the performance of two groups of English-Spanish bilinguals in a translation recognition task. We exploited the sensitivity of comparing event-related potentials (ERPs) and behavioral measures to evaluate the time-course of activation of lexical and conceptual information. Both form and semantic interference were observed on behavioral and ERP measures, regardless of proficiency level. Slowed reaction times and decreased accuracy were found for both distractor types, as compared to matched control trials,

and semantic interference was more robust than form interference for both groups. ERP results confirmed that both semantic and lexical information were active across groups. Semantic distractors produced an N400 effect in both groups, with related pairs producing smaller N400s on the target words than matched controls. There was also a prolonged positive shift for the semantic distractors in the less proficient group at anterior sites. For the form distractors there was no N400 effect in the less proficient group but an enhanced frontal N400 in the more proficient group, consistent with an inhibitory process affecting lexical competitors of the translation. Form distractors also resulted in a positive peak around 550 milliseconds for both groups, although the effect was much larger for the less proficient group. Results suggest that both lexical and conceptual information are active regardless of a bilingualís proficiency level in this task. However, the ERP results suggest that the locus of interference may shift during L2 development, such that less proficient learners may consider the distractors as potential translations, while more proficient learners may find it difficult to activate and process competitors because they have inhibited them.

28. 6:00 p.m. - 7:00 p.m.
Bilateral posterior activity is modulated by proficiency in the bilingual brain
Leonard, M.K. (1), Torres, C. (2), Travis, K.E. (3) Brown, T.T. (3), Hagler, D.J. (2), Dale, A.M. (2,3), Elman, J.L. (1), and Halgren, E. (2,3). 1. University of California, San Diego, Department of Cognitive Science, La Jolla, CA, USA. 2. University of California, San Diego, Department of Radiology, La Jolla, CA, USA. 3. University of California, San Diego, Department of Neurosciences, La Jolla, CA, USA
Background: In a previous study, we used magnetoencephalography (MEG) constrained with magnetic resonance imaging (MRI) to study the organization of the first (L1) and second (L2) languages within the brains of bilinguals. We found that, compared to L1, L2 words evoke greater activity in right hemisphere and bilateral posterior visual areas as early as ~135 ms, and that this activity persists through lexico-semantic processing at ~400 ms (Leonard et al., 2010). However, although these subjects began learning L2 at around 6 years old, they remained more proficient in L1, and it was unclear whether proficiency or order of acquisition determined the extent of bilateral posterior activity. Additionally, the occipito-temporal location of the activity to L2 words could be related to the fact that words were presented in a written form. Methods: MEG was recorded in 16 Spanish-English bilinguals while they either read or listened to single words and performed a size judgment task ("Does this object fit into a shoebox?"). The subjects were all dominant in English, which they began acquiring around age 6. Anatomical MRI scans were acquired and used to constrain the MEG inverse solution to the cortical surface. Results: In the visual modality, the results were similar to the previous study, in that written words in the less proficient language evoked greater activity in bilateral posterior areas ~400 ms after a word was shown. Areas that showed this less proficient > more proficient pattern included lateral and ventral occipito-temporal (LOT and VOT) cortex, which are secondary visual regions involved in object processing. For auditory words, a similar pattern was observed as in the visual modality. Conclusions: In contrast to the previous study where the less proficient language was L2, the subjects in this study were less proficient in their native language, Spanish. The finding of greater bilateral posterior activity in the less proficient language suggests that relative language proficiency plays a dominant role in determining the amount of bilateral posterior activity that is evoked during word processing. This activity is not due to persistent sensory processing, as it is also observed when subjects hear words. The recruitment of these areas might reflect a neural processing strategy in which right hemisphere and non-classical language areas are used when the task is more difficult, and activity in visual areas such as LOT and VOT could suggest a more perceptually-grounded lexico-semantic system in the less proficient language.

29. 4:45 p.m. - 5:45 p.m.
Learning "Alienese": How do we pick up new grammatical structures?
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How little exposure is required to learn a new language, including syntax and vocabulary, without explicit instruction on the syntactic structures in this language? We used a syntactic priming paradigm to find early evidence of such learning. We constructed a miniature language, "Alienese", with a new vocabulary of words of two to three syllables with a consonant-vowel-consonant structure. The grammar of Alienese was made up of three transitive (verb-object-subject, object-subject-verb, subject-verb-object) and one intransitive word-order (subject-verb). Subject-verb-object and subject-verb are existing word-orders in Dutch, while verb-object-subject and object-subject-verb were novel to the participants. Day 1 of the experiment consisted of vocabulary training on the words for woman, man, boy, girl; the 4 possible actors in the pictures. On day 2 participants started reading Alienese transitive and intransitive sentences. The meaning of the verbs and the sentence structures could be extrapolated from accompanying photographs depicting the transitive and intransitive actions. One of the novel transitive word-orders was more frequent than the other transitive word orders: 60% vs 20 %. On day 3 the participants again read Alienese sentences with an underlying syntactic priming paradigm. Participants first read a prime sentence, followed by a corresponding picture describing the relevant

action. Next, a second sentence was presented with the same (primed) or different (unprimed) structure, followed by two pictures with reversed roles (e.g., a man kissing a woman versus a woman kissing a man). Participants had to choose the picture that matched the sentence, which required that they had learned the three transitive word-orders. After this session they could correctly translate 45% (range: 13 to 96 %) of the 46 Alienese verbs into their native language. Moreover, participants were significantly better at choosing the correct picture after syntactic structure repetition (primed: 89%, unprimed: 81%). Between the novel structures this effect was stronger for the infrequent word order (improvement after syntactic repetition: 14%) than for the frequent one (improvement: 4%). Thus, participants were able to learn two new word-orders after only 2 hours of exposure. Moreover, they showed good extrapolation of vocabulary from the sentence-picture presentation paradigm. Priming improved sentence-picture matching performance for both the novel and existing word-orders. Furthermore, the infrequent word-order was primed more strongly indicating that syntactic priming might be a mechanism for learning novel and especially infrequent sentence structures as proposed by the implicit learning theory of syntactic priming (Ferreira & Bock, 2006). In the fMRI experiment, we will investigate the learning process on day 2 within the first hour of reading Alienese sentences. The hypothesis is that already at this early stage repetition of syntactic structure will lead to priming effects that manifest themselves as repetition effects in the brain, indicating a role of syntactic priming in language learning right from the start. Ferreira, V., & Bock, K. (2006). The functions of structural priming. Language and Cognitive Processes, 21, 1011-1029.

30. 6:00 p.m. - 7:00 p.m.

Language effects in second language learners: A longitudinal study using event-related potentials

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Are the mechanisms involved in word recognition in early L2 learners different from those of more proficient L2 users and how do these mechanisms evolve during learning? Midgley et al. (2009) found evidence of amplitude differences in the N400 component to L1 as compared to L2 items in advanced learners of a second language and McLaughlin et al. (2004) found evidence for very rapid change in the N400 component elicited by L2 items in learners who were in the very early stages of L2 acquisition. Based on these findings our study sought to identify and closely track language effects in beginning learners of an L2. Event-related potentials (ERPs) were recorded to L1 and L2 items to investigate the changes over time of L2 processing in beginning learners. Twelve monolingual L1 English-speakers enrolled in introductory Spanish at Tufts University were first trained on a list of 228 Spanish words and their English translations. These critical items were chosen from the vocabulary to be learned in their Spanish class over the course of the semester. Behavioral data from this training session and from the following experimental sessions showed expected learning effects. In three experimental ERP sessions conducted at intervals throughout the semester participants performed a go/no-go lexical decision task to blocked and mixed lists of L1 and L2 items. Replicating Midgley et al., our results showed overall larger negativities in the N400 epoch to L1 items than to L2 items. The differences varied significantly across sessions in that amplitudes in the traditional N400 epoch to L2 items became more negative over the course of the semester. (See attached figure; caption - ERPs from central posterior electrode site, Pz, to L1 items and L2 items by session.) This pattern was similar for both list types. We propose that the increase in N400 amplitude to L2 items is the result of increased L2 orthographic and semantic connectivity in the mental lexicon due to L2 learning. This study provides the first evidence of a language effect in the N400 component in the earliest stage of L2 acquisition. Our results also suggest that this language effect evolves quickly as a result of increasing L2 proficiency. In addition to the few existing studies that have investigated L2 learning, the findings from the current study suggest that while learning a second language as an adult may seem difficult and slow, the language system's plasticity allows for a quite rapid integration of a second language into the mental lexicon. Midgley, K. J., Holcomb, P. J., & Grainger, J. (2009). Language effects in second language learners and proficient bilinguals investigated with event-related potentials. Journal of Neurolinguistics, 22(3), 281-300. McLaughlin, J., Osterhout, L., & Kim, A. (2004). Neural correlates of second-language word learning: minimal instruction produces rapid change. Nature Neuroscience, 7(7), 703-704.

31. 4:45 p.m. - 5:45 p.m.

Progressive aphasia in Chinese speakers: clinical and neuroradiological findings

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Objective. Identifying the specific cause of dementia is increasingly important as effective, disease-specific treatments become available. For example, clinicians need a method to accurately differentiate frontotemporal dementia (FTD) from dementia of the Alzheimer's type (DAT). The first symptom of DAT is typically memory loss, while the hallmarks of FTD are behaviour and language disturbance. However, both disorders cause an insidious, gradually progressive de-

mentia that lacks distinctive physical signs, and patients with FTD frequently meet diagnostic criteria for AD. It is not surprising therefore that FTD is frequently misdiagnosed. Neuroimaging studies show characteristic differences of grey matter abnormalities in FTD and DAT. In FTD, MRI studies report regional patterns of grey matter atrophy in primarily frontal lobe regions (see Figure 1), similar to the regional patterns of functional changes measured by reduced cerebral blood flow and glucose metabolism from SPECT and PET studies. By comparison, brain atrophy in DAT is initially observed in medial temporal lobe regions, whereas functional changes are more prominent in the parietal lobe (including posterior cingulate gyrus and lateral parietotemporal areas). The frontal lobe regions are generally spared in DAT until late stages. New MRI findings have also shown a different regional distribution of white matter loss in DAT and fMRI. One means of distinguishing FTD and DAT is via assessment of aphasia. Primary progressive aphasia (PPA) is a language disorder characterised by a gradual and isolated deterioration of language function. All patients with PPA display word retrieval impairments (anomia) in the early stages of the illness. However, there are at least two distinct variants of PPA labelled fluent and non-fluent. In the fluent variety, speech production is largely preserved whereas comprehension and semantic memory are impaired. In non-fluent aphasia (NFA), speech is characterised by agrammatic output with speech comprehension, with semantic memory and also episodic memory intact. Progressive aphasia has been reported in several languages including English, French, German, Italian, Japanese, Portuguese, Spanish and Turkish. The pattern of language deterioration in fluent and non-fluent cases is remarkably similar across different languages despite differences in grammatical features. Here we report a study of Chinese speaking patients with dementia investigating the hypothesis that progressive aphasia distinguishes between FTD and DAT. Methods. Patients were recruited from Queen Mary Hospital, Hong Kong and classified using a Cantonese version of the Mini-Mental State Examination. All patients were diagnosed based upon information obtained from clinical history and physical examination. The MR images were used to rule out other major neuropathologies. Imaging was performed on a 3 Tesla (Phillips) MRI system. An experienced radiologist reviewed the severity of white matter signal hyperintensities (WMSH) on MRI. Results. The main findings were: (i) FTD is associated with nonfluent and fluent aphasia, (ii) DAT is associated with memory disorder, (iii) FTD is associated with more extensive brain degradation than DAT. Conclusions. The regional brain alterations suggest that FTD and DAT are each associated with a characteristic distribution of clinical and neuropathological degradation. Brain imaging provides additional diagnostic information to distinguish DAT from FTD in Chinese speakers.

32. 6:00 p.m. - 7:00 p.m.

Phonological representations in bilingual word recognition: Evidence from ERP's

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The aim of this study was to investigate whether phonological representations from both the first (L1) and second (L2) languages of bilinguals are activated during silent reading in the second language specific context. Studies involving interlingual-homophones have suggested that bilinguals activate phonological representations of both languages during L2 word recognition (Dijkstra, Grainger & Van Van Heuven, 1999; Haigh and Jared, 2007; Lemhofer and Dijkstra, 2004). However, the data from these behavioral studies is inconsistent with respect to the role of phonological overlap across languages, i.e. whether it facilitates or inhibits word recognition. Herein, we used ERPs as a means to complement existing behavioral data and help resolve these contradictory results regarding the activation of phonological representations in bilinguals during silent reading. Monolingual English speakers and French-English speakers performed a semantic categorization task while reading silently in English. The critical items were interlingual homophones (e.g., pool in English which has substantial phonological overlap with the French word "poule", meaning "chicken") and control words matched for frequency, length and orthographic overlap. Results showed a reduction in N400 amplitude in response to interlingual homophones in comparison to control words for bilingual speakers but not for English monolinguals who showed no variation in the N400 amplitude as a function of homophone status. The reduced N400 response to homophones specifically for the bilinguals suggests facilitation rather than inhibition of word recognition. Overall, these results suggest parallel activation of both L1 and L2 phonological representations when reading silently in L2. These findings point to a nonspecific language model for bilinguals at the phonological level of representation. In addition, the finding of parallel activation of L1 and L2 phonological representations in bilinguals provides further support to the theories of phonological mediation in visual word recognition, which can be generalized to bilingual word processing.

33. 4:45 p.m. - 5:45 p.m.

ERP evidence of reduced automatic differentiation of words and consonant strings in English-Welsh bilinguals

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As part of a group of event-related potential (ERP) studies considering the influence of language transparency on the simultaneous processing of letter strings, this task builds on an orthographic task (Lallier et al, in preparation) which

provided evidence of a delayed distinction between ERPs generated for English words and consonant strings by early English-Welsh bilinguals (EWBs) compared to English monolinguals (EMs). This study adapted the task from letter decision (deciding whether a target letter had been previously presented within a rapidly presented five-letter word or letter string), to colour monitoring (deciding whether a coloured letter in one presentation of the word or consonant string was the same colour in a second presentation following a mask), to investigate whether the delay between groups in ERP separation of words and consonant strings remained when the task did not require whole string processing and the task was orthographically irrelevant. Behaviourally, word stimuli elicited significantly faster correct colour responses and EWBs were found to perform significantly slower overall. In the ERP waves, as in the previous study, a split was observed between word and consonant string ERPs at posterior electrodes, shortly after the N1 peak. For comparison with the letter task, t-tests were performed every millisecond from 220 ms (prime offset; N1 time window) to 280 ms (target onset) to determine the latencies at which the ERPs for word and consonant string primes begun to significantly differ. Unlike the comparison letter task, the onsets of the orthographic split between the groups were not significantly different, onsetting on average at 223 ms for monolinguals and 234 ms for bilinguals. However, mean amplitude analyses also performed over the same window revealed, in addition to an expected main effect of stimulus showing greater amplitudes to consonant strings compared to words, a further significant interaction of stimulus with group. Planned comparisons showed that this interaction related to a significantly smaller difference in amplitude between words and consonant strings in the bilingual group, in the absence of a group main effect. Interestingly, this difference may have been driven by the split differences being only marginally significant over the right hemisphere for the EWBs, whilst they reached high significance ($p < .01$) over the left and bilaterally for the EMs. Despite the minimal orthographic processing demands in the present task, bilinguals were slower at responding to colour targets than monolinguals, whereas their reaction times were unaffected in a nonverbal auditory task (cf Lallier et al, in prep). In line with previous studies showing an overall slowness of bilingual individuals when processing lexical/orthographic stimuli, the present results suggest that a greater asymmetry in the N1 range (see Grossi et al, in press) might affect the automatic global processing of visual strings in bilinguals, resulting in their overall reduced orthographic sensitivity as compared to monolinguals.

34. 6:00 p.m. - 7:00 p.m.

Knowledge of a second language influences auditory word recognition in the native language, both without and in sentence context

Duyck, W., Lagrou, E., and Hartsuiker, R.J. Ghent University, Belgium.

Many studies in bilingual visual word recognition have demonstrated that lexical access is not language selective. However, research on bilingual word recognition in the auditory modality has been scarce, and yielded mixed results with regard to the degree of this language nonselectivity. In the present study, we investigated whether listening to a second language (L2) is influenced by knowledge of the native language (L1) and, more importantly, whether listening to the L1 is also influenced by knowledge of a L2. Additionally, we investigated whether the listenerís selectivity of lexical access is influenced by the speakerís L1 (and thus his/her accent). With this aim, Dutch-English bilinguals completed an English (Experiment 1) and a Dutch (Experiment 3) auditory lexical decision task. As a control, the English auditory lexical decision task was also completed by English monolinguals (Experiment 2). Targets were pronounced by a native Dutch speaker with English as the L2 (Experiment 1A, 2A and 3A) or by a native English speaker with Dutch as the L2 (Experiment 1B, 2B and 3B). In Experiments 4 and 5, targets were embedded in high- and low-constraint sentences (i.e. sentences in which the target is highly predictable, or not). In all experiments, Dutch-English bilinguals recognized interlingual homophones (e.g., lief (sweet) ñ leaf /li:f/) significantly slower than matched control words, whereas the English monolinguals showed no effect. These results indicate that (a) lexical access in bilingual auditory word recognition is not language selective in L2, nor in L1, (b) language-specific phonological cues do not annul cross-lingual interactions and (c) linguistic and semantic context provided by sentences does not make lexical search language-selective either. Results are discussed in relation to theories of bilingual word recognition.

35. 4:45 p.m. - 5:45 p.m.

Discrimination of English coronal vs. non-coronal consonants by native speakers of English with childhood exposure to additional languages

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The present study attempts to determine if individuals with childhood exposure to additional languages significantly differ in representation and processing of abstract information about English speech sounds from those without, so as to be classified as a separate population. Previous studies on English and German monolinguals seem to provide evidence for a theory of underspecification, demonstrating that coronal consonants (/n/ and /d/) have an abstract, underspecified place of articulation, whereas non-coronal consonants (/m/ and /b/) have a specified place of articulation. In English, [d] and [n] are pronounced by pressing the tip of the tongue (i.e. coronal) against the back of the gums (i.e.,

alveolar). However, this place of articulation may differ for other languages. For example, Spanish [d] is pronounced towards the back of the teeth (i.e., dental) with the tip of the tongue. In addition, languages such as Spanish have contrast amongst coronal places of articulation (e.g., n in mundo is dental, wheres n in lancha is alveolar), whereas in English there is none. Previous bilingual research has shown these differences have developmental consequences, providing evidence that early learners of a second language tend to broaden and simplify similar speech sounds in the two languages.2 This simplification results in merged categories, which tend to be resolved as the learners progress in both languages. To determine if these merged categories are still prevalent and affecting those exposed to unattained languages, we compared English monolinguals with and without childhood exposure to additional languages. Method: Thirty-seven participants were asked to complete an auditory lexical decision task. Among them, 18 were exposed to additional languages as children. Target consonants were manipulated for lexicality (real vs. pseudowords) and crossed by coronal, nasal (/n/, /m/ vs. /d/, /b/), and geminate (nn, mm, bb, dd vs. singleton n, m, b, d) factors. By such a manipulation, picnic becomes picmic, and helmet becomes helnet. Reaction times and number of errors were measured; only reaction times with correct decisions were analyzed. Results and Discussion: A time-step analysis was performed for the reaction times of participants with an accuracy rate at 85% or higher. A lexicality x coronality interaction was significant for both groups, which suggests that the theory of underspecification will hold for both groups. Similarly, a main effect of nasality became significant for both groups. However, the exposure group obtained significance at an earlier time-step than the non-exposure group. These results suggest that those with childhood exposure to additional languages might be more attentive to nasal coronals than their non-exposure counterparts. Traces of the characteristics of the merged categories may still exist, producing an ìexpertise effectî. Therefore, childhood exposure to additional languages may aid in faster processing of phonemes if the exposed language adds emphasis to a particular phoneme. References: 1. Friedrich, C.K., Eulitz, C., & Lahiri, A. (2006). Not every pseudoword disrupts word recognition: and ERP study. Behavioral and Brain Functions, 2, 36. 2. Sundara, M. & Polka, L. (2008). Discrimination of coronal stops by bilingual adults: the timing and nature of language interaction. Cognition, 106, 234-258.

36. 6:00 p.m. - 7:00 p.m.

Lexical competition in a spoken sentence context

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In this study the visual world paradigm was used to examine lexical competition in auditory word recognition. More specifically, we investigated the effect of a low constraining sentence context on parallel language activation when listening in a second language (L2), but more importantly also when listening in the native language (L1). With this aim, eye movements were recorded while Dutch-English bilinguals listened to low constraining sentences in L2 (Experiment 1; e.g., ìThat man finally got a flower, and thatís why he is happyî) or in L1 (Experiment 2; e.g., ìDie man kreeg eindelijk een fles (bottle), en was daarom gelukkigî). The results demonstrated that (a) participants fixated more on competitor pictures with Dutch names (e.g., fles (bottle)) phonologically related to English target names (e.g., flower) than on phonologically unrelated distractor pictures and (b) participants fixated more on competitor pictures with English names (e.g., flower) phonologically related to Dutch target names (e.g., fles (bottle)) than on phonologically unrelated distractor items. However, this effect was only observed when the phonologically related onset of the competitor picture was pronounced identical to the phonologically related onset of the target picture. Together, this study provides evidence for lexical competition in a spoken sentence context when listening in L2 and in L1, but highlights the importance of subtle phonological cues.

37. 4:45 p.m. - 5:45 p.m.

Does the specific acoustic structure of a language shape auditory attention underlying speech perception? Behavioural and ERP evidence in Welsh-English bilinguals

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During speech acquisition, specific acoustic features act as cues in order to segment and access the lexical forms embedded in speech streams. Therefore, the speed at which temporal auditory attentional focus engages and disengages may adapt, depending on the acoustic cues present in the oral structure of the language acquired. The auditory stream segregation threshold is a measure of the shortest stimulus onset asynchrony (SOA) for which automatic attention can disengage and reengage between two successive stimuli of different frequency. This measure could index the temporal attention abilities underlying speech perception (Lallier et al., 2009; Lallier et al., under review), and therefore may differ between speakers of different languages. The aim of the present study was to show that early bilinguals show different auditory attentional shifting speed compared to monolinguals. In Experiment 1, we showed that 12 Welsh-English bilingual adults started to perceive two distinct segregated high- and low-pitch streams (instead of one-stream composed of high- and low-pitched sounds) at significantly slower SOAs (segregation threshold = 146 ms) than 12 English monolingual adults (segregation threshold = 110 ms) matched for age, non verbal IQ, and vocabulary skills. In Experiment 2, auditory attentional shifting skills of 14 Welsh-English bilinguals and 14 English monolinguals were monitored through an

oddball paradigm. The oddball task consisted of continuous auditory streams, composed of the same tones as Experiment 1, and the response required was the detection of variation in the speed of the alternation of the stimuli (i.e. the oddball). Three SOAs were chosen based upon Experiment 1: standard SOA = 360 ms, one-stream perceived in both groups; fast deviant SOA = 60 ms, two-streams perceived in both groups; ambiguous deviant SOA = 120 ms, one-stream perceived in monolinguals, two-streams perceived in bilinguals. In bilinguals, both fast and ambiguous deviants were expected to elicit large P3 because of salient perceptual changes from one- to two-streams. In monolinguals however, ambiguous deviants were expected to elicit smaller P3 because of absence of change in the stream pattern perceived (i.e. one- to one-stream) as compared to fast deviants (i.e. one- to two-streams). Analysis on P3 mean amplitude was conducted over centro-parietal electrodes. As expected, a significant group by deviancy interaction was found showing that P3 peaks elicited by fast deviants were larger than P3 peaks elicited by ambiguous deviants for monolinguals only. The present study demonstrates that Welsh-English bilinguals perceive auditory stimulus sequences differently than English monolinguals, which is further likely to result from different auditory attentional shifting speeds between groups. We argue that this may relate to variations in the rhythmic structure between Welsh and English (e.g., stress and syllable lengthening). These results suggest that the perceptual and attentional mechanisms employed during auditory scene analysis are influenced depending on the language acquired. Therefore, auditory processing disorders may vary across languages, and specific linguistic structures should be taken into account for oral language impairmentsí diagnostic and remediation.

38. 6:00 p.m. - 7:00 p.m.

The neurophysiological indices of Mandarin lexical tone processing: Cross-language comparison

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Lexical tone is a common phonological property used to distinguish words in many languages of the world. Despite this, the neural mechanisms that underlie lexical tone processing are understudied (Chandrasekaran, Gandour and Krishnan, 2007; Kaan, et al., 2008). The major objectives of the current study is to replicate Chandrasekaran and colleague's (2007) study using naturally-produced bisyllabic speech to explore the influence of language experience and stimulus salience on the cortical responses to lexical tone contrasts. Two language groups, native Mandarin speakers and monolingual English speakers, were tested. The stimuli consisted of 60 naturally-produced tokens of disyllabic nonwords with three types of Mandarin tones (tone 1/high-level, tone 2/ rising tone and tone 3/ dipping tone) embedded in the first syllables, presented in an oddball paradigm (tone 1 versus tone 2, tone 2 versus tone 3, and tone 3 versus tone 1). Event-related potential responses (ERPs) were collected using 65-channel electroencephalogram caps. Preliminary results showed that all three tone contrasts yielded the ERP discriminative component, mismatch negativity (MMN), both for native Mandarin speakers and monolingual English participants. The two language groups differed most in terms of the following P3a responses, which indicated orienting to the contrast difference. The result will be discussed in terms of the Automatic Selective Perception model (Strange & Shafer, 2008).

39. 4:45 p.m. - 5:45 p.m.

Learning to produce non-native speech sounds: An fMRI training study

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Oral motor movements necessary for producing native speech sounds are highly over-learned and automatic. In contrast, those necessary for non-native phonemes are unfamiliar and require greater engagement of sensorimotor neural feedback systems. Our previous work has shown that regions involved in integrating motor feedforward signals with sensory feedback are more active during non-native speech production than native. This study used a prospective training fMRI paradigm to explore the functional importance of this increased sensorimotor activation for producing non-native speech sounds. Subjects were monolingual native speakers of English and were scanned both before and after a week of training in producing these non-native phonemes. These novel sounds varied systematically in place of articulation and in difficulty to produce for native-English speakers. Familiarity with non-native speech sounds led to reductions in activation within the network of regions involved in the motor feedforward and sensory feedback production of speech. The data presented here suggest that plasticity of the cortex in sensorimotor speech regions arises as an early response to familiarization with a non-native language. Further, the results emphasize the important, and overlooked, role of sensorimotor control in acquiring a new language.

40. 6:00 p.m. - 7:00 p.m.

The neural signatures of switching language and switching task

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Selecting among competing linguistic responses recruits a set of neural regions, among them left frontal cortex and anterior cingulate cortex (ACC). Recent findings suggested that the left ACC is especially engaged in a multilingual naming context compared to a single-language, multi-task context, perhaps indicating its role in preventing interference between two languages (Abutalebi et al, 2008). A multilingual context might engage various control processes, including both global monitoring and trial-by-trial selection of an output language. The present study aimed to identify the neural areas specifically engaged by trial-by-trial selection of a language—ie., those that are facilitated when using the same language in succession. Another question was whether the regions engaged by switching languages are the same or different from those used to switch task sets more generally. We employed a unique event-related approach, in which language and task switching trials were embedded in a single context. Two types of task blocks were designed. In the semantic block, participants were presented on each trial with a picture of two objects, and alternated between verbally judging size (small/large) or animacy (living/non-living). Participants were cued to switch between responding in L1 and L2. In the relational block, they alternated between position (above/below) and proximity (near/far) judgments for the same objects. Relational judgments are thought to rely more on knowledge specific to a particular language than do semantic judgments, and tend to incur greater language switching costs (Duncan et al., 2010). Critically, task and language response sets across both blocks had an equal number of response options. Study 1 measured switch costs behaviourally (RT) in highly proficient English-French bilinguals (n=15, average age of exposure (AOE) 4.0 years). Response latencies were longer for trials where language changed than when it stayed the same, indicating a language switch cost. Trials when task switched also incurred an independent cost. During the semantic block, participants experienced a greater language switch cost than a task switch cost. For the relational tasks, the pattern reversed: there was a greater task switch cost than language switch cost, consistent with past findings (Duncan et al., 2010). Thus, language and task switch costs were behaviourally dissociable across blocks, and could be independently measured within blocks. Study 2 implemented this design in an event-related functional magnetic resonance imaging (fMRI) experiment to identify neural regions specifically involved in task and language selection. A separate group of highly proficient, English-French bilinguals (n = 11, average AOE 4.0 years) participated. fMRI findings isolated the ACC as an important neural locus for selection processes, among other previously reported control areas (middle frontal gyrus, superior parietal lobule). These regions were more active on trials where language switched than when it was repeated, and when task switched more than when it repeated. These regions were equally involved during relational and semantic judgment tasks, despite the tasks' opposite behavioural demands on language and task switching. Taken together, these results suggest that, among other regions, the ACC is engaged both in language and task selection processes, and furthermore, that language selection shares neural resources with more general task selection processes. Abutalebi, J., Annoni, J., Zimine, I., Pegna, A. J., Seghier, M. L., Lee-Jahnke, H., et al. (2008). Cerebral cortex, 18(7), 1496-505. Duncan, H.D., Karpowicz, L., Segalowitz, N., Phillips, N.A. (2010). Behaviour and Cognitive Science 2010 Annual Meeting, June 11-13th, 2010, Halifax, NS.

41. 4:45 p.m. - 5:45 p.m.

Proficiency and transfer effects in L1-L2 nominal morphology: ERP evidence from French and Mandarin learners of English

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Objectives: The goal of the present study was to advance our understanding of how (i) possible transfer effects [2] between convergent vs. divergent properties in first (L1) and second language (L2) grammars [3] as well as (ii) differences in L2-proficiency level might influence on-line sentence processing of L2. We used ERPs to probe the processing of Nominal Morphology (NM; [7,8]), i.e., articles and their interaction with plural/singular markers. Some languages, such as English and French, make use of this information ñ with variations in the phonological marking of nouns (i.e. plural forms are often unmarked in French). In contrast, languages which are devoid of NM (e.g., Mandarin [4]) raise the still controversial issue of whether the absence of such features in the L1 favors native-like processing of the L2 [1] or not [5]. Further, though some neurophysiological evidence has pointed to distinct processing mechanisms in L1 and late acquired L2, it has also been suggested that reliance on L1-like mechanisms in L2 learners increases with L2 proficiency [6]. However, the precise ways in which proficiency and L1 transfer interact and modulate brain responses are still to be understood.Methods and Predictions: Data from native French speaking (French-L1 group, N=20) and Mandarin speaking (Mandarin-L1, N=18) late-learners of English were compared to those of native English controls (English-L1, N=17) in an English sentence reading/judgment ERP study. Target sentences contained noun phrases (NPs) involving

mismatching plural morphology and singular indefinite articles (e.g. ìThey paved a road/a *roads in the summerî). Whereas we expected this morphological deviance in English to elicit a morphosyntactic response in native speakers (LAN/P600), the same mismatch was likely to be detected differently in Mandarin and/or French speakers, with possible variations in brain responses related to differences in L1-background, age of acquisition (AoA) and L2-proficiency measures (Cloze-test and error rates in behavioural tasks).Results and Discussion: As predicted for the natives, the mismatching target nouns (ìa *roadsî) elicited a significant left anterior negativity (LAN, 350-450 ms), followed by a P600 (Figs_1A/2A). In contrast, an N400/P600 pattern and a subsequent anterior negativity were visible in both French and Mandarin participants (B/C in Figs_1+2). Though the late negativity in these populations is a new finding, and not easily explainable, the N400/L2 versus LAN/L1 difference is consistent with a lexical/declarative versus a grammatical/procedural basis for this type of morpho-syntax in L2 versus L1 [6]. Interestingly, irrespective of L1 background, the P600 amplitude in L2 learners was found to significantly correlate with proficiency level (Fig_3), and more so for structure-specific measures (error rates) than for general L2 proficiency (cloze-test). Our results do not provide clear support for either positive or negative L1-background/transfer effects (French vs. Mandarin). In contrast, L2 proficiency level was found to significantly modulate P600 amplitude, in line with models predicting that L2 neurocognition is better described in terms of a proficiency-dependent continuum than by a categorical (AoA-dependent) L1 vs. L2 distinction [6]. Overall, the present results emphasize the role of structure-specific proficiency in shaping L2 learnersí native-like processing of their second language.

Perception

42. 6:00 p.m. - 7:00 p.m.

Neural correlates of interaural temporal integration in duplex speech perception

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Duplex speech perception refers to the simultaneous perception of an auditory event as a speech sound and a non-speech chirp. In this fMRI study, the neural mechanisms of complex auditory object formation were investigated using a stimulus onset asynchrony (SOA) manipulation to induce duplex speech perception. In this paradigm, syllable identification is dependent on interaural temporal integration, whereas chirp identification is dependent on the processing of monaural local spectral properties. The SOA between the spectral transition portion of syllables containing the distinctive cue for syllable identification (the chirp, presented to one ear) and the remaining syllable structure (the base, presented to the other ear) was varied between 0 and 80 ms in 4 steps. In two tasks, participants (n=24) were asked to identify the chirp (rising, falling) or the syllable (ba, ga). Identification was superior in the duplex chirp task compared to the duplex syllable task in each SOA. Duplex chirp identification remained constant across SOAs. In contrast, identification of the duplex syllable declined with SOA and was lower in SOAs 40 and 80 compared to 0 and 20 ms, reflecting its dependence on temporal integration. FMRI activation for duplex chirp compared to duplex syllable identification was stronger in the supramarginal gyrus, bilaterally, consistent with prior reports suggesting a role for this region in increased attention to local properties of objects. Activation in the superior temporal gyrus (STG), bilaterally, increased proportionally to SOA for duplex syllable identification, implicating this region in temporal integration of auditory information. Comparison of duplex syllables at SOA 0 ms with natural speech syllable identification revealed stronger activation in a network of regions including the left planum temporale. This region may be part of a neural network involved in interaural integration. The results shed new light on the function of temporal and parietal cortex regions in the formation of perceptually coherent auditory objects including speech syllables.

43. 4:45 p.m. - 5:45 p.m.

Is Broca's area essential in speech perception: evidence from an ERP study of dichotic listening of Mandarin lexical tones and stop consonants

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Whether Brocaís area plays an essential role in speech perception was heatedly debated in the last yearís conference on neurobiology of language. Bearing this question in mind, I reanalyze my previous ERP experiment that examined the perception of tones and consonants under the dichotic listening paradigm, and find that the anterior/posterior factor interacts significantly with the consonant/tone conditions, which brings about the hypothesis that perceiving tones requires more effort from Brocaís area than perceiving consonants. The evidence used to argue against the role of Brocaís area in speech perception is that Brocaís aphasics preserve the categorical perception (CP) of consonants. However, since this CP exists in both newborn infants and other primates, it is more like to be an innate general auditory processing of different acoustic features (e.g. rapid changing temporal cues in speech formant transitions), rather than the CP of an ëacquiredí linguistic phonological category. And that Brocaís aphasics preserve the CP does not nullify an

essential role in perceiving the acquired phoneme categories. For tone perception, which is non-categorical in nature, the phoneme categories are established along with tone language experience. Therefore, the CP of lexical tones is more than a general auditory processing, and it may require more efforts in the frontal brain regions, especially Brocaís area. In the current experiment, 32 native Mandarin listeners participate in the dichotic listening task. They are all right-handed persons with normal and balanced hearing levels in their two ears. They are asked to identify both the consonant and tone in the post-assigned side after they hear two syllables simultaneously and respectively in their two ears. The two syllables in a dichotic trial differ only in tone or consonant. Both the behavioral and ERP results show a greater left lateralization for consonants than tones, consistent with the previous literature. In addition, the N1 amplitude in the frontal/parietal electrodes (Fz and Pz) interacts with the consonant/tone conditions ($F(1,31) = 19.881$, $p < .001$). In the post-hoc t-test, the amplitude in the consonant condition is more negative than that of the tone condition at Fz ($t(31) = -2.41$, $p < .022$), and less negative than the tone condition at Pz ($t(31) = 3.28$, $p < .003$). In order to localize the source of the ERP waves, I use sLORETA for the analysis with 69 electrodes in the 10-10 system at 50-150 ms after the stimulus onset. The result indicates that comparing to the consonant condition, in the tone condition there is a significantly stronger activity in the frontal cortex including Brocaís area (BA44 and BA45), even though the sources of these two conditions are similar. This result supports the hypothesis that Brocaís area is more important for acquired phoneme categories than for natural phoneme categories. As for vowels, which are also non-categorical in nature, further experiments are needed.

44. 6:00 p.m. - 7:00 p.m.

Phonetic categories influence auditory feedback control of speech

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Auditory feedback enables the online control of speech, allowing the speaker to monitor speech output and make adjustments when it fails to match what was intended. This feedback-based control may occur at a relatively low level, without the influence of experience-dependent perceptual categories, or it may occur at a higher level, after phonetic categorization takes place in the cortex. To test the hypothesis that learned phonetic categories influence feedback-based control, we used functional magnetic resonance imaging (fMRI) to measure neural responses to subjects' speech under three conditions: no auditory perturbation, perturbation across a phonetic category boundary, and perturbation within a phonetic category. During perturbed trials, participants' speech was shifted in both the first and second formant frequencies (F1 and F2) before being fed back through headphones, creating a sudden, unexpected mismatch between the vowel target and the perceived realization. The across- and within-category perturbations were of the same magnitude for a given subject, allowing a direct comparison of a phonetic change — for example, from the word "bed" to the word "bad" — and a non-linguistic auditory change — for example, from a prototypical example of "bed" to an altered version of the same word. Psychophysical results showed a compensatory shift of the first two formants during the perturbed conditions. fMRI data for seventeen subjects showed greater cortical activation in bilateral superior temporal gyrus (STg) and bilateral inferior frontal gyrus (IFg) in perturbed conditions than in the normal speech condition. Cortical activation was greater in extent for shifts that crossed a category boundary than for those that did not, even though these shifts were of the same magnitude. Furthermore, speakers' ability to oppose the perturbation was correlated with perturbation-related activation in bilateral STg and IFg. The amount of correlated activation was greater for across-category shifts than for within-category shifts. This suggests that sensitivity to phonetic changes in auditory feedback may drive the corrective response.

45. 4:45 p.m. - 5:45 p.m.

The influence of sentence context on word categorization: An fMRI investigation

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During language processing listeners integrate various sources of perceptual and contextual information (e.g. acoustic, lexical, sentence) to understand the linguistic message. Earlier research has shown that the perception of speech can be influenced by sentence level processing, especially when the speech input is ambiguous or degraded (Borsky et al., 1998). Although there has been a great deal of inquiry into the neural mechanisms involved in speech perception, much of this research has focused on how the auditory input maps onto phonetic or phonological representations. The goal of the current study is to examine the neural mechanisms recruited when there are multiple sources of information that contribute to the perception of phonetic categories and ultimately to auditory word recognition. The potential interactive effects of top-down, sentence level processing on word recognition were investigated with fMRI using a word categorization task. Stimuli included two target words, ëgoatí and ëcoatí, which differed in the voice onset time time (VOT) of the initial stop consonant. These comprised two good exemplars, one for [k] and the other for [g], and one boundary stimulus for which the phonetic identity of the initial stop consonant (and hence the word) was am-

biguous. These stimuli were appended to a sentence fragment creating three different sentence contexts (coat-biased, goat-biased, and neutral). Participants listened to the auditory presentation of the stimuli and were instructed to press a button to indicate whether they heard the word ëgoatí or ëcoatí. These conditions allowed for the examination of the perceptual shift in phonetic category structure as a function of sentence context while controlling for the absolute VOT of the stimulus. Preliminary behavioral results from 6 participants show an influence of sentence context on word identification for the boundary target stimulus with a greater proportion of ëcoatí responses for the coat-biased compared to the neutral sentence context. These effects were statistically reliable only for the coat-biased sentence context. Endpoint stimuli were not influenced by sentence context. A context (coat-biased vs. neutral) X target stimulus (endpoint-coat vs. boundary) analysis of variance on the imaging data revealed a significant interaction in the left posterior STG, demonstrating a pattern of activation that is sensitive to both the phonetic goodness of the auditory input and the sentence context. Looking first at the effects of differences in the acoustic input as a function of sentence context, the neutral sentence condition showed increased activation for the endpoint target compared to the boundary stimulus. This difference failed to emerge in the coat-biased sentence context where both endpoint and target stimulus showed the same level of activation. Turning to the effects of sentence context on the same acoustic stimulus, significant differences in the activation pattern emerged only for the boundary stimulus, with greater activation for coat-biased sentences compared to neutral sentences. Taken together, these results extend previous findings showing that the posterior STG integrates information across multiple modalities (Hikosaka, 1988) and suggest that it also integrates multiple sources of linguistic information during language processing. Research was supported by NIH RO1-DC06220 and NIH 2T3MH09118-9

46. 6:00 p.m. - 7:00 p.m.

fMRI-guided transcranial magnetic stimulation reveals that the superior temporal sulcus is a cortical locus of the McGurk effect

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A compelling example of auditory-visual multisensory integration is the McGurk effect, in which an auditory syllable is perceived very differently depending on whether it is accompanied by a visual movie of a speaker pronouncing the same syllable or a different, incongruent syllable. Anatomical and physiological studies in human and non-human primates have suggested that the superior temporal sulcus (STS) is involved in auditory-visual integration for both speech and non-speech stimuli. We hypothesized that the STS plays a critical role in the creation of the McGurk percept. Because the location of multisensory integration in the STS varies from subject to subject, the location of auditory-visual speech processing in the STS was first identified in each subject with fMRI (figure part A). Then, activity in this region of the STS was disrupted with single-pulse TMS as subjects rated their percept of McGurk and non-McGurk stimuli. TMS of the STS significantly reduced the likelihood of the McGurk percept (figure parts B and C) but did not interfere with perception of non-McGurk stimuli. TMS of the STS was only effective at disrupting the McGurk effect in a narrow temporal window from 100 ms before auditory syllable onset to 100 ms after onset (figure part D), and TMS of a control location did not influence perception of McGurk or control stimuli. These results demonstrate that the STS plays a critical role in the McGurk effect and auditory-visual integration of speech.

47. 4:45 p.m. - 5:45 p.m.

Perceiving pitch direction in syllables: Effects of native language and musical experience

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Tone languages, such as Thai and Mandarin Chinese, use pitch differences to distinguish lexical meaning. Previous behavioral and event-related potential (ERP) studies have shown that native speakers of non-tone languages such as English perceive lexical tones differently from native speakers of tone languages (e.g., Chandrasekaran et al. 2007), and are especially sensitive to the onset frequency of the syllables (e.g., Gandour and Harshman 1978; Kaan et al. 2008). Furthermore, musicians have been shown to be better at perceiving lexical tones than people without musical experience (e.g., Wong et al. 2007; Chandrasekaran et al. 2009). The aim of the present study was to see how English speakers with and without musical training compare with native speakers of Chinese in attentive as well as non-volitional perception of pitch direction in syllables, abstracting away from onset and average pitch. Stimuli were 34 tokens of the syllable [ba:], 450ms long, with either a linearly rising or falling pitch. The onset frequency differed from the offset by 10 Hz. Onset pitch of the tokens ranged from 96 to 170 Hz with steps of 4 Hz. Native speakers of Mandarin Chinese without musical training, and native speakers of American English with and without musical training (n=12 per group) were tested in (a) a behavioral same/different discrimination task, in which participants decided whether the pitch direction of a token was different from that of three preceding tokens; (2) a behavioral oddball detection task, in which participants had to detect occasional deviants with a different pitch direction; and (3) an ERP study using a passive oddball paradigm, in which participants watched a silent movie while falling deviant stimuli were presented among rising standards, and vice versa. Only tokens from the mid frequency range of the stimulus set were used as deviants, hence deviants tokens did

not differ from standard tokens in terms of average, onset or offset pitch. In the behavioral oddball detection task, the English musicians performed better [dí= 1.44] than the Chinese speakers [dí=.75; p<.05], who in turn were better than the English non-musicians [dí=.67, p<.05]. Results from the discrimination task showed numerically the same pattern and correlated strongly with the oddball scores [ρ =.79, p<.001]. No mismatch negativity (MMN) was found, suggesting that the MMN previously observed with natural lexical tones was mainly due to pitch onset differences. A late negativity was seen for the deviant versus the standard tokens for all groups. This negativity started earlier in the Chinese (440ms) than in English musicians (680ms) and non-musicians (740ms). The amplitude of the negativity was smaller the better the performance in the oddball detection task, especially for the falling stimuli [ρ= .351, p=.036], replicating findings by Kaan et al. (2008). Both musical and language background therefore affect attentive perception of pitch direction, whereas a tone language background accelerates non-volitional perception. Furthermore, the late negativity amplitude is related to behavioral performance, cutting across language and musical experience.

48. 6:00 p.m. - 7:00 p.m.

Neuroanatomy of speech perception in noisy conditions: A lesion study

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Recent imaging and transcranial stimulation studies suggest that inferior frontal regions may contribute to speech perception in degraded, difficult situations. In addition, numerous studies have demonstrated a tight link between sensory and motor speech processes. However, few studies have assessed the effects of lesions to inferior frontal regions on degraded speech perception. The present study explored this possibility by measuring speech comprehension abilities of patients with left hemisphere focal chronic lesions (n = 21) and age-matched controls. Subjects completed a psycholinguistic battery to assess their phonological, lexical, and sentence-level speech comprehension and production abilities. This battery included auditory word-to-picture matching tasks in which an auditory single word was presented alone, and in white noise 14 db above the root mean squared of the word. The task was to select which picture in a 4-item array corresponds to the word presented. The picture array contained the target, as well as a phonological, semantic, and unrelated foil picture. For purposes of group analysis, lesion patients performing at least two standard deviations below the mean control subject performance on a given task were categorized as impaired, and patients performing within one standard deviation were categorized as unimpaired. Seemingly in support of frontal regions contributing to speech perception in noisy situations, patients with impaired speech comprehension in noise had overlapping lesions in Broca's area (pars triangularis & pars opercularis), as well as posterior superior temporal gyrus (STG), and supramarginal gyrus (SMG). However, a subtraction of the regions lesioned in the unimpaired performers from the regions lesioned in these impaired performers reveals that Broca's area lesions are present in both groups, whereas the temporo-parietal lesions are predominately associated with impaired performance. Furthermore, Broca's area lesions were not associated with a greater decrease in performance between the "no noise" and "noise" conditions than that of the control subjects. Analyses of error types indicate that the rate of phonological errors is not correlated with any specific lesion pattern, but that the semantic and unrelated error rates are driving the temporo-parietal lesion pattern associated with impaired speech comprehension in noise, as well as the similar pattern correlated with a greater decline in performance between the "no noise" and "noise" conditions. These preliminary results suggest that speech comprehension in noisy conditions may engage Broca's area, but is not dependent upon Broca's area.

49. 4:45 p.m. - 5:45 p.m.

Intersubject differences in the STS account for variability in the perception of the McGurk Effect

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A compelling example of auditory-visual multisensory integration in speech perception is the McGurk effect, in which an auditory syllable is perceived very differently depending on whether it is accompanied by a visual movie of a speaker pronouncing the same syllable or a different, incongruent syllable. However, unlike many other illusions, the strength of the McGurk effect varies greatly from individual to individual, such that some subjects always perceive the illusory McGurk syllable while others never perceive it. Is there a neural basis for this variability? The human posterior superior temporal sulcus (STS) is thought to be important for multisensory integration of audiovisual speech. The BOLD fMRI signal in the STS increases for audiovisual speech compared with unisensory auditory or visual speech, and may represent a neural signature of multisensory integration. We hypothesized that subjects who perceive the McGurk effect integrate the auditory and visual components of the McGurk stimuli, and that this increased multisensory integration should be reflected in increased BOLD activity in the STS. To test this hypothesis, we measured the amplitude of BOLD response during perception of McGurk incongruent syllables, non-McGurk incongruent syllables and congruent syllables in 10 subjects. Consistent with previous reports, there was a high degree of variability in the perception of the McGurk effect, measured with behavioral pre-testing (mean McGurk percept 45%, range 0% to 100%). The STS multisensory

region was first identified using a separate fMRI localizer. Then, subjects were presented with McGurk, non-McGurk, and congruent stimuli in a rapid event-related design. Across subjects, we found a significant correlation between McGurk effect perception and the amplitude of that subjectís STS response to McGurk syllables ($r = 0.76$, $p = 0.01$). Interestingly, these intersubject differences in perception were not reflected in the pattern of STS responses to other stimuli. There was no correlation between the amplitude of the STS response to non-McGurk syllables or congruent syllables and McGurk effect perception ($r = 0.37$, $p = 0.29$ for non-McGurk and $r = 0.14$, $p = 0.70$ for congruent syllables). This suggests that the presence or absence of a robust STS response to McGurk stimuli may be the neural signature of the multisensory integration that results in a McGurk percept. These findings buttress the idea that activity in the STS is the neural substrate for audiovisual integration in the McGurk effect and speech perception.

50. 6:00 p.m. - 7:00 p.m.

Neuromagnetic evidence for pitch context effects on auditory cortical responses

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Purpose: We investigate the effect of pitch context on the neuromagnetic auditory M100 response. Specifically, we study whether responses to acoustically matched vowels are sensitive to the fundamental frequency (F0) of a preceding vowel. Background: Previous studies have shown that the latency of the auditory M100 component can be modulated by acoustic properties of the signal, such as tone frequency (Roberts & Poeppel, 1996), and this finding has been extended to speech perception research (and to vowels in particular (Poeppel et al., 1997; Obleser et al., 2004)). Building upon these studies and others that have shown that the M100 can also be modulated by additional factors, such as contextual phonological knowledge (Flagg et al., 2006; Hwang et al., 2010), this study investigates whether the latency of the auditory M100 response elicited by vowel stimuli is sensitive to local pitch context. Experiment: Natural tokens of [a] and [u] were produced by an adult female speaker of English, and 400ms segments of these vowels were edited using Praat, where the natural pitch points were first removed and then set to have either 145Hz (v̀) or 245Hz (v́) F0 values. Vowel pairs were created by concatenating the two 400ms vowel segments with the addition of a 50ms silent interval between them, resulting in the following sequences: á-á, à-à, á-à, à-á, and ú-ú, ù-ù, ú-ù, ù-ú. Using MEG, we recorded evoked auditory activity time-locked to the onset of each vowel. Subjects ($n = 8$) were asked to identify by button press whether the pair of sounds they heard were "same" or "different" while brain activity was recorded (MEG 157-channel, whole head axial gradiometer, KIT, Japan). If the M100 is modulated by pitch context, we expect to find differences among acoustically matched vowels that are preceded by different stimuli. Results: Overall, behavioral accuracy was very high (>95%). For both [a] and [u], we find a significantly shorter auditory M100 peak latency to a low-pitch vowel following a high-pitch vowel (v́-v̀) compared to the same acoustic token preceded by the same-pitch vowel (v̀-v̀) ($p<0.05$). However, we do not find M100 peak latency differences to a high-pitch vowel following a low-pitch vowel (v̀-v́) compared to the same acoustic token preceded by the same-pitch vowel (v́-v́). This suggests an asymmetry in response based on the direction of the pitch change (rising vs. falling) across vowel pairs. Conclusion: We conclude that the M100 is not only sensitive to acoustic properties of the signal, but also shows sensitivity to local pitch contexts (for high-low pitch pairs). This offers further support that the M100 reflects more than simple acoustic processing of the current input, and the results bear on issues in processing of intonation in language.

51. 4:45 p.m. - 5:45 p.m.

Sublexical processing in left inferior frontal gyrus depends on word intelligibility

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The left inferior frontal gyrus (IFG) is particularly engaged when people listen to high phonotactic frequency words (Vaden & Hickok, 2009), words composed of speech sounds that co-occur with high frequency in the English language (Vitevitch & Luce, 1999). The current experiment aimed to further characterize the relation of phonotactic frequency to left IFG activity by manipulating word intelligibility and varying age. Thirty six native English speakers, 19-79 years old (mean = 50.5, SD = 21.0) indicated with a button press whether they recognized 120 binaurally presented consonant-vowel-consonant words during a sparse sampling fMRI experiment (TR = 8 sec). Word intelligibility was manipulated by low-pass filtering (cutoff frequencies of 400 Hz, 1000 Hz, 1600 Hz, and 3150 Hz). A continuous broadband noise was presented with the words to minimize the impact of individual differences in hearing thresholds; average pure tone thresholds were positively correlated with age, R-squared = 0.62, $p < 0.001$. Group analyses were performed in normalized study-specific space to identify consistent positive or negative effects of phonotactic frequency. A significant positive effect of phonotactic frequency was observed for left IFG activity, which was unaffected by age and hearing thresholds. In contrast, the relation between phonotactic frequency and IFG activity was positively affected by word intelligibility. A region of interest analysis revealed that phonotactic frequency modulated IFG activity to a greater extent for the most intelligible words (low-pass filtered at 3150 Hz) than for the other filter conditions ($F(3,105) = 6.3$, $p <$

0.001). This result suggests that declines in word intelligibility may alter and disrupt the normal representation of sublexical word features that are hypothesized to aid in word recognition.

52. 6:00 p.m. - 7:00 p.m.

Speech development of monolingual and bilingual toddlers: Language measures and event-related potential responses

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Several studies suggest that speech perception in bilingual versus monolingual infants develops differently (e.g.,Bosch & Sebastian-Galles, 1997). The current study employed Event-related Potential (ERP) Mismatch responses (MMRs to investigate developmental changes in speech processing from 16 months to 3 years of age in monolingual and bilingual toddlers and to explore whether bilingual exposure to Spanish and English affects processing of vowel sounds that are phonemic only in English. Over 60 toddlers (between 16 months and three years of age) listened to 250ms-long, phonetically similar English vowel contrasts (I vs. E) presented in an oddball paradigm while ERPs were collected from 65 scalp sites. English-learning children were recruited from monolingual English-speaking household, and bilingual children were from Spanish-English household. Detailed language background questionnaire and a battery of language-related tests were administered. ERP results show that a positive MMR followed by a negative MMR were obtained from the majority of monolingual and bilingual children across all the age groups. The latency of these MMRs shifted earlier with increasing age. A number of children from the bilingual group demonstrated later p-MMR responses than the age-matched monolingual controls. The shortening of peak latency of the p-MMR is likely to be due to the increase in amplitude and shortening of latency of the following n-MMR. We hypothesize that this n-MMR is the precursor of the adult MMN and can serve as an index of the development of phonological categories. An overall more negative MMR from the bilingual group indicates more attention allocation to these stimuli possibly due to exposure to two vowel systems. Bilingual children with less Spanish exposure had MMR patterns similar to other bilingual children rather than monolingual English children.

53. 4:45 p.m. - 5:45 p.m.

Neural influence of vision on illusory filling-in of degraded speech

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Objectives: Illusory filling-in of degraded speech requires the brain to suppress its usual sensitivity to acoustic changes, such as at the onset and offset of interruptions. Since visual cues behaviorally enhance the auditory filling-in illusion, we hypothesized that neural sensitivity to speech interruptions will be reduced in the presence of congruent lip-movements.Methods: Using electroencephalography (EEG) we examined the phase-locking index (PLI) of theta band activity to the onset and offset of interruptions of the illusory percept for when the words were accompanied by congruent or incongruent mouth movements. A greater PLI to either onset or offset reflects a more salient representation of the interruption. Results: We show that phase-locking of auditory theta band activity is suppressed at the offset, though not at the onset, of interruptions for congruent compared to incongruent conditions. This rendered the offset theta band of the illusory percept similar to that of the physically continuous stimulus. Moreover, increased right lateral-temporal PLI of theta and alpha bands followed the onsets of interruptions, except when the stimuli were audiovisually incongruent. This suggests a higher-level process involved in initiating repair that is disturbed by audiovisual incongruency. Conclusions: Vision alters the temporal fidelity of auditory processing during illusory filling-in, but this influence is contingent upon initial evidence of degradation (e.g. onset of interruptions) and audiovisual congruency.

54. 6:00 p.m. - 7:00 p.m.

Characterizing the discriminabilty of visual speech syllables using a physical measure of dissimilarity

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In order to understand visual speech perception (a.k.a. lipreading or speechreading) and its neural underpinnings, we need a theory about what is the functional visual speech stimulus. Previous research suggests that the perceptual dissimilarity of visual speech syllables is related to a physical measure of the dissimilarity of utterances of those syllables (Jiang et al., 2007). This physical measure is based in part on the Euclidean distances computed on 3-D components of seventeen points on the talkerís face over time. Here, we test the hypothesis that pairs of syllables with low dissimilarity are less discriminable than pairs of syllables with high dissimilarity. Discrimination is tested with a natural and a synthetic talker that incorporated the same information that was used to calculate syllable dissimilarity. This allowed us to test whether the modeled information was actually the basis for discrimination. Syllable discriminability was measured

using percent correct, response time, and dí sensitivity in a same/different task performed by twelve normal-hearing participants. The results of all three measures of discriminability showed that physically near pairs of syllables were less discriminable than far pairs in both natural and synthetic visual-only speech. Participants more accurately discriminated natural compared to synthetic speech syllables, however regression analysis showed that the association between dissimilarity and discriminability was stronger when stimuli were synthetic compared to when they were natural speech. The overall discriminability advantage in the natural speech condition suggests that there is information in the talking face that is not captured by the particular physical dissimilarity measurement. This is not a surprise, as the measurement did not directly include tongue motion or position, and lipreaders do use visible tongue movement. Despite this, the predicted relationship between dissimilarity and discriminability was still reliably observed. The stronger association between measured dissimilarity and discriminability under synthetic speech conditions is consistent with the likelihood that non-measured cues are used in addition to, rather than instead of, the physical cues captured by the distance measures. Thus, the complex visual speech stimulus can be characterized using physical measurements of the talking face that do not require any assumptions about feature extraction. This demonstration leads the way towards investigating neural responses during visual speech perception.

55. 4:45 p.m. - 5:45 p.m.
Activity in primary auditory cortex is enhanced by visual speech
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Previous neuroimaging studies of audiovisual speech report activity in auditory and language related regions such as inferior frontal gyrus, superior temporal gyrus and superior temporal sulcus. Primary auditory cortex is less consistently reported in the literature, and the extent and involvement of primary auditory cortex remains unclear. The aim of the present fMRI study is to investigate the influence of visual speech on auditory speech in primary auditory cortex. On each trial, subjects heard one of four syllables. In half of the trials, the auditory syllables were presented with a still face, while in the other half of trials the syllables were presented with congruent visual speech. A standard group analysis contrasting the audiovisual speech condition with the auditory only condition yielded activity in bilateral superior temporal sulcus, a region previously implicated in multisensory integration. This contrast did not yield significant activity near primary auditory cortex, presumably because auditory-related activation is subtracted out in this contrast. However, timecourse analysis performed on voxels from primary auditory cortex revealed a significant amplitude difference between the two conditions. We found greater amplitude in the audiovisual condition compared to the auditory only condition. That is, while holding the auditory input constant across the two conditions, the addition of visual speech enhanced the activity in primary auditory cortex. Our results demonstrate that visual speech can exert influence on heard speech by increasing its response in auditory cortex.

56. 6:00 p.m. - 7:00 p.m.
Perceiving manner- and place-of-articulation contrasts in speech: An MMN study
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To fully grasp the mechanisms of speech perception we have to understand more about the fine structure of stored lexical information. The present study was designed to query the notion of underspecification as a basic principle in storing phonological information in the mental lexicon. Previous neurobiological studies have mainly shed light on the underspecification of certain place-of-articulation features. Here our focus is on manner-of-articulation. Moreover, the contrast sensitivity in different featural dimensions was compared. We examined the brainís automatic change-detection responses to nonwords pairs differing in medial consonants [edi], [eni], [ezi] and [egi] using Mismatch Negativity (MMN). Assuming abstract underspecified representations, the varying consonants are predicted to evoke symmetric MMNs for the [ezi]~[eni] reversal (bi-directionally conflicting manner features), and for the [egi]~[eni] reversal (conflicting manner in one direction and conflicting place in the reversed case), but asymmetric MMNs for the reversal of the [edi]~[eni] contrast due to the underspecification of the phonological feature [PLOSIVE] for /d/. The observed pattern of MMNs supported these predictions. Combined place and manner conflicts resulted in MMN differences suggesting an enhanced contrast sensitivity for manner-of-articulation changes.

57. 4:45 p.m. - 5:45 p.m.
Acoustical cues used to segment phonemically identical speech sequences: An EEG study
Elsa Spinelli1, Véronique Boulanger2, Emmanuel Ferragne2, Stéphane Pota2,3 & Fanny Meunier2 1 Laboratoire de Psychologie et NeuroCognition, Université Pierre Mendès France & CNRS, Grenoble, France 2 Laboratoire Dynamique Du Langage, Université Lumière Lyon 2 & CNRS, Lyon, France 3 Laboratoire Stem Cell and Brain Institute, INSERM, Lyon, France
Because the speech signal is continuous, listeners must segment the speech stream in order to recognize words. Due to elision, some spoken utterances in French are phonemically ambiguous (e.g., l'amie 'the friend' vs. la mie 'the crumb',

both [lami]), and correct segmentation is necessary for comprehension. There are however, some acoustic differences between members of such ambiguous pairs (l'amie vs. la mie) that are likely to be used by listeners during word segmentation. Among those, there are clear intonational differences between the two sequences. There is often a rise in fundamental frequency beginning at the left edge of the first content word syllable. For example, the rise begins at [la] for the first syllable of l'amie 'the friend'; but it begins a syllable later, at [mi] for the first (and only) syllable of mie 'crumb' in la mie. Consequently, F0 is lower for the first vowel in the consonant initial items (la mie) than in the vowel initial items (l'amie). There is now a growing body of evidence suggesting that information beyond the phonemic level is available to the lexicon. During spoken word recognition, fine-grained differences in the speech signal influence processing at the lexical level and modulate lexical selection (Spinelli, McQueen & Cutler, 2003; Spinelli, Welby & Schaegis, 2007; Shatzman & McQueen, 2006; Cutler & Van Donselaar, 2001). Furthermore, there is converging evidence from a variety of paradigms that language-specific intonational cues play a role in word segmentation. Spinelli, Grimault, Meunier & Welby (2009) showed that French listeners relied on early intonational cues to segment ambiguous sequences like /selami/ 'it is the friend/ crumb'. In a two-alternative forced choice task, they showed that increasing the F0 in the /a/ of la mie increased the percentage of vowel-initial (amie) responses. Moreover, they showed with a cross modal lexical decision task that raising the F0 in the natural consonant-initial production of la mie /la#mi/ increased activation of the lexical representation of vowel-initial target (amie). This suggests that the recognition system seems to exploit such intonational information to guide segmentation towards the beginning of content words. In this study, we examined the electrophysiological correlates of the use of such segmentation cues with a modified version of the Oddball paradigm (Brunellière, Dufour, Nguyen & Frauenfelder, 2010). Event related potentials (ERPs) were recorded while French participants were presented with four standard [la] syllables (coming from four productions of carrier sentences containing e.g., la mie) and a fifth deviant [la] syllable that was excised either from another production of la mie (same segmentation condition) or from l'amie (different segmentation condition). The experiment also included l'a1 to 4 standards from (l'amie) and la (from la mie) deviants. We examined and compared the mismatch negativity (MMN) elicited for the test syllable in the different segmentation condition (for example, la1, la2, la3, la4, l'a) and in the same segmentation condition (here, la1, la2, la3, la4, la5). This experiment shows the particular status of fine acoustical cues needed by cognitive processes involved in speech comprehension such as segmentation.

58. 6:00 p.m. - 7:00 p.m.

The mismatch negativity to the tonal changes of pseudosyllables in adults and preschoolers

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Mandarin Chinese is a tone language. The four tones, including T1, T2, T3, and T4, can be phonetically described as high level, high rising, low falling rising, and high falling tones, respectively. Our recent study used the mismatch negativity (MMN) to trace the brain response to tonal changes in adults and in 4- to 6- year-old preschoolers. We investigated two pairs of contrast: one contrast between two acoustically similar tones (T2/T3, deviant: "yi2", standard: "yi3"), and the other between two acoustically dissimilar tones (T1/T3, deviant: "yi1", standard: "yi3."). For both contrasts, the adults showed typical frontal-central distributed MMNs, and the MMN for T1/T3 contrast showed earlier onset and larger amplitude than that for T2/T3 contrast. In preschoolers, the adult-like MMN for T1/T3 contrast were found in all age groups. However, the 4-year-old preschoolers showed no significant MMN response to T2/T3 contrast, and both 5- and 6-year-old groups showed the positive mismatch response (P-MMR) to T2/T3 contrast. Previous studies have demonstrated the influence of meaning on the perception of speech sounds. Given that these three syllables were not well-matched in token frequency (115866, 34886 and 111184 per ten million for "yi1", "yi2" and "yi3", respectively) in previous studies, it is hard to tell if "T2/T3 contrast elicited smaller MMN than T1/T3 did" is due to the difference of acoustic similarity or lexical frequency. The present study aims to reexamine this issue by tracing the brain response to the changes of Mandarin lexical tones which were embedded in pseudosyllables without the contamination of lexical memory from preschoolers to adults. Methods: 18 adults, 52 preschoolers (age 4: 17, age 5: 17, age 6: 18) participated in the multi-deviants oddball paradigm in which pseudosyllables " fi1" and "fi2" served as deviants (10% for each) and pseudosyllables "fi3" served as the standard (80%). The whole experiment consisted of 1000 trials. The stimuli were pronounced by a female native speaker of Mandarin, and their duration were normalized to 250 msec. Participants were requested to passively listen to those sounds while playing computer games or watching silent video. The EEG was recorded at a sampling rate of 500 Hz from 32 sintered Ag/AgCl Quikcap with SYNAMPS2 (Neuroscan). Results: The adults showed typical frontal-central distributed MMNs for both T1/T3 and T2/T3 contrasts from 150 to 300 msec. The 4-year-old preschooler showed an adult-like MMN for the T1/T3 contrast and but no significant mismatch response to the T2/T3 contrast. On the other hand, the 5- and 6-year-old groups showed typical adult-like MMNs for both T1/T3 and T2/T3 contrasts. Conclusion: The larger MMN amplitude for the T1/T3 relative to the T2/T3 condition was only evident for 4-year-old group. Moreover, preschoolers showed adult-like MMN to T1/T3 contrast in all age groups. This is congruent with the findings of developmental study of speech production that the mastery of lexical tone is achieved around 3 years old, the level tone and the falling tone were acquired before the rising tone and the

dipping tone, and that most errors involved the lack of distinction between the rising tone and the dipping tone (Clumeck, 1977; Li & Thompson, 1977; Zhu, 2002). Discussion of significance: The present study demonstrated the feasibility of using MMN to index the subtle difference between T1/T3 and T2/T3 contrasts in 4-year-old preschoolers. It might serve as a neurophysiological marker for the early identification of children with language or reading deficits.

59. 4:45 p.m. - 5:45 p.m.

Establishing speech-evoked activity in the auditory cortex of deaf children following cochlear implantation using near-infrared spectroscopy

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Cochlear implants (CI) are the most common treatment for deafness. Although many factors influence the ability of a deaf child to develop speech and language skills while hearing through a CI, a key factor is proper programming of the CI itself. Implementing the optimal CI program is a challenging, individualized, and iterative process with variable success. Therefore, we sought to establish a novel neurophysiological measure to supplement existing behavioral testing techniques for establishing CI function. In normal hearing populations, a variety of noninvasive techniques can be used for detecting neural activity in response to auditory stimuli. However, all these techniques have critical limitations when applied to the CI subject population. fMRI is the most common method for measuring human brain function, but the ferromagnetic components of modern CIs are incompatible with the high magnetic fields generated by the MR scanner. Electroencephalography (EEG) can be used to identify cortically-generated event-related potentials. However, when testing CI users the auditory stimuli are generally limited to short sounds, such as tone pips or clicks, to minimize artifacts due to the electrical current produced by the CI (Gilley et al. 2006). Thus, it is difficult to measure the cortical response to running speech, the stimulus category of greatest interest, with EEG. Positron emission tomography (PET) involves the use of ionizing radiation, which is not ideal for testing children or for repeated use. Finally, magnetoencephalography (MEG) techniques are limited by the magnetic fields generated by the CI device. We hypothesized that near-infrared spectroscopy (NIRS) would allow measurement of blood-oxygen level dependent changes in cortical activity, similar to fMRI, without interference with CI function. We first compared responses in primary and parabelt regions of auditory cortex bilaterally as measured with NIRS and fMRI in normal-hearing adults. We then examined four participant cohorts with NIRS alone. Speech-evoked cortical activity was observed in 73% of normal-hearing adults (8 of 11), 82% of normal-hearing children (9 of 11), 61% of deaf children who have used a CI >4 months (22 of 36), and 89% of deaf children on the day of CI initial activation (8 of 9). Thus, our data suggest that NIRS may be a useful technique to study brain development in children hearing through a CI. Although this study was a preliminary attempt to determine if NIRS could be used to assess auditory function in deaf children using CIs, an interesting observation that should be investigated in future studies is that responses in deaf children hearing with a CI for the first time were predominantly in the hemisphere ipsilateral to the CI, which was most often the right hemisphere (with the CI in the right ear). This finding of right-sided activation is in contrast to the normal adult finding of left-hemisphere dominant language and suggests that auditory brain development in deaf children may be altered by the lack of normal sensory input (Neville and Bavelier 2002). Age of hearing loss onset and age of implantation are among the factors that we plan to examine in future research. Gilley PM, Sharma A, Dorman M, Finley CC, Panch AS, Martin K (2006) Minimization of cochlear implant stimulus artifact in cortical auditory evoked potentials. Clinical Neurophysiology 117: 1772-1782. Neville, H, Bavelier, D (2002) Human brain plasticity: evidence from sensory deprivation and altered language experience. Review Article. Progress in Brain Research, 138, 177-88.

60. 6:00 p.m. - 7:00 p.m.

The interface of language and perception: When motion meets animacy

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Embodied cognition approaches argue that sentence comprehension involves the partial re-enactment of the action described, and therefore engages sensory-motor representations shared with action and perception [Zwaan et al., 2002]. Here we use fMRI to investigate the specificity by which perceptual areas are recruited during sentence processing. We manipulated the motion and animacy of sentences in a 2x2 design (motion-non-motion, animate-inanimate). Motion perception studies have shown that distinct areas of occipito-temporal cortex respond selectively to all motion (V5/MT), human motion (superior temporal regions), and object motion (middle/inferior temporal regions) [Beauchamp et al., 2002]. Thus embodied approaches predict similar modulations in these regions by language and perception. Two tasks were conducted in the scanner. The motion perception task presented participants with visual events varying in motion and/or animacy. These conditions were used to define the regions sensitive to visual motion, including V5, human or object motion perception (localizers). The sentence comprehension task used the blank-screen paradigm. A visual scene was presented for 2 sec. After the screen went blank, a sentence that related back to the scene

was auditorily presented. This design thus encourages visual representations, as previously demonstrated [Altmann, 2004]. The results revealed that in perception, V5 was active for all stimulus conditions, and human and object motion elicited distinct regions in posterior temporal cortex. However, there was no effect of language in V5, only in more anterior motion perception areas. Moreover, sentences modulated activity within all visually identified temporal regions, indicating that language does not elicit region-specific responses to humans or objects. Interestingly, all visually-defined temporal regions, as well as prefrontal regions that were inactive in perception, show the same pattern of activation: an interaction between animacy (human vs. object) and motion (motion vs. non-motion). Human motion sentences elicited as strong activity as human non-motion sentences. However, object motion sentences elicited stronger activity than object non-motion sentences. This suggests that within perceptual areas, human sentences elicit equally strong levels of activity regardless of motion, whereas object sentences only elicit strong activity in conjunction with motion. Results suggest that sensory-based representations in language do not have the specificity found in visual perception (no V5 activation, no separate object vs. human regions), even when reference to a visual scene was encouraged. This evidence contradicts embodied theories of language processing. Instead, we found evidence that language activates a network of posterior and pre-frontal regions that although partially overlap with perception, are distinctively modulated by sentence composition. We argue that the potential for motion inherent to humans, particularly in subject position, caused similarly high activation levels for human motion and non-motion sentences, whereas object sentences follow the motion vs. non-motion pattern found in posterior temporal cortex in previous verb studies [Kable et al., 2002]. This suggests strong conceptual and language-specific influences of animacy in sentence processing that do not match action perception.

61. 4:45 p.m. - 5:45 p.m.

The effects of phonological and semantic ambiguity on spoken word recognition: Behavioural and neural evidence

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Ambiguities in phonological form and semantic meaning represent a psycholinguistic challenge to speech comprehension that is reflected empirically in slower behavioural responses. Lexical status has been shown to affect processing of phonemically ambiguous words whilst responses to ambiguous non-words (ìsmodî-ìsmobî) are seemingly not disrupted by conflicting cues (Marslen-Wilson & Warren, 1994). Semantically ambiguous words (ìbarkî) have also been shown to produce a disadvantage in both visual and auditory lexical decision tasks (Rodd et al., 2002). These effects are more successfully modelled by distributed accounts, where featural information is mapped onto separate lexical representations (Gaskell & Marslen-Wilson, 1997; 1999), than localist models with top-down feedback to a phonemic level (McClelland & Elman, 1986). We assessed lexical processing of phonemically ambiguous syllables by creating natural sounding morphed continua using ìStraightî software (Kawahara et al., 1999), generating 10 intermediate tokens at 10% steps from 5% (similar to word 1 in the pair) to 95% (similar to word 2). Participants heard either a high-ambiguity (35% or 65% morph) or low-ambiguity (5% or 95% morph) single syllable created from mixing two words (porch-torch), two non-words (pash-tash) or a word and a non-word (punt-tunt, poy-toy). Lexical decision responses revealed significantly slower reaction-times (RTís) for phonemically ambiguous words but not for non-words. However, slower RTís for non-words with a real word neighbour (e.g. punt-tunt, poy-toy) suggests that lexical information might also influence non-word responses (Ganong, 1980; Norris et al., 2003). Lexical decisions to spoken words with multiple-meanings and either a single-spelling (bark) or multiple-spellings (knight/night) were compared to matched single-meaning controls (bed) and revealed significantly slower RTís for semantically ambiguous words, supporting previous behavioural findings (Rodd et al., 2002). Recent neuroimaging evidence suggests that the anterior and posterior left inferior frontal gyrus (LIFG) may play a role in semantic and phonological processing respectively (Poldrack et al., 1999). Using the same ambiguous stimuli from the lexical decision tasks, we found that the phonemically ambiguous words produced increased activation in more posterior regions of LIFG (opercularis) whilst semantically ambiguous versus unambiguous single words produced increased activation both within posterior regions of LIFG (opercularis), as observed for phonemic ambiguity, as well as additional regions of anterior LIFG (triangularis). This supports both the Poldrack et al., (1999) meta-analysis as well as previous findings revealing bilateral IFG activation (strongest on the left) for ambiguous versus unambiguous sentences (e.g. ëthere were dates and pears in the fruit bowlí/ëthe secrets were written in her diaryî) (Rodd et al., 2005) and suggests that semantic and phonological ambiguity resolution may load separately on anterior and posterior frontal systems.

62. 6:00 p.m. - 7:00 p.m.

Electrophysiological evidence for the impact of non-native regional accent imitation on sentence comprehension

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In this study, we explored whether imitating a non-native regional accent helps speakers to understand sentences produced in that accent. To this aim, we measured the cloze probability effect with event-related potential (ERP) recordings

in Southern French speakers after they imitated sentences spoken by a French Belgian speaker. The wordís rated cloze probability is the proportion of individuals who provide that particular word as the most likely completion for a given sentence fragment. High-cloze probability ratings are known to induce a decrease in the amplitude of both the N200 and N400, relative to low-cloze probability ratings (Kutas and Hylliard, 1984; Connolly et al., 1992). Here, we examined whether, after imitation of sentences produced by a French Belgian speaker, Southern French speakers more easily integrate a final word into the preceding sentential fragment produced by the same Belgian speaker, compared with a no-imitation control condition. In a first stage, half of the speakers (Test group) were asked to imitate fifteen auditorily presented sentences produced by a Belgian speaker, while the other speakers (Control group) had to carefully listen to the same sentences. In a second stage, the test and control groups were instructed to listen for comprehension to 150 other sentences (50 high cloze, 50 middle cloze, 50 low cloze) separated in five blocks. At the end of each block, participants were asked to answer true-false questions. Participants answered the comprehension questions with a mean accuracy of 84% in the Control group and 83% in the Test group. In the N200 time window, we did not find a cloze probability effect in the Test group. In contrast, in the Control group, a larger N200 was observed for the low-cloze sentences compared with the high-cloze sentences. This negativity was larger for the low-cloze sentences in the Control group than in the Test group. In a second time window around 320 ms after the final word onset, a larger negativity centered on centroparietal sites was observed for the low-cloze sentences than for the high-cloze ones in both groups of participants. In a third time window around 400 ms, we again observed, in the Test group, a larger negativity at centroparietal sites for the low cloze sentences. Interestingly, a higher positivity was found at right posterior sites for the low-cloze sentences than for the high-cloze sentences in the Control group. This positivity was larger for the low-cloze sentences in the Control Group than in the Test group. Our results first suggest an absence of early difficulty of integration of the last word into the low-cloze sentences relative to high-cloze sentences in the Test group in comparison to the Control group as reflected by the N200. In addition, contrary to the Test group, the Control group exhibited a late positivity wave for the low-cloze sentences compared to the high-cloze ones consistent with a reanalysis and repair process. Taken together, these electrophysiological results provide support for our hypothesis that imitation of a non-native regional accent facilitates sentence comprehension.

63. 4:45 p.m. - 5:45 p.m.

Perceptual learning in speech comprehension governed by power law dynamics

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Power law dynamics are ubiquitous in biological systems, and have proven particularly useful in describing learning and adaptation in cellular and systems neuroscience. We therefore hypothesized that perceptual learning in speech comprehension would be governed by such processes. We tested this prediction by studying listeners' adaptation to speech manipulated using two orthogonal types of acoustic degradation (Fig 1a). In a behavioral study we presented 75 listeners with 30 time-compressed and 30 frequency-compressed sentences, using word report as a trial-by-trial measure of intelligibility. Across subjects, perceptual learning was indeed well characterized by a power function (Fig 1b, blue). We then conducted an fMRI experiment using analogous methods, taking advantage of the assumption that adaptation effects are driven by underlying power law processes. Under this assumption, our behavioral measure of word report reflects both perceptual learning (which we assume to occur smoothly over time), and attentional, executive, and linguistic processes (which we expect to cause intertrial variability). To dissociate these two contributions, we fit a power law function to each subject's recall data, which we entered into our statistical model separately from recall scores. We first looked for neural activation associated with listening to both kinds of speech and word report (i.e. intelligibility) (Fig 1c). Next, for each type of acoustic degradation we used the individually-fit power functions to search for regions of the brain that showed a profile associated with perceptual learning for time- or frequency-compressed speech (Fig 1d). Anatomically distinct regions showed associations with learning across the two manipulations. These results demonstrate for the first time that listeners' ongoing adjustments to the speech stream obey power law dynamics, and suggest that the networks subserving these learning processes may depend on the acoustic characteristics of the signal.

64. 6:00 p.m. - 7:00 p.m.

Differential influences of spectral and temporal features of speech on human oscillatory brain dynamics

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Objective: This study investigates the oscillatory brain dynamics in human EEG in response to acoustic features of speech. We specifically hypothesized that effortful yet successful comprehension under adverse listening conditions should affect time-course and extent of event-related desychronizations in the alpha (8--13 Hz) band. Methods: Spectral and temporal features of acoustically degraded words were parametrically varied. We analysed evoked and induced

(non-phase-locked) EEG responses in 24 healthy German participants, who listened and rated comprehensibility after each trial. Trials were grouped according to spectral detail (2-, 4-, 8-, 16-band vocoding) or temporal detail (2-, 4-, 8-, 16-Hz lowpass filtering of the vocoding envelopes). Permutation tests of a regression t-statistic for time-frequency-electrode clusters were run on wavelet transform data as well as conventional evoked potential data, followed by beamformer locations of effects of interest. Results: The most salient result was a first left-posterior, then broadening cluster of alpha desynchronization from 600 to 900 ms after stimulus onset: Alpha power appeared linearly suppressed for more spectral detail in a trial, and hence a more likely success of comprehension. Temporal detail had a very comparable effect in the same time/frequency range, but its effects were strongest over right-posterior channels. Beamformer localisations of the relevant time--frequency clusters added evidence for these hemispheric differences in source space. Thus, comprehension-coupled alpha power behaves inversely and contralaterally to BOLD changes observed previously for these manipulations. When pooling across all spectral/temporal conditions in left and right mid-posterior channels, a significant negative correlation of Alpha power and comprehension ratings. Generally, comprehension-rating scores confirmed the known predominance of spectral detail for word comprehensibility. In the same vein, parametric increases of spectral detail (i.e., increasing intelligibility) led to decreases of N100 and N400 amplitudes to word onsets, while left-anterior theta (4--6 Hz) synchronisation linearly increased. Conclusion: Our results offer a new link between speech comprehension, processing of acoustic features, and oscillatory brain dynamics. The relatively stronger and prolonged alpha synchronization in response to less intelligible stimuli parallels current interpretations of Alpha as a signature of functional inhibition; which might be less required when processing well-comprehensible speech. The observed differential effects of spectral and temporal features on the laterality of this effect encourage more studies on the oscillatory brain dynamics in speech comprehension.

65. 4:45 p.m. - 5:45 p.m.

Speech reconstruction from spectro-temporally tuned ECoG signals in human temporal, parietal, and frontal cortex

Pasley, B.N. (1), David, S.V. (2), Mesgarani, N. (2), Flinker, A. (1), Shamma, S.A. (2), Crone, N.E. (3), Chang, E.F. (4), and Knight, R.T. (1). 1. University of California, Berkeley. 2. University of Maryland, College Park. 3. Johns Hopkins University School of Medicine. 4. University of California, San Francisco.

Speech perception depends on both the spectral and temporal structure of the speech signal. Modulation of spectral energy across time conveys critical phonological information, including formants in the spectral dimension and syllable patterns in the temporal dimension. The neural representation of these spectro-temporal properties has been described by substantial research in mammalian auditory systems, but less is known about this encoding process in human cortical areas. To study the neural representation of speech in human cortex, we investigated which spectro-temporal properties can be decoded from population neural responses measured directly from the peri-sylvian cortex in patients (n = 14) undergoing neurosurgical procedures. Electrocorticographic (ECoG) recordings were made using low- or high- density electrode arrays (spacing 10 or 4 mm), with simultaneous recordings from lateral temporal, parietal, and frontal cortices. A large corpus of isolated words and sentences were presented aurally in a passive listening paradigm. A linear decoder (Wiener filter) was used to reconstruct the speech signal from high gamma (70-150 Hz) ECoG activity. Reconstruction accuracy was quantified by the correlation coefficient between the actual and predicted speech parameters in an independent test data set. Accuracy was evaluated for two distinct representations of the speech signal. First, we examined a spectrogram representation which characterizes the time-varying envelope of the speech signal at different frequencies. Second, we investigated a multi-resolution cortical model which measures the energy of spectro-temporal modulations explicitly at different rates, scales, and frequencies in the speech stimulus. Significant reconstruction accuracy ($r \sim 0.4$, $p < 0.001$) was obtained for both spectrogram and multi-resolution parameterizations. Local neural populations may therefore encode temporal modulations both through envelope-locking and through a phase invariant energy-based coding scheme. At the highest temporal modulations (> 8 Hz), the multi-resolution model yielded higher reconstruction accuracy, suggesting predominance of a rate-based representation. Across cortical areas, reconstruction accuracy was highest in temporal auditory cortex, although robust decoding was also found in frontal and parietal cortices, suggesting neural responses in these areas contain information about spectro-temporal properties of sound. The fidelity of speech reconstructions available from human cortical recordings may prove useful for future work on communication neuroprosthetic applications. SUPPORT: NS21135, NS40596, K99 DC010439, F32 NS061552, K99 NS065120

66. 6:00 p.m. - 7:00 p.m.

Optimal information for decoding intelligible speech is found in the left anterior temporal lobe

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College London, London, UK. 3. Department of Fundamental Neuroscience, University Medical School, Geneva, Switzerland. 4. Computational, Cognitive and Clinical Neuroimaging Laboratory, Imperial College London, London, UK.
An anterior 'what' pathway, concerned with extracting meaning from auditory input, has been identified in non-human primates (Tian et al 2001; Rauschecker, 1998). An analogous pathway has been suggested in humans but there is controversy over the degree of left lateralisation this pathway exhibits and the location at which responses to intelligible speech emerge (Rauschecker & Scott, 2009; Hickok & Poeppel, 2007). We have previously demonstrated that the left anterior Superior Temporal Sulcus (STS) responds to intelligible speech above and beyond an acoustically complex baseline of rotated speech (Narain et al 2003; Scott et al 2000). A recent study applied a multivariate pattern analysis to stimuli from these studies and demonstrated that both anterior and posterior STS bilaterally contained sufficient information to separate intelligible from unintelligible speech (Okada et al 2010). Furthermore they claimed that as the left anterior STS successfully separated an additional acoustic contrast, this made it an unlikely candidate region for resolving intelligible speech. Significantly in this study no attempt was made to directly compare the relative contribution of anterior and posterior STS in separating intelligible from unintelligible speech. In the present study we replicated our original Scott et al (2000) study and carried out a whole brain univariate and multivariate pattern analysis within Regions of Interest (ROIs) in order to understand which regions contributed most to separating intelligible from unintelligible speech. ROIs included left, right and combined left and right: Heschl's Gyri (HG), Superior Temporal Gyri (STG), Middle Temporal Gyri (MTG), Inferior Temporal Gyri (ITG), Inferior Occipital Gyri (IOG), and the combination of all bilateral temporal and Heschl's Gyri. In the pattern analysis all combined left and right temporal and Heschlís Gyri were able to separate intelligible from unintelligible speech; the classification performance of the STG and MTG were significantly better than all other regions. When left hemisphere ROIs were contrasted with right, they were shown to perform similarly except the left MTG, which performed better than the right. The classifier weights were extracted from a classifier which included all temporal and Heschl's gyri. The weights of greatest magnitude associated with intelligibility were located predominately in the left anterior Superior Temporal lobe. Furthermore in the univariate analysis, the conjunction null of the intelligible over unintelligible conditions exclusively activated left anterior STS. Thus to conclude, we have show that whilst there is sufficient information to separate intelligible from unintelligible speech across all temporal gyri, the voxels characteristic of a response to intelligible speech which contributed most to classification, were found within the left anterior temporal lobe. As such the univariate and multivariate analyses converged in emphasising the importance of the left anterior, over bilateral posterior, temporal lobe in responding to intelligible speech.

67. 4:45 p.m. - 5:45 p.m.

Quantity matters: Number of feature specifications modulates brain magnetic activity

Scharinger, M., Poe, S., and Idsardi, W.J. University of Maryland, Department of Linguistics, College Park, MD, USA.
Recent neuro-physiological research has provided sensor- and source-space evidence for the neural sensitivity to phonetic and phonological features during speech perception at around 180 ms after stimulus onset (e.g. Obleser, Lahiri, & Eulitz, 2004). Earlier ERP components, such as the N100m/M100, seem to be more sensitive to the acoustic bases of these features, particularly the first formant frequency (F1, cf. Poeppel & Marantz, 2000). Since the M100 is also claimed to initially map extracted features to long- term memory representations, we suggest that the M100 latency is not only modulated by acoustic stimulus characteristics, but also by the number of features to be integrated. The latency of the Mismatch Negativity (MMN) response, on the other hand, should be more sensitive to a featural contrast than to a pure acoustic contrast between standard and deviant. We employed these two diagnostics – M100 and MMN peak latency – in order to test the temporal structure of acoustic and feature-based processing of Turkish vowels. Turkish has a symmetric 8-vowel set, distinguishing between high/non-high, round/non-round, and front/back vowels. Using monovalent feature specifications and assuming coronal underspecification (Kaun, 1993), the least specified Turkish vowel is [ɛ] and the most specified one [u]. Six exemplars of each of the 8 vowels were recorded from a native male Turkish speaker. These vowel exemplars were normalized for loudness (70 dB) and length (200 ms) and used for the subsequent experiments. In Experiment 1 (M100), all vowel exemplars were presented randomly (n=100) to the participants (n=13, all native Turkish speakers) while they lay supine in a 157 channel whole-head MEG scanner (KIT, Japan). Participants had to attend to the vowels and were asked to press a button whenever they heard a friction noise occurring with same probability as the vowels. In Experiment 2, (MMN) the vowels [ɛ], [œ] and [ɯ] were used in a passive odd-ball paradigm. We tested the larger acoustic contrast between [ɛ] and [œ], and the larger featural contrast between [œ] and [ɯ] (cf. Table 1). The results of Experiment 1 revealed a significant positive correlation between M100 peak latency and number of specified features ($F(1,165)=4.74$; $p<.05$), but also an effect of F1 ($F(1,165)=10.60$, $p<.01$). Experiment 2 revealed a significantly earlier MMN peak latency for the large feature distance compared to the large acoustic distance ($F(1,81)=4.80$, $p<.05$), but no effects for deviant F1 or the distance between standard and deviant F1 (all $Fs < 1$). Taken together, the results of Experiments 1 and 2 are best explained by referring to the amount of specified (phonetic) vowel features rather than the acoustic differences in F1. We thus provide further evidence for a temporal sequencing during speech perception where the extraction and integration of phonetic features from the acous-

tic input is followed by an evaluation of these features with respect to their more abstract long-term memory representations (cf. Eulitz & Lahiri, 2004). The nature of these representations is rather symbolic and appears to be detached from their acoustic bases.

68. 6:00 p.m. - 7:00 p.m.
Categorical perception of /s/ and /sh/: An MMN study

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Previous research has extensively explored how phonemic inventories affect the segmentation of the acoustic space for both vowels (Näätänen et al. 1997, Hacquard et al. 2007) and consonants (Phillips et al. 2000, Kazanina et al. 2006). Prior studies on categorical perception, however, have obtained mixed results for the sibilant fricative /s/-/sh/ continuum (Fujisaki & Kawashima 1968, Repp 1981, Healy & Repp 1982). While there was a correlation between the category boundaries in identification and discrimination performance in these tasks, within-category discrimination was better than predicted (Fujisaki & Kawashima 1968, Healy & Repp 1982), suggesting continuous rather than categorical perception. Recent findings on the voiced/voiceless continuum of stops, involving neurophysiological methodologies, support categorical perception and suggest that it is pre-attentive and automatic (Philips et al., 2000), while behavioral studies may attenuate categorical effects by task-dependent strategies. We therefore re-evaluated categorical perception of English sibilant fricatives in a MEG study. For this purpose, we synthesized a /s/-/sh/ continuum in PRAAT (Boersma & Weenink, 2010), using the Klatt Synthesizer platform. We determined the endpoints on the basis of natural productions of /si/ and /shi/, from which we extracted the amplitude envelope as well as the two high frication formants F5 and F6. We mapped the two frication formants to values, which allowed us to obtain an acoustic distance of 3 Barks between /sh/ and /s/ in each band, giving us a psycho-acoustically more accurate scale when compared to previous work. Frication formant amplitudes were held constant for F5 and F6, but attenuated for the lower frication formants. The individual steps of the continuum were created by increasing F5 and F6 in steps of 0.3 Barks (starting from /sh/). A second continuum was created with the same characteristics and step sizes, but with /s/ as starting point. We thus arrived at two continua, spanning the same acoustic distance, but differing on the basis of the category boundary between /sh/ and /s/ in the first continuum, which was clearly discernible from a psychoacoustic behavioral pre-test. The second continuum, in contrast, consisted of within-category exemplars of /s/. Across and within-category exemplars were used in a passive oddball paradigm. Three exemplars, each at the lower and upper side of the two continua, served as standards and deviants and guaranteed acoustic variability in the design. Standards and deviants were presented over earphones while participants lay supine in a 157-channel MEG scanner (KIT, Japan). They passively listened to the fricative stimuli while a silent movie kept them engaged and reduced eye movements. Preliminary results showed a left-dominant amplitude mismatch effect, which was only significant in the across-category continuum ($F=6.63$, $p<0.05$). Further, the mismatch response peaked around 20 ms earlier in the across-category than in the within-category continuum. We interpret these results together with the behavioral findings as evidence for categorical sibilant fricative perception in English. The larger mismatch response in the across-category condition is in line with previous findings and strengthens the hypothesis that phonemic inventories crucially shape the acoustic space for speech sounds, even in higher frequency bands.

69. 4:45 p.m. - 5:45 p.m.
Cortical discrimination of FM sweep direction and duration using multivariate pattern classification

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Evidence from animal neurophysiology and human psychophysics suggest that the primate cortical auditory system is well equipped for identifying the direction of frequency-modulated (FM) sweeps, a critical acoustic component of speech and other conspecific communication signals. Though the notion that there exist specialized populations of FM direction-sensitive neurons in the human cortex is highly plausible, no direct neuroimaging evidence of such populations exists. The current fMRI study used multivariate pattern-classification analysis to assess whether neurons in the human auditory cortex can discriminate upward from downward frequency sweeps, and whether discrimination is affected by sweep duration. Stimuli were either 100 or 400 ms multitone logarithmic FM sweeps consisting of a 5-tone complex with 1/3 octave spacing. In a sparse-sampling procedure, speakers of Mandarin Chinese determined the direction of successive presentations of FM sweep complexes in a random-block design. Contrast analysis showed that despite robust activity in auditory cortex, no regions were found that discriminated up versus down sweeps or between sweep durations. Using multivariate pattern-classification analysis, however, we found that primary auditory areas, bilaterally, successfully discriminated between different sweep durations. Additionally, these regions also discriminated up from down sweeps, but only in the right hemisphere. These findings demonstrate existence of FM-selective networks in

human cortex and emphasize the utility of adjunctive analysis methods such as pattern classification in fully determining the neural response properties of the brain. [Work supported by NIH and NSC-Taiwan]

70. 6:00 p.m. - 7:00 p.m.

Disentangling the neural organization of lexical representation

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Words function as a critical interface for integrating low-level acoustic information with high-level, abstract representations. Despite the importance of words for language theories, the neural organization of lexical representation is not well understood and has proven difficult to study due to 1) the complex relationship between the sound properties of words and 2) the difficulty of connecting them to well-defined meanings. Additionally, it remains unclear if word recognition is mediated by highly distributed neural activations or by localized activations, where many features of lexical knowledge are stored together. To approach these questions, we used fMRI and pattern classification techniques to provide a methodological basis for studying the organization of natural language words and to provide suggestive evidence for the separability of the neural dimensions underlying words. Subjects (n=4) were divided into two groups. Each group was presented with three frequency-matched, monosyllabic, body-part words recorded in natural speech. Words (length=0.8s) were presented in three acoustic modes, which generated nine possible stimulus combinations: sinewave speech, vocoded speech, and unaltered, full-bandwidth speech. Subjects were pre-trained on stimuli and tested to ensure ceiling-levels of identification performance. Stimuli were presented continuously in 20 pseudo-random Type-1, Index-1 sequences with an inter-stimulus interval of 1.5s. This allowed the direct effect of each stimulus on the BOLD response to be estimated, independently of first-order carry-over effects (the repetition-suppression effect that may be present on trial n, as a function of trial n-1). We utilized a sparse logistic regression (SLR) algorithm on whole-brain data that finds pattern classifiers by recursively eliminating voxels without imposing spatial constraints on voxel selection. Within-subject classifiers were sought for 1) the exact item type, 2) acoustic class of item independent of lexical-type, and 3) lexical-type independent of acoustic class (chance = 50%). Classifiers were validated 100 times by training on 80% of the data and testing on the remaining 20% via a jackknifing procedure. Across all subjects, the algorithm successfully learned the relationship between stimuli and fMRI data patterns. Mean classification performance for exact item-type was 84.22% ($p<0.001$). Mean classification performance was 53.33% ($p<0.001$) for lexical-item and 55.44% ($p<0.001$) for acoustic class (Figure 1). This suggests that separating an abstract dimension from a word is more difficult, but possible, than classifying simultaneously along multiple dimensions (e.g., acoustic and lexical). This may reflect either an increasing non-linearity in neural responses or distance from input as higher-level abstractions are considered, or sub-voxel level coding. We are exploring these questions further. Our data indicate that the responses of a small number of voxels can accurately characterize words, at least for words which have semantic properties that are plausibly represented in pre-motor cortex. Furthermore, abstract, separable patterns of activity may underlie the neural representation of words. Most importantly, this study provides the first application of continuous carry-over designs and SLR to study lexical representation. This forms an important methodological foundation for studying distributed patterns of neural activity underlying natural words, while acquiring a robust data-set from a small number of subjects.

References: Aguirre, G. (2007). Continuous carry-over designs for fMRI. NeuroImage, 35, 1480-1494. De Martino, F., Valente, G., Staeren, N., Ashburner, J., Goebel, R., Formisano, E. (2008). Combining multivariate voxel selection and support vector machines for mapping and classification of fMRI spatial patterns. NeuroImage, 43, 44-58. Drucker, D., Kerr, W., Aguirre, G. (2009). Distinguishing Conjoint and Independent Neural Tuning for Stimulus Features With fMRI Adaptation. Journal of Neurophysiology, 101, 1-15. Formisano, E., De Martino, F., Bonte, M., Goebel, R. (2008). "Who Is Saying "What"? Brain-Based Decoding of Human Voice and Speech. Science, 322, 970-973. Yamashita, O., Sato, M., Yoshioka, T., Tong, F., Kamitani, Y. (2008). Spare estimation automatically selects voxels relevant for the decoding of fMRI activity patterns. NeuroImage, 42, 1414-1429.

71. 4:45 p.m. - 5:45 p.m.

Phonologically underspecified mental lexicon and nasal confusability

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The purpose of the present study is to determine the extent to which predictable abstract information about speech sounds is stored in the mental lexicon and how it is processed online. Past studies (e.g., Friedrich et al., 2006) investigated this question by contrasting the processing of coronal consonants (/n /, /d/) that have alternating surface forms (e.g., /n/ pronounced as [n] in rain, [m] in rainbow) with that of non-coronal consonants (/m/, /b/) that do not. Linguistic studies supported the claim that /n/ has an abstract, un(der)specified place of articulation to accommodate alternating surface forms, whereas /m/ has a specified place of articulation. Acoustic perception studies (e.g., Miller and Nicely, 1955) suggest that these experimental findings may instead be explained by the physical similarity of [m] and [n]. To help distinguish these competing explanations of the results of the linguistic studies, we added two factors that were

not previously controlled for: nasality (/n/, /m/ vs. /d/, /b/) and gemination (neutralized geminate nn, dd, mm, bb vs. singleton n, d, m, b; Ghini, 2001). The study had four independent variables: Lexicality (real vs. pseudo word), Coronality (coronal vs. non-coronal place), Nasality (nasal vs. oral manner), and Gemination (neutralized geminate vs. singleton quantity). For each condition, 20 monomorphemic, disyllabic, English nouns were selected from the CELEX lexical database; each noun had stress on the first syllable and a uniqueness point with a coronal (/d/, /n/) or a non-coronal (/b/, /m/) as the first phoneme of the second syllable. A pseudoword was created from each real word by switching the place of articulation from coronal to non-coronal (e.g., picnic to *picmic) or from non-coronal to coronal (e.g., helmet to *helnet). Because acoustic cues for phoneme features might become available at different time points (McMurray et al., 2008), for both real and pseudo stimuli, preceding phoneme's offset (Time 1), target phoneme's burst point (Time 2), and following phoneme's onset (Time 3) were identified using spectrograms. Lexical decision reaction times were measured from these three points and the midpoints of Time Steps 1 and 2 (Time 1') up to a lexical decision button press. Spoken stimuli were presented to (n = 39) participants via headphones. Four 4-way repeated-measures ANOVAs were performed, with reaction times as the dependent variable in a time-step analysis. As predicted by underspecification, the reaction time difference between real and pseudo pairs was larger in the Non-Coronal than in the Coronal condition, demonstrating the place mismatch causing a delay in processing. This Lexicality x Coronality interaction was non-significant at Time 1, but was significant at Time Steps 2 and 3 with a qualitatively different large effect size. This interaction was not qualified by Gemination or Nasality. The Lexicality x Nasality interaction was significant at Time Steps 1 to 3 with a constantly large effect size, demonstrating the Nasal Confusability effect. The lack of three-way interactions suggests that nasality processing and coronality processing might be independent of each other. Moreover, the asynchronous results suggest that perceptual nasality processing might precede abstract coronality processing.

72. 6:00 p.m. - 7:00 p.m.

Using age-appropriated MRIs for more accurate source localization in infants: Event-related responses to consonant-vowel contrasts

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During the first year of life, infants undergo remarkable structural, electrophysiological and behavioral changes. This is particularly true for speech perception and formation of speech sound representation to the native language. Auditory event-related potentials (ERPs) have been used to understand how the infant brain processes linguistic and non-linguistic signals, and to track developmental changes in sensory systems. Source localization, a technique used to identify the loci of neural activation measured at the scalp is increasingly being applied to younger populations. Due to the dramatic structural changes seen during infancy, it would seem justified to use an age-appropriate brain template and parameters to explore the localization of auditory ERP sources in infants. At present, however, the majority of studies use brain templates derived from older children and even adults. Objectives: In this study source localization of the auditory ERP generators to consonant-vowel contrasts were examined. In addition, we describe the methods used to find age-appropriate estimates for skin and skull thickness and subarachnoidal width and for structural conductivity in infancy, measures needed to accurately map ERPs to age-appropriate MRIs. Methods: A group of 28 normally-developing 6-month-old infants were presented with a two-deviant oddball paradigm using three stimuli: 80% of the time a standard consonant-vowel stimulus was presented (phonetically relevant in both English and Spanish), 10% of the time a native deviant (phonetically relevant in English) and 10% of the time a non-native deviant (phonetically relevant in Spanish). Dense-array EEG/ERPs were collected using 62-channel EGI nets. Each child's T1 3D SPGR MRI sequence was acquired during natural sleep, without sedation, in a 1.5 T GE scanner, then processed in BrainVoyager and imported into BESA for source localization. Dipole and discrete source models were combined with individual and averaged infant MRIs. Results: Consonant-vowel contrasts elicited a positive deflection at about 200 ms followed by a negative deflection that peaked around 400 ms, larger in amplitude for the deviants. The source models placed the dipoles at the temporal areas (close to auditory cortex) for both positive and negative deflections. In addition, the positive deflection showed a frontal component near cingulate cortex. When infant parameters were used the source was localized more medially whereas using adult parameters the source was localized more laterally. Conclusions: Using infant MRIs and infant tissue parameters had a major effect on consonant-vowel ERP source localization as compared to using adult MRIs and adult parameters, thus allowing more accurate localization and analysis of speech information processing in infancy.

73. 4:45 p.m. - 5:45 p.m.

The contributions of spectral and amplitude modulations to speech perception: Dissociating acoustic and linguistic responses with fMRI

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We investigated the neural responses to amplitude and spectral modulations in speech, and how these interact with speech intelligibility, with the specific aim of addressing previous claims for hemispheric asymmetries in acoustic and linguistic processes in speech perception. Stimuli derived from the first two formants of simple English sentences, in which modulations of spectrum (S) and amplitude (A) were either (i) absent (S0A0) (ii) applied singly (S0Amod, SmodA0) or (iii) applied in combination (SmodAmod), were presented to normal-hearing adults (N=16) in two functional runs of a passive listening paradigm in fMRI. The SmodAmod items were constructed in two ways – spectral and amplitude modulations from the same original sentence were combined to create intelligible items (SmodAmod(intell)), while versions in which the modulations were taken from different sentences were not intelligible (SmodAmod). All participants received pre-scan training on a set of SmodAmod(intell) sentences. In a univariate analysis, additive responses to spectral and amplitude modulations for the four unintelligible conditions were seen in bilateral superior temporal gyrus (STG), with no clear indication of hemispheric asymmetries in the response profiles (RFX; $p < .05$ FWE; >30 voxels). A comparison between the intelligible and unintelligible versions of the SmodAmod condition (SmodAmod(intell) > SmodAmod) gave a strongly left-dominant pattern of activation along the extent of the superior temporal sulcus (STS) and STG, and in the left inferior frontal gyrus (LIFG). The strongest responses in this contrast for both left and right hemispheres lay in anterior STG, toward the temporal pole (RFX; $p < .05$ FWE; >30 voxels). In order to explore the intelligibility effect further, we carried out a multivariate pattern analysis on the classification of the SmodAmod(intell) and SmodAmod conditions. A linear support vector machine (SVM) was used to train and validate models. There were 3 regions-of-interest analysed: Heschl's gyrus (HG), combined superior temporal gyrus and middle temporal gyrus (STG + MTG), and inferior occipital gyrus (IOG). The temporal regions (HG, STG+MTG) were tested separately for the left and right hemisphere, and left+right in combination, while the occipital control site (IOG) was tested only for the left+right combination. The accuracy of the classifier was estimated by training the classifier on one functional run and testing on the other (and vice versa), with the "true" accuracy estimated by averaging performance across both tests. Early analyses indicate that all STG+MTG regions perform classification significantly above chance (with Bonferroni correction), while both the control region (IOG) and HG perform no better than chance. These results indicate that the two conditions used in our intelligibility contrast are very well matched for acoustic responses in early auditory cortical areas (cf Okada et al., 2010). Okada, K., Rong, F., Venezia, J., Matchin, W., Hsich, I.-H., Saberi, K., Serrences, J. T. and Hickok, G. (2010). Hierarchical organization of human auditory cortex: Evidence from acoustic invariance in the response to intelligible speech. Cerebral Cortex, doi:10.1093/cercor/bhp318.

74. 6:00 p.m. - 7:00 p.m.

Spatiotemporal sequence of auditory cortical activation in the child brain

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Background: Development of the cortical auditory system provides the basis for spoken language skills and, further, for literacy acquisition. The functional development of the auditory system has been studied mainly using electroencephalography (EEG). Development seems to be accompanied by dramatic changes in the timing and morphology of the auditory evoked response (Wunderlich et al., 2006, Hear Res 212:185-202). However, the spatial and temporal characteristics of the neural populations underlying auditory evoked responses have not been described in children. Accordingly, it is difficult to identify corresponding components of auditory responses between adults and children. We studied the sequence of auditory activation in children using magnetoencephalography (MEG) that enables characterization of both the timing and location of activated cortical areas. Importantly, we used a paradigm that allows for separate examination of the ipsi- and contralateral activation in both the left and right hemisphere. Methods: The magnetic signals were measured with a 306-channel whole-head neuromagnetometer (Electa Neuromag), and the activated brain areas were modelled using equivalent current dipoles. The subjects were 19 first-grade students (7-8 yrs, 10 females) and the results were compared to those of adults (10 subjects). The stimuli were 1-kHz, 50-ms sine-wave tones, presented alternatingly to the right and left ears. The interstimulus interval varied between 0.8 and 1.2 seconds. Results: The children showed clearly later and longer-lasting auditory responses than the adults. The earliest response was detected at around 100 ms, with the direction of current flow similar to that in adults at ~50 ms (P50m). It was followed by a prominent and more sustained activation peaking at around 240 ms in the left and at around 250 ms in the right hemisphere, with the direction of current flow similar to that of the adult N100m. In some children, the sustained 250-ms activation was preceded by a transient activation resembling the adult N100m response; this type of response was detected more often in the right than left hemisphere, regardless of the stimulated ear. Conclusions: Our results indicate

that the cortical auditory system is clearly immature in 7- to 8- year-old children. Moreover, there are intriguing hemispheric asymmetries in the auditory responses of children. In previous EEG studies the P50 response was shown to emerge by early school years, whereas the N100 response was detectable later in childhood (Wunderlich et al., 2006, Ceponiene et al., 2002, Clin Neurophysiol 113:870-82). The rightward lateralization of the N100m type of response in our MEG study indicates a maturational lag in the left-hemisphere auditory cortex. Faster maturation of the right than left hemisphere would be in line with both postmortem (Chi et al., 1977, Arch Neurol 34:346-8) and in-vivo experiments (Dubois et al., 2008, Cereb Cortex, 18:1444-54) showing earlier emergence of gyral complexity in the right than left hemisphere in preterm infants. It is tempting to speculate that this hemispheric asymmetry in cortical maturation is relevant also for language development, but follow-up studies are needed to better understand the development of auditory responses in the two hemispheres and its link to behavioural skills.

75. 4:45 p.m. - 5:45 p.m.
High-frequency EEG correlates of rhythmic attending in song perception
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Singing is a universal human behavior that had received little attention in cognitive neuroscience until recently. Composers tend to incorporate linguistic prosody when setting words to melody, so that expected linguistic stress coincides with strong metrical positions in the music. The present study was designed to explore the idea that temporal alignment serves to capture attention and help listeners better understand song lyrics. To shed light on this phenomenon, three types of stimuli were created by aligning metronome clicks with all (well-aligned), some (varied), or none (misaligned) of the strong syllables in sung sentences. Electroencephalogram (EEG) was recorded from 16 participants while they listened to the sung sentences (primes) and performed a lexical decision task on subsequently presented visual targets (words and pseudowords). The EEG data was analyzed with wavelet-based time-frequency transformations, and a cluster-based randomization method was applied to assess statistical significance. Results showed that the induced beta and evoked gamma power, which have been shown to peak at the onset of metrically strong tones in rhythmic sequences, increased significantly when strong syllables occurred on strong beats (well-aligned). Interestingly, weak syllables occurring on strong beats (misaligned) were associated with decreased induced beta and evoked gamma power, suggesting that beat tracking is disrupted by lack of alignment. Moreover, strong syllables occurring on weak beats (misaligned) also elicited a delayed peak in evoked gamma power, suggesting that listenersí attention has shifted toward strong syllables, as predicted on the basis of studies showing that attention is preferentially allocated to strong syllables to facilitate speech segmentation. In addition, targets that followed well-aligned sentences elicited greater power in induced alpha and beta activity compared to targets that followed misaligned sentences. These modulations may be related to increased attentional demands for linguistic processing in misaligned sentences, due to the conflict between expected stress patterns in the prime. Since induced beta desynchronization (i.e., decreased power) was also observed for misaligned syllables in the primes, it is possible that these beta fluctuations reflect either rhythmic syncopation or linguistic binding mechanisms involved in sentence comprehension. Finally, task performance was adversely affected when visual targets followed misaligned and varied sentences. Overall, these findings suggest that alignment of linguistic stress and musical meter in song enhances beat tracking and linguistic segmentation by entraining periodic neural oscillations to the stimulus. This approach may begin to explain the mechanisms underlying the relationship between linguistic and musical rhythm in songs, and how rhythmic attending facilitates learning and recall of sung language. Moreover, the observations reported here coincide with a growing number of studies reporting interactions between the linguistic and musical dimensions of song, which likely stem from shared neural resources for processing music and speech.

76. 6:00 p.m. - 7:00 p.m.
Motor cortex is not selectively activated by speech sounds
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While there have been several demonstrations that motor regions can be driven by acoustic stimuli, the ways that this activation might parallel the neural responses seen in auditory areas is not known ñ for example, can motor regions be shown to show selective responses to speech stimuli? To establish whether motor and auditory cortical fields respond in similar or distinct ways to mouth sounds, we used fMRI to investigate their response profiles to naturally produced examples of familiar speech and non-speech mouth sounds. The speech sounds used were unvoiced consonants, and the non-speech sounds were ingressive 'click' sounds, which are consonants in some African Languages. Click sounds cannot be assimilated into English phonetic categories, and are processed as non-speech sounds by English speakers (although the clicks we utilized can be recognized and produced by English speakers). Signal-correlated noise versions of the mouth sounds were also presented, a transformation that preserves the overall amplitude envelope of a sound. There was a differential sensitivity to the mouth sounds in auditory areas, with greater activation to the speech sounds mid superior temporal gyri/sulci, and a greater response to non-speech mouth sounds in posterior medial planum

temporale. In contrast, motor cortex responses were equivalent to speech and non-speech mouth sounds. These results suggest that there are qualitative differences in the ways that temporal and motor areas were activated by different sounds: the temporal lobe areas being sensitive to the acoustic/phonetic properties of the sounds, while the motor responses showed more general responses to the acoustic stimuli.

77. 4:45 p.m. - 5:45 p.m.

Categorical perception results from clustering of hypermodal neural representations of sounds and syllables: Evidence from computer simulation experiments

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Objective: Categorical perception is assumed to be a typical feature of human speech processing. It already has been shown that categorical perception is more pronounced for consonants than for vowels, which has been underlined quantitatively by a smaller difference of measured vs. calculated discrimination for consonants compared to vowels. A recently developed quantitative computer-implemented neurophonetic model of speech production and perception was capable to reproduce these behavioral results. Hence, we used that model in order to test the hypothesis that the difference in categorical perception of consonants and vowels can be attributed to differences in the topological organization of neurons representing vocalic and CV-syllabic states (C = consonant; V = vowel) within a hypermodal ìphoneticî cortical map; A phonetic map is assumed to represent phonetic features of single vowels and frequent syllables in that model and is assumed to be strongly connected to motor, sensory and phonemic cortical maps. Method: 20 ìvirtual listenersî (i.e. 20 instances of the neurophonetic model) were trained in order to learn a ìmodel languageî comprising a five-vowel-system (/i/, /e/, /a/, /o/, /u/), a three-consonant-system (/b/, /d/, /g/) and the resulting 15-CV-syllable-system by passing a babbling and imitation phase of speech acquisition. After training, behavioral identification and discrimination experiments were performed for a vocalic /i/-/e/-/a/-stimulus continuum (13 stimuli) and for a consonantal /ba/-/da/-/ga/-stimulus continuum (13 stimuli). Results: It came out that the difference of measured and calculated discrimination is less for consonants than for vowels; i.e. categorical perception is stronger for consonants than for vowels. Thus, in addition a cluster analysis was performed for all neural states representing the 13 vocalic and the 13 CV-stimuli within the hypermodal phonetic map. For the 13 CV-stimuli, a clustering of its neural correlates appeared in 48 of 60 cases (80%), while such a clustering only appeared in 22 of 60 cases (37%) for the V-stimuli. Conclusions: The quantitative neurophonetic model of speech production and perception used in this study allows a direct comparison of functional behavioral data (e.g. results of identification and discrimination experiments) to the underlying neural functioning. In our case this comparison indicates that categorical perception co-occurs with a clustering of neural states which represent the test stimuli on the level of a hypermodal phonetic neural map. These resulting neuron clusters can be interpreted as phoneme regions. fMRI experiments are planned in order to support these results by biological data.

78. 6:00 p.m. - 7:00 p.m.

An MMF asymmetry in processing illicit onset consonant clusters

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We present novel evidence from MEG that phonotactic constraints are operative at an early stage in processing and which suggests that ill-formed consonant clusters have a degraded representational status compared to well-formed counterparts. Using monosyllabic tokens with consonant cluster onsets not present in English ([mleb] and [mdeb]), which we refer to as ill-formed, and fully licit, well-formed disyllabic counterparts of these ([meleb] and [medeb]), we find that monosyllabic tokens with clusters that violate a sonority constraint ([mdeb]]) elicit a smaller magnetic mismatch field (MMF) than those that do not violate such a constraint ([mleb]]), despite the ill-formedness of both tokens. Importantly, we find an asymmetry in whether an MMF is elicited depending on the position of the ill-formed token in the stimulus. No MMF is elicited when an ill-formed token is in the standard position in an oddball paradigm. We take this to suggest that ill-formed tokens have neural representations that are degraded when compared to well-formed tokens. Sonority is a property of speech sounds that is associated with their relative loudness and resonance. Across languages, it has been observed that in word-initial consonant clusters, less sonorant sounds, like [d], tend to be followed by more sonorant sounds, like [l], and not the reverse (e.g., [dl] is more common than [ld]). This preference for an increasing sonority slope across a cluster has been called the sonority sequencing constraint (SSC). Using MEG and the MMF response, we investigate whether a preference for consonant clusters of rising sonority resulting from the SSC is reflected in early automatic processing in the auditory cortex. Berent et al. (2008), in a behavioral study, found that Korean speakers perceived monosyllabic words with word-initial consonant clusters of falling sonority, but not rising sonority, as disyllabic, suggesting a possible repair operation that inserted an epenthetic vowel in these clusters. Because in Korean all consonant clusters are illicit word-initially, Korean speakers should have no experience-based preference for rising or falling sonority in word-initial clusters. The present study attempts to replicate the findings of the previous study in the neural response using word-initial clusters of rising and falling sonority that are illicit in English

([ml], [md]). We employ an MMF-eliciting oddball design comparing the neural response to [mleb] and [meleb] in the rising sonority condition and [mdeb] and [medeb] in the falling sonority condition. Stimuli were created by recording disyllabic tokens ([meleb] and [medeb]) and splicing out the first inter-consonantal vowel, producing monosyllabic [mleb] and [mdeb]. Native English-speaking participants (n=12) passively listened to stimuli presented in an oddball paradigm during MEG recording (160-channel whole-head-axial-gradiometer MEG system; KIT, Japan). Four blocks were run: two using monosyllabic tokens as the standard and two using disyllabic tokens as standard. We find that the rising sonority and falling sonority tokens elicit an MMF with an onset at 200ms when a disyllabic token is in the standard position ($p < 0.05$). However, no MMFs are elicited when an ill-formed monosyllabic token is in the standard position ($p > 0.05$). When MMFs are elicited, the amplitude of the MMF elicited by a rising sonority token is greater than that elicited by a falling sonority token, suggesting that participants are better able to perceptually distinguish [mleb] from [meleb] than [mdeb] from [medeb], in agreement with the Berent et al. (2008) results. We conclude that linguistic constraints come online early and play an active role in auditory processing and that phonotactically ill-formed clusters do not yield reliable representations.

79. 4:45 p.m. - 5:45 p.m.

Neural systems for individual differences in phonological short-term memory

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Neuroimaging studies of the neural networks underlying performance in different stages of phonological short-term memory (pSTM) have revealed distinct pattern within the frontal-temporal-parietal network. While brain activity during encoding reflects largely the sensory characteristics of the information, activity during maintenance would reflect the active manipulation of information and other executive processes, like rehearsal grouping and chunking processes. This network includes sensory and motor regions (superior temporal cortex, motor and supplementary motor areas (SMA)), frontal regions (inferior frontal gyrus (IFG), dorsolateral prefrontal cortex (DLPFC) and superior frontal cortex) and inferior parietal cortex (IP) (Wagner and Smith 2003). We used fast event related functional Magnetic Resonance Imaging (fMRI) to assess neural activity during the three main stages of a pSTM task: encoding, maintenance, and recall. The task used was auditory verbal cued pseudo-words repetition. In order to assess memory load effects, we used three different length sequences: 3, 4 or 5 pseudo-words. Participants listened to a sequence and at the end of each sequence a visual cue indicated the task to perform: forget the sequence (encoding only), rehearse silently (encoding then maintenance) or recall (encoding, maintenance and recall). This paradigm allows us to separate brain activity during encoding, maintenance and recall. Since participants only knew the task required at the end of the sequence, the cognitive processes during encoding are the same for all three conditions. Results obtained in 20 right-handed native English speakers highlighted an extended frontal-temporal-parietal network. Encoding engaged bilateral regions of the middle temporal gyrus, inferior temporal regions, frontal regions (inferiorly and superiorly), premotor cortex, occipital regions and SMA. Recall engaged bilateral regions of the superior temporal gyrus, premotor cortex and SMA. Silent rehearsal elicited activation in bilateral prefrontal regions with left dominance, in the left inferior parietal lobule, in the cerebellum and SMA. In higher load conditions (4 and 5 pseudo-words), we also observed activation in DLPFC. The load effect during encoding reflects an auditory acoustic load only, as it is restricted to the auditory cortices (Figure 1). The load effect during maintenance appears in DLPFC, bilateral premotor cortex, insula, cerebellum and the SMA, and reflects the active information maintenance during silent rehearsal (Figure 2). Individual differences in correct recall performance showed positive correlation with brain activity during rehearsal in two regions: the left precentral gyrus and the left inferior parietal lobule (Figure 3). Individual differences in pSTM capacity thus appears to be linked to dorsal stream processes involved in mapping heard speech onto articulatory mechanisms.

80. 6:00 p.m. - 7:00 p.m.

Speech perception in the brain: A transcranial magnetic stimulation study

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This study examines the role of the premotor cortex (PMC) in processing spoken language. The aim is to establish the necessity of the PMC in the perception of spoken language, using rTMS to the PMC, posterior superior temporal gyrus (pSTG) and a control site, left occipital pole (OP). It is predicted that, if motor representations are involved in phoneme judgements, but not comprehension, rTMS to the PMC should produce slower reaction times, relative to baseline, on a phoneme judgement task, but should not affect performance on a semantic task. The pSTG site should slow RTs for both semantic and phonological judgement tasks as it contains auditory association cortex. The motor theory of speech perception states that brain areas involved in producing speech, such as the PMC, also participate in processing spoken language (Galantucci et al., 2006). Neuroimaging studies have provided some support for this theory (i.e., Watkins & Paus, 2004), but cannot conclude that the motor cortex plays a necessary role in this process. Recent TMS research confirms that the PMC has a role in explicit phoneme perception tasks. Existing studies have only examined phoneme perception tasks which are not a naturalistic assessment of speech perception and which may involve cogni-

tive control and metalinguistic knowledge. For example, Meister et al. (2007) required participants to discriminate voiceless stop consonants in single syllables (consonant-vowel syllable in noise), post rTMS to PMC. They found that left PMC is involved in the perception of speech, as TMS to the PMC disrupted speech discrimination relative to baseline. Mottoenen and Watkins (2009) applied rTMS to the lip area of the motor cortex (left M1) measuring whether the motor representations of articulators are involved in the categorical perception of speech, in a 2AFC task. Using rTMS they impaired categorical perception for speech sounds involving the lips, implicating a role for the PMC in the processing of speech. Although these TMS studies indicate that PMC plays an essential role in phoneme judgements, other aspects of speech processing, such as mapping sounds onto meaning, may proceed without the involvement of motor speech areas. The current study aims to use rTMS to modify performance on two tasks, involving phoneme and semantic judgements. This study involves two alternative forced choice tasks: two speech perception tasks and a visual control task. The phonological task requires participants to identify how a heard word ends (i.e., 'p' or 't' for 'chat'). The semantic task requires participants to choose which category a heard word falls into (i.e., 'action' or 'object' for 'chat'). The scrambled picture control task involves choosing which of two pictures matches the target picture. The data for this experiment are currently being collected, but will be analyzed and discussed by the conference date. The results of this experiment will be interesting, both if the hypothesis is supported or refuted, in that in both cases something about areas that are or are not crucial to language processing will be revealed.

81. 4:45 p.m. - 5:45 p.m.

Differential cortical processing of words and pseudowords – evidence from intracranial recordings

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Cortical processing of single words has been extensively investigated in humans. While several studies have identified cortical sites differentiating intelligible and non-intelligible speech it remains unclear whether these regions are sensitive to lexical-semantic attributes. Investigations of word and pseudoword stimuli to date have shown little evidence of dissociated activity. Using sub-dural recordings we provide evidence for differential cortical processing of words and pseudowords in several regions of the human neocortex. We recorded electrocorticographic activity (ECoG) directly from the cortex of patients undergoing neurosurgical treatment. The subjects participated in a word repetition task and were instructed to repeat every word they heard. Word stimuli consisted of 23 pseudo-words, 23 real words and 4 proper names. Words and pseudowords shared similar acoustic, phonetic and phonotactic probability attributes. All five subjects showed robust cortical responses (ΥHigh: 70-150 Hz) locked to stimulus onset commencing in the temporal lobe and subsequently spreading to inferior parietal cortex, inferior frontal gyrus and lastly to motor cortex. Several cortical sites including the superior temporal gyrus, inferior parietal lobule and Broca's area exhibited differential responses to words and pseudowords as early as 400 ms post stimulus onset lasting up to articulation. Furthermore, a connectivity analysis of these regions exhibited differences in low frequency coupling (θ: 4-8 Hz) between the word and pseudoword stimuli. Our findings provide evidence for a distinct cortical network that is sensitive to lexical-semantic attributes during word processing. Supported by NINDS grants NS21135, PO40813, NS061552 and NS40596.

82. 6:00 p.m. - 7:00 p.m.

Acoustic-phonetics of coronal vs. non-coronal stops and nasal confusability

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Two currently competing theories for the rain/rainbow puzzle in speech processing are the Abstract Linguistics Account and the Acoustic Perception Account. The former argues that predictable, abstract information about speech sounds may not be stored in the mental lexicon. To determine to what extent this hypothesis is true, participants are typically presented with audio recordings of real/pseudo words in which the pseudo word is a manipulated form of the real word (e.g., picnic → picmic; helmet → helnet) (e.g., Friedrich et al., 2006). In the current study, to confirm whether these lexicality manipulations are successful, spectrogram analysis (N=314) was performed on audio recordings of words where Lexicality was crossed with coronality, nasality, and gemination. Specifically, F2 frequencies (Hz) and intensity (dB) were measured for three acoustic events - the offset of the preceding phoneme (Time 1), the target burst point (Time 2) and the onset of the following consonant (Time 3) along with the midpoint of its closure period (Time 1i) - because the relative frequencies of F2 are affected by place of articulation and nasality (Hon, 2002), whereas the relative burst intensities are affected by nasality. If the Lexicality manipulations were successful, the F2 frequency distribution between real and pseudo words should be complementary, and a clear-cut boundary should exist

at 1800 Hz for real vs. pseudo F2 frequencies. Furthermore, two assumptions of the theories were investigated. A version of Phonological Underspecification qualifies the claim of absolute underspecification, arguing that geminates that are neutralized in duration to their singleton counterpartsí are specified, whereas singletons are underspecified (Ghini, 2001). Consonant closure duration was compared between geminate and singleton consonants. Acoustic Perception Account argues for Nasal Confusability ñ specifically, that nasal consonant pairs are more confusable than orals pairs (Miller and Nicely, 1955). The degree of difference of acoustic correlates should be smaller for the nasal real/pseudoword pairs than for the oral real/pseudoword pairs. As expected, a Lexicality x Coronality crossover interaction for F2 was observed: in the coronal condition, F2 was higher for real words than for pseudo words; in the non-coronal condition, F2 was lower for real words than for pseudo words; this effect was significant at all the three acoustic events, but with effect size changing along the time course in an inverted-U curve. The predicted boundary between real and pseudo words emerged, with more overlap for nasal pairs than for oral pairs, significant at Time 1. Regarding burst intensity, a strong effect of nasality was observed. The Lexicality x Coronality x Nasality interaction was observed at Time 1í, Time 2 and Time 3, suggesting that the nasal confusability by intensity difference started at later time steps of acoustic events than the coronality F2 cue did. Geminate neutralization was found to occur for closure duration. These results are of methodological value, suggesting that multiple time-point locking is necessary in any study involving reaction times and event-related potentials in response to cues made available at different time steps and with different magnitudes along the time course of acoustic events.References: Friedrich, C. K., Eulitz, C., & Lahiri, A. (2006). Not every pseudoword disrupts word recognition: an ERP study. Behavioral and Brain Functions, 2, 36. Ghini, M. (2001). Asymmetries in the Phonology of Miogliola. Berlin: Mouton de Gruyter. Hon, E. (2005). An Acoustic Analysis of Labialization of Coronal Nasal Consonants in American English. (Masterís Thesis, Massachusetts Institute of Technology). Retrieved from dspace. mit.edu. Miller G. A. & Nicely, P. E. (1955). An analysis of perceptual confusions among some English consonants. Journal of the Acoustical Society of America, 27, 338-352.

83. 4:45 p.m. - 5:45 p.m.

Song-sensitive and song-selective regions of the human brain

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Song, like speech, occurs in every human culture. Both use structured patterns of pitch, rhythm, and timbre, yet they have many acoustic differences and are easily distinguished. Furthermore, singing and speaking can be dissociated after brain damage (e.g., preserved singing in nonfluent aphasia). How different are their underlying neural mechanisms? Several prior functional magnetic resonance imaging (fMRI) studies have compared song and speech (in perception, production, or both). Broadly, these studies have found widespread overlap, as well as some regional specificity for song. However, none has clearly distinguished brain regions uniquely activated by song ("song-selective" regions) vs. those activated by both domains but more strongly by song than by speech ("song-sensitive" regions). This distinction requires the comparison of song, speech, and a baseline condition (e.g., rest), and is relevant for understanding how song and speech differ as well as overlap in the brain. The goal of the current study was to identify song-sensitive and song-selective regions of the human brain. 16 right-handed native Japanese speakers underwent fMRI at 3T while hearing or producing familiar Japanese songs, either in sung or spoken form. Rest served as the baseline. In the perception task, RMS energy and syllable rate was matched across the song and speech conditions. In the production task, covert production was used to avoid motion artifacts and to avoid auditory feedback of the subject's own voice. Functional T2*-weighted images were acquired using a gradient echo-planar imaging sequence in a block design. Regional brain activity for the different conditions was assesses using statistical parametric mapping SMP2 with a mixed effects model. Song-sensitive regions were defined as those showing significant activation to speech vs. baseline AND which showed significantly stronger activation to song than speech. Song-selective regions were defined as those showing significant activation to song vs. baseline AND no significant activation to speech vs. baseline. In perception, song-sensitive regions occurred bilaterally, in the superior temporal gyrus (STG) and auditory cortex (BA22 and 41). Song-selective regions for perception occurred in right pre-supplementary motor area (BA6), right basal ganglia (globus pallidus), and left cerebellum. These motor activations in a purely perceptual task may indicate that hearing song triggers internal singing / mirroring of the sung melody. Further song-selective regions for perception were found bilaterally in STG, near the song-sensitive regions mentioned above. In production tasks, no-song sensitive regions were found. Three song-selective regions were found, all in the right hemisphere: auditory cortex (BA42), insula (BA13), and right cerebellum. Previous work has identified the right hemisphere insula as involved in overt singing (vs. speech) but the current study found activation in this area in a covert task, raising new questions about its functional role in song. Overall, the findings of this study support the view that song involves a number of brain regions not engaged by speech processing, as well as driving certain "speech areas" of the brain at higher rates of metabolic activity. The study also demonstrates that hemispheric lateralization of song vs. speech is stronger for production than for perception.

84. 6:00 p.m. - 7:00 p.m.

Efficient coding of speech in the auditory cortex

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The efficient coding (EC) hypothesis states that at each level of processing, perceptual systems have evolved to represent their input in a way that optimally balances efficiency and fidelity. This hypothesis is broadly supported by the fact that EC-based computational models of the statistical structure of perceptual inputs across levels and modalities learn representations that are functionally similar to the analogous perceptual systems. With some notable exceptions (e.g. Karklin & Lewicki, Neur. Comp., 2005; Smith & Lewicki, Nature 2006), work in this area has focused on vision. Speech perception provides a unique opportunity to push these models further into the domain of audition, as well as to use them to shed light on what continues to be a deeply difficult problem in cognitive science. Understanding speech perception requires linking the rich perceptual structure of the speech signal to the underlying linguistic categories, which are themselves not fully understood. EC models are a promising candidate for such a link, being models of generalization and abstraction that are neurobiologically-plausible. By shedding light on how and why the perceptual system generalizes over inputs, EC models can point the way towards a neural theory of linguistic categories at the level of single segments. To this end, I investigated an EC model of how speech is processed at the level of the primary auditory cortex. Speech samples from the TIMIT corpus were preprocessed using a model that simulates the processing that occurs before the signal reaches the cortex, and were then used to train Hurri and Hyvarinen's (2003) temporal coherence model. This model learns an efficient code for the input by maximizing the squared activation of each unit over a time window, thereby taking advantage of speech's inherent temporal structure. This model learned to represent speech in a way that is functionally similar to the spectro-temporal receptive fields (STRFs) of single units in the mammalian primary auditory cortex (A1). The learned representations exhibit a range of frequency-, rate-, and bandwidth-sensitivity (figure). More importantly for the analogy with biological STRFs, the learned representations exhibit temporal symmetry, a pervasive property of A1 neurons, indicated by the greater correlation between their rank-2 and quadrant-separable (QS) approximations than between rank-4 and QS ($r=0.92$ vs $r=0.85$, $p<0.001$, see Simon et al., 2007, Neur. Comp.). The extent to which the learned representations might aid in speech recognition was evaluated with a classification task. Using a 10-nearest neighbor classifier, the identities of 1,748 segments were identified with 11.5% accuracy using the EC representations, substantially better than chance (1.7%) and the cochlear representations (5.6%). Thus, representations of speech learned by an EC model not only correspond to the way that such signals are represented in the auditory cortex but also approaches the underlying linguistic structure of the signal. This is particularly striking given that the algorithm used is both linguistically and neurobiologically naive. While this work clearly has much further to go, it constitutes progress towards a convergence of biological, computational, and linguistic understanding of speech perception and language in general.

85. 4:45 p.m. - 5:45 p.m.

Abnormal brain activation patterns in developmental stuttering during listening and covert reading

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Previous functional imaging studies involving overt speech tasks have identified abnormal activity in the language and motor areas of people who stutter (PWS). One study using PET in four PWS suggested that stuttering-related brain activation patterns could be replicated using covert speech (Ingham et al., 2001). Abnormal brain activity observed during covert speech could be considered characteristic of the stuttering brain rather than simply reflecting differences related to the motor symptoms that accompany stuttered speech. The present brain imaging study was designed to examine whether covert speech produced the same abnormal brain activation patterns as overt speech in PWS. In twelve PWS and 17 controls, functional MRI was used to investigate the neural correlates of (i) reading covertly, (ii) passive listening and (iii) reading covertly while listening to the same sentence. In overt speech, stuttering frequency can be dramatically reduced when reading in unison with another speaker, so the third condition was used to mimic this 'chorus effect' for covert speech. For group comparisons, peaks were considered significant at a voxel threshold of $Z>2.3$, $P<0.001$, uncorrected. The reading covertly condition revealed reduced activity in the inferior frontal gyrus (IFG) bilaterally and in the left sensorimotor cortex in PWS relative to controls. While listening to speech, PWS showed increased activity compared to controls in the superior temporal gyrus (STG) bilaterally. During chorus reading, PWS showed reduced activity relative to controls in the putamen and the supplementary motor area (SMA) bilaterally as well as in the left IFG, pars triangularis. The observation of increased activity in the STG bilaterally contrasts with findings from previous studies that robustly report a reduction of activity in the STG in PWS relative to controls during overt speech tasks. It is assumed that this reduction is due to inhibition of auditory areas during self-produced speech. Our findings suggest that the auditory cortex in PWS is abnormally overactive during speech perception alone. The abnormal activity observed in the putamen and the SMA of PWS is consistent with the hypothesis that stuttering

is associated with impairments of the basal ganglia and specifically its outputs to the SMA (Alm 2004). Our data support the conclusion that abnormal neural activation in PWS in speech areas, the basal ganglia and premotor areas can be observed even during covert speech tasks. Yet, these stuttering-related activations and deactivations are different from the neural signatures of stuttering observed previously during overt speech tasks.

Production

86. 6:00 p.m. - 7:00 p.m.
Differential brain activation for the perception and production of lexical items--modality matters

Deschamps, I. (1), Klepousniotou, E. (2), Baum, S. (1), Pike, G. (1), and Gracco, V. (1,3). 1. Centre for Research on Language, Mind & Brain, McGill University, Montreal, Quebec, Canada. 2. University of Leeds, Leeds, UK. 3. Haskins Laboratories, New Haven, CT, USA.

The cortical motor system of primates contains multiple body representations within regions of the frontal lobe. Based on anatomical and functional considerations multiple representations have been associated with different functions. The more rostral prefrontal cortex is associated with cognitive functions while the more caudal frontal cortex is associated with the control of movement. For spoken language production a core sensorimotor network involving only the caudal frontal regions (BA 4, and lateral and medial BA 6) are activated for repetition of heard speech (Gracco et al., submitted). In contrast, word generation, a more cognitive task, recruits more rostral prefrontal regions including the inferior frontal gyrus and pre-SMA. A number of recent functional imaging studies have demonstrated that within both rostral and caudal regions, similar or overlapping areas are activated for both speech production and speech perception. In the present study we examined the differentiation and overlap in the production and perception of the same lexical items when evoked in different manners and sensory modalities. Our analysis focused on two different but overlapping issues: 1) whether the manner and modality of stimulus presentation during single word production recruited different frontal and prefrontal areas, and 2) whether these same areas are activated when subjects are passively exposed to the same stimuli. METHODS Tasks: Fifty lexical items (all nouns selected from the Snodgrass and Vanderwart set) were presented either in written, picture or auditory form. Three conditions (rest, passive stimulus presentation and overt word production) of ten trials each were blocked with the order of presentation counterbalanced across subjects. Prior to each block subjects were instructed to either passive view or listen to the stimuli or they were instructed to name the picture, read the word aloud or repeat the auditory word. A rest condition was interspersed and subjects were instructed to lay quietly with eyes open to a blank screen. All stimuli and subject responses were timed to occur during the silent interval. Subjects: Ten right-handed adults (average age=26 years) balanced for gender. Scanning: Thirty six 4x4x4 mm axial slices were acquired on the 3 T Siemens Trio scanner at the Montreal Neurological Institute in 2.16 sec with a 2.84 sec silent interval (TR=5 sec). All stimuli were presented and all responses were produced during the silent interval. All speech responses were recorded directly to disk. Each session included two experimental runs and a high-resolution anatomical image. TR = 5 sec. Three conditions (rest, passive stimulus presentation and overt word production) were used and presented in blocks with the order of presentation counterbalanced across subjects. Subjects listened to words, viewed written text or viewed black and white line drawings representing the same lexical items. In the speech production condition, the same stimuli were presented and the subjects were instructed to repeat the heard word, read the written text aloud or name the picture. No visual or auditory stimulation (other than scanner noise) was present during the rest condition. A sparse sampling design with a silent interval was used. Overall, the caudal frontal motor areas were activated for each production task. The most consistently activated areas included the primary motor cortex and the medial and lateral premotor cortices (BA 6). However, each task resulted in modifications in activation magnitude suggesting that while the different sensory inputs converge on the same frontal motor regions, the projections are not equivalent. As in our previous work, repetition of heard speech did not activate caudal frontal regions while picture naming and word reading did. Substantial differences were noted in medial BA 6 (SMA) across the elicitation conditions with the repetition and reading condition yielding less SMA activation compared to picture naming. Finally, passive listening, viewing of pictures and reading words resulted in activation in any frontal regions dependent on stimulus modality. In addition to the frontal areas, we also identified a number of parietal and temporal regions that contribute to the overall network activation for speech that depend on the manner in which the lexical items are presented suggesting domain specific regions for storage of lexical items and transforming visual or auditory input into motor output.

87. 4:45 p.m. - 5:45 p.m.

Mirror mechanisms and predictive sensorimotor of coding during vowel perception and production: A sparse- sampling adaptation fMRI study

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Recent studies on mirror mechanisms and motor control have provided evidence for sensorimotor interactions in both speech production and perception. During speech production, decrease neural responses observed within the auditory and somatosensory cortices are thought to reflect feedback control mechanisms in which sensory consequence of the speech-motor act are evaluated with actual sensory input in order to further control production. Conversely, motor system activity observed during speech perception has been proposed to partly constrain phonetic interpretation of the sensory inputs through the internal generation of candidate articulatory categorizations. To identify possible sensory-to-motor and motor-to-sensory loops involved in predictive coding during both speech perception and production, we used a repetition suppression paradigm while measuring neural activity with functional magnetic resonance imaging. This adaptation paradigm refers to decreased activity in specific neural population due to either repeated motor acts or perceptual stimuli and has been proposed to reflect reduced prediction errors by means of top-down projections. In a first task, participants passively listened to 9 vowels (/i/, /y/, /u/, /e/, /ø/, /o/, /ɛ/, /œ/ and /ɔ/) previously recorded from their own voice. In a subsequent task, they produced the same vowels according to visual instructions. To determine adaption effects, each vowel occurred six times in a row in both tasks. In order to minimize scanner noise and movement-related imaging artifacts, a sparse sampling acquisition technique was used where vowel perception or production occurred during a silent interval between successive image acquisitions. To minimize possible covert motor simulation, the passive perception task was first performed in separate functional runs with the participants just being instructed to pay attention to the auditory stimuli. A conjunction analysis performed at the group-level showed common activations in the superior temporal gyrus and around the posterior part of the superior temporal sulcus (pSTS) bilaterally. Crucially, neural responses in the IFG, bilaterally, the left pSTS, the left inferior parietal lobule (IPL) and the anterior cingulate gyrus were suppressed during both repeated vowel production and perception. Compared to the perception task, the suppressed responses observed during vowel production however differed in terms of magnitude and response curves and therefore cannot only be attributed to auditory feedback. The observed common brain areas sensitive to phoneme repetition during both perception and production provide evidence for mirror perceptuo-motor mechanisms involved in predictive coding and further highlight the sensorimotor nature of speech representations. References : Grabski, K., Lamalle, L., Schwartz, J.-L, Vilain, C., Vallée, N. Troprès, I., Baciu, M. Le Bas, J.-F & Sato, M. (2010). Neural correlates of vowel perception and production. 16th Annual Meeting of the Organization for Human Brain Mapping, June 6-10, Barcelona, Spain.

88. 6:00 p.m. - 7:00 p.m.

The effect of articulatory complexity in audio-visual speech perception and production: An fMRI study

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Intro: It has been shown that passive listening to speech sounds activates frontal motor regions within and around the ventral premotor cortex (PMv), suggesting a role for the motor system in speech perception (Wilson et al., 2004, 2006; Skipper et al, 2005), and supporting the existence of a human observation/execution matching system. Interestingly, other studies have found that repetitive TMS to PMv has little or no effect on participantsí ability to perceive/categorize speech sounds in the absence of ambient noise (Sundara et al., 2001; Sato, Tremblay and Gracco, 2009), suggesting that motor system involvement is not critical for speech perception. The goal of the present study was to further investigate the role of the motor system in speech perception and production by examining brain activation during passive observation of an actor producing simple and complex words and during overt repetition of other (matched) words. Methods: 21 right-handed native English speakers participated in this fMRI study, which consisted of two tasks: (1) passive observation of an actor producing single words, and (2) observation and subsequent repetition (imitation) of words produced by the same actor. Participants always completed the observation task first, and they did not know ahead of time that they would be required to speak. The stimuli were 120 short videos of a female actor articulating a set of simple (i.e. contained no consonant cluster) and complex nouns (i.e. contained 1-3 clusters) that were matched for number of syllables, concreteness and familiarity. The data were acquired on a Siemens 3.0T Trio MRI scanner (32 axial slices, 3*1.7*1.7 mm, TR = 2sec). Images were spatially registered, motion-corrected, time-shifted, de-spiked and mean-normalized using AFNI. We used FreeSurfer to create surface representations of each participantís anatomy. Data were smoothed on the surface using SUMA with a Gaussian 6-mm FWHM filter. We conducted a 2*2 mixed model ANOVA with repeated measurements on tasks and complexity. We also examined the conjunction of all tasks. Results and discussion: Preliminary whole-brain analysis results showed no activation in the primary motor cortex during passive observation. However, PMv was active in the conjunction of all tasks. Moreover, it was modulated by motor com-

plexity during both speech perception and speech production (fig.1). Overall, our results suggest not only that PMv is involved during passive observation tasks but also that its activation is related to articulatory/phonological processes. These results suggest a role for PMv in speech perception.

89. 4:45 p.m. - 5:45 p.m.

Converging to a common speech code: Automatic imitative and perceptuo-motor recalibration processes in speech communication

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Unintentional imitation is one of the major processes by which humans smooth social interactions. Such convergent behaviors also occur during speech communication, as highlighted by our tendency to automatically 'imitate' a number of phonetic characteristics in another speaker's speech. This phonetic convergence effect is thought to facilitate conversational exchange by contributing to setting a common phonetic ground between speakers, and it provides evidence for perceptuo-motor adaptive processes during speech communication. Based on f0 and F1 acoustic analyses of speech production in various laboratory tasks, the present study aimed to better characterize sensory-to-motor adaptive processes involved in unintentional as well as voluntary speech imitation, and to test possible motor plastic changes due to global auditory-motor remapping. To this aim, three groups of participants involved in speech production or imitation tasks were exposed via loudspeakers to vowel utterances spoken by different speakers. The first task was designed to induce unintentional imitation of acoustically presented vowels and to measure the magnitude of imitative changes in speech production as well as possible motor after-effects. Participants were instructed to produce vowels according to either an orthographic or an acoustic cue, without any instructions to repeat or to imitate the acoustic cues. A block design was used where participants produced the vowel target according first to an orthographic cue (baseline), then to an acoustic cue (phonetic convergence) and finally to an orthographic cue (motor after-effect). To compare phonetic convergence and voluntary imitation of the acoustic vowels, we asked the second group of participants to imitate the acoustically presented vowels. In a third task, we tested whether motor after-effects can also occur without prior unintentional or voluntary vowel imitation but only after auditory exposure of the acoustic targets. The three tasks were performed in a soundproof room using the same experimental setting and participants' productions were recorded for offline analyses. A semi-automatic analysis of the recorded vowels (around 14'000 utterances) was performed on f0 and F1 acoustic parameters. In the first task, analyses of covariance demonstrate that producing a vowel according to an acoustic cue led to a small but significant unintentional imitation of f0 and F1 (all p's $< .001$) and to short-term motor plastic changes in the subsequent productions based on orthographic cues (f0: $p < .008$; f1: $p < .01$). As expected, similar results were observed in the second imitation task with a much greater magnitude of imitative and after-effect changes (all p's $< .001$). Finally, simple auditory exposure to vowels in the third task led to similar after-effects as observed in the first task (f0: $p < .001$; F1: $p < .02$). These results demonstrate automatic imitative processes during speech communication even at a fine-grained acoustic-phonetic level and highlight the role of ambient speech in adjusting phonemic auditory-motor goals. They provide evidence for both mirror mechanisms and feedback control mechanisms as suggested by recent neurophysiological and behavioral studies on speech perception and production.

90. 6:00 p.m. - 7:00 p.m.

Cortical mechanisms of auditory feedback-based modulation of human vocal motor control

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Auditory feedback is critical for the maintenance and online control of human vocalization. Feedback distortions, for example, can produce compensatory movements of articulators to maintain desired vocal output during singing or speaking. The neural mechanisms underlying the integration of sensory feedback and motor control are unclear. Here, we used direct cortical surface recordings in human neurosurgical patients to determine the neural mechanisms underlying the sensorimotor control of vocalization. The experiment consisted of a speaking condition and a listening condition. In the speaking condition, subjects phonated the vowel /a/ for roughly 3.5 seconds. At a random latency from onset, a real-time feedback alteration device was directed to perturb the pitch of the auditory feedback during phonation. Pitch feedback was perturbed by +/- 200 cents (i.e. two semitones). Analysis of the speech produced and feedback heard by the subject in the speaking condition showed that the pertubation induced subjects to make large pitch compensations. Neural recordings focusing on the high-gamma frequency band revealed bi-directional modulation of auditory speech cortex, depending upon whether the acoustic targets met the motor generated expectations. Auditory cortex activity in the superior temporal gyrus was suppressed during normal vocalization, but strongly augmented during pitch-altered feedback. Functional connectivity measured revealed specific and strongly enhanced coherence patterns between auditory cortex, speech motor cortex, and a unique sensorimotor integration area-Spt, by unexpected

feedback. These results support a new model of sensorimotor control of vocalization in humans through the dynamic coordination of multiple cortical areas.

91. 4:45 p.m. - 5:45 p.m.

Phonetic complexity modulates brain regions for motor speech programming

Kellmeyer, P. (1,2), Ewert, S. (2,3), Kaller, C. (1,2), Kümmerer, D. (1,2), Weiller, C. (1,2), Ziegler W. (4), and Saur (5). 1. Department of Neurology, University of Freiburg Medical Center, Germany. 2. Freiburg Brain Imaging, University of Freiburg Medical Center, Germany. 3. Faculty of Medicine, University of Freiburg Medical Center, Freiburg, Germany. 4. Clinical Neuropsychology Research Group, City Hospital Munich, Germany. 5. Department of Neurology, University of Leipzig, Germany.

Introduction: Recently, a model for assessing the architecture of phonetic encoding plans was proposed (Ziegler, 2009) that accounts for differences in articulatory difficulty of words. Based on this complex non-linear, gesture-based model of articulatory accuracy (Fig. 1), it was concluded that the architecture of phonetic plans should be conceived of as hierarchically nested rather than sequenced. For apraxia of speech, an impairment at the stage of speech motor planning or phonetic encoding (Code, 1998), these findings suggest that the phonological structure of words seems to play an important role for the error pattern observed in apraxic speech. The aim of the study presented here was to investigate the brain regions that particularly respond to the modulation of articulatory difficulty based on the gesture-based model of articulatory speech planning (Ziegler, 2009) using an fMRI scanning paradigm of overt repetition in healthy volunteers. Methods: In total, 25 healthy, right-handed volunteers (mean age 24 y, age range 18-32, 14 females) participated in an fMRI study. In the experiment in the scanner, 48 words and 48 pseudo-words from a clinical test battery for apraxia of speech (Liepold et al. 2003) were aurally presented and participants were instructed to overtly repeat the stimuli as quickly and as accurately as possible. These stimuli have been evaluated behaviourally in previous studies in the framework of the non-linear, gesture based model of articulatory accuracy (e.g. Ziegler, 2009). Computationally, this model is based on a factor representing the likelihood of accurate production (henceforth „phonetic complexity factor", PCF) composed as the product of the probabilities of accurate vocal gesture based on different parameters like rime gestures or coda gestures. Response latency (in ms) was computed by subtracting the response onset from the stimulus onset. In addition, response duration was measured. The fMRI data was analysed using statistical parametric mapping (implemented in SPM8) where the PCF was used as a parametric modulator across all stimuli. Results: A main effect of lexical status was found for response latency (mean for words 1235 ms, pseudowords 1354 ms; $F(1,24)=175.20$, $p<0.0001$) but not for response duration (Fig. 2). In addition, a main effect of syllable pattern (consonant-vowel [CV] vs. consonant-consonant [CC] pattern) for response latency (mean for CV stimuli 1253 ms, CC stimuli 1335 ms; $F(1,24)=300.16$, $p<0.001$) but not for response duration was found (Fig. 2). The fMRI group analysis (Fig. 3) of the data, in which the PCF was used as a parametric modulator, revealed a predominantly left lateralised network including activation peaks (FWE corrected, $p<0.05$) in primary superior temporal sulcus (STS), inferior frontal gyrus (IFG) BA 44 and 45, the insular cortex (IC), the frontal operculum (fOP) and the right cerebellum (not visible in Fig. 3). In the right hemisphere, the network was confined to anterior and posterior STS and parts of inferior parietal lobule. However, no right hemispheric inferior frontal activation was observed. Conclusions: We suggest that behaviourally, the main effect of lexical status for response latency reflects the increased efforts for speech planning associated with pseudo-word repetition while the main effect of syllable pattern stems from the increased articulatory difficulty of CC words over CV words. In the fMRI analysis, the left anterior regions of activation reflect the speech planning requirements associated with the variation of the stimulus materials. The activation pattern in this region is consistent with lesion sites that result in apraxia of speech. The bilateral temporal activation may be attributable to the fact that complex articulatory patterns often entail complex acoustic patterns. It is plausible, that this network could be particularly prone to resulting in apraxia of speech following brain damage. References: (1) Ziegler, W. (2009), "Modelling the architecture of phonetic plans: Evidence from apraxia of speech."Lang Cogn Process, vol. 24, no. 5, pp. 631-61. (2) Code, C. (1998), "Major review: Models, theories and heuristics in apraxia of speech", Clinical Linguistics and Phonetics, vol. 12, pp. 47-65. (3) Liepold, M. (2003), "Hierarchische Wortlisten. Ein Nachsprechtest für die Sprechapraxiediagnostik." Verlag Modernes Leben.

92. 6:00 p.m. - 7:00 p.m.

Sex differences in brain connectivity underlying chronic stuttering

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Sexually dimorphic brain development may lead to differential vulnerability between the sexes for neurodevelopmental disorders such as persistent developmental stuttering. Developmental stuttering occurs with near equal sex distribution at symptom onset but becomes much more prevalent in males than females during later childhood. Most young girls who stutter recover naturally, leaving many more boys with persistent stuttering in adolescence and adulthood. In this study we examined sex-specific differences in structural and functional connectivity within the left perisylvian regions

using DTI tractography/FA analyses and functional connectivity (Psychophysiological interaction; PPI), respectively. Based on previous findings we hypothesized that there would be attenuated connectivity between the left ventral premotor-motor regions along the left superior longitudinal fasciculus (SLF) in stuttering individuals. We expected that females with chronic stuttering would have an exaggerated pattern of this deficit, as most females who stutter recover from stuttering during childhood. 18 stuttering (10M) and 14 (7M) healthy adults participated in this study. DTI tractography and PPI analyses were conducted using subject-specific seeds in the left inferior frontal gyrus (LBA44) derived from peak voxels in an fMRI study involving overt speech production. The DTI tractography, FA, and PPI data all supported attenuated connectivity between LBA44 and the left precentral gyrus in stuttering compared to the control group regardless of sex. Stuttering females additionally had FA decreases (indicating less white matter integrity) in the right SLF homologue area and greater decreases in FA in the left frontal area of SLF compared to their male counterparts. The male stutterers had more right-sided FA increases in the precentral region of the SLF. Female stutterers had more FA increases in the SLF in the temporoparietal regions. Functional connectivity was also increased between the left IFG and the temporoparietal area in stuttering females for speech production. Both males and females exhibited increased FA in the body and splenium of the corpus callosum compared to gender-matched controls. These findings suggest that left-sided connectivity decreases and increased bilateral involvement of the two hemispheres are common for both male and female stutterers and that female stutterers may additionally have over-connectivity between the frontal motor and temporoparietal regions. This may indicate greater reliance on sensory feedback for speech motor execution that may be detrimental to achieving efficient speech processing.

93. 4:45 p.m. - 5:45 p.m.

Auditory efference copies in speech: MEG evidence from an adaptation design

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Previous research supports the concept of an internal forward model in speech production. A core component of such a model is the sensory prediction generated during output planning. Consistent with this view, recent magnetoencephalography (MEG) data from mental imagery of speech provide direct and temporally constrained evidence for auditory cortex activation consequent to imagined articulation. Here we performed an MEG study using an adaptation/repetition design to investigate the characteristics of an auditory efference copy in speech. We tested whether the response to an overt auditory probe was modulated by overt and covert (mental imagery) adaptors. Four adaptors (all consonant-vowel syllables) were presented in four different conditions. Participants were required to passively listen (hearing), overtly pronounce (articulation), imagine articulating (articulation imagery), and imagine hearing (hearing imagery). An auditory probe (syllable) always followed the adaptor. Neuromagnetic recordings were performed throughout (KIT System, Kanazawa, Japan). The neurophysiological adaptation effects were quantified by comparing the responses to the auditory probes as a function of the adaptors. Typical repetition suppression was found around 200 ms after probe onset (M200) in the control hearing condition (two identical auditory stimuli presented sequentially). Similar response amplitude decreases were also observed in the M200 component for hearing imagery. Interestingly, repetition enhancement was obtained with similar timing in the articulation imagery condition, when participants were required to imagine pronouncing the syllables preceding the probe. No effect was found in the articulation condition. The common timing of the adaptation results in the hearing, hearing imagery, and articulation imagery conditions implicates overlapping neural systems. However, the different direction of the adaptation effects (repetition enhancement in articulation imagery vs. repetition suppression in hearing imagery) demonstrates distinctions in the top-down processes generating auditory representations and, specifically, highlights that planned speech activates auditory cortex in absence of any external stimulation, supporting the idea of an auditory efference copy.

94. 6:00 p.m. - 7:00 p.m.

Electrophysiology of speaking: Exploring the spatio-temporal dynamics of word selection

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Lexical selection is the process by which we access to the mental representation of a word from a given concept when we speak. We investigated the spatio-temporal dynamics of lexical selection using the blocked cyclic picture naming paradigm. This paradigm elicits a semantic interference effect believed to reflect the competitive nature of this selection. Neuropsychological and functional neuroimaging studies have suggested that the left inferior frontal gyrus is at the core of the competition under consideration, and that other structures, such as the left temporal cortex, are sensitive to semantic context. However, the temporal dynamics of the involvement of these structures is yet to be described. We compared lexical selection to an other, non-linguistic, interference task, namely the Simon task. The Simon effect is also thought to reflect the competitive nature of response selection, but not at the lexical level. Potential interference-related components specific to the picture naming task will thus reflect lexico-semantic competition, and not simply generic conflict-related activities. Twelve French speakers performed a blocked cyclic picture naming task and a verbal Simon task. The stimuli could appear on either side of a fixation point and were colored in green or purple. They were

presented in semantically homogeneous or heterogeneous blocks. Participants saw exactly the same type of stimuli, and the same sequences of trials, in both tasks. In the naming task, participants spoke out loud the name of the picture; in the Simon task, they said ìrightî or ìleftî on the basis of the color of the picture. We used high-resolution electroencephalography to measure brain activity. As in previous studies, we used a blind source separation algorithm (based on the Canonical Correlation Analysis) to reduce articulation-related artifacts and Current Source Density of the signal to enhance its spatial resolution. Behavioral performance was as expected: a semantic interference effect in the naming task, and a laterality congruency effect in the Simon task. A difference between tasks was observed on a positive component recorded over the left frontal cortex, peaking about 200 ms post-stimulus onset. The peak was significantly larger in picture naming than in the Simon task. There was no effect of the task on the contra-lateral recording site, and the pattern was not modulated by the side of stimulus presentation. In picture naming, the amplitude of this positivity tended to be affected by semantic context: it was larger in hom. context than in het. context. Even though participants saw exactly the same pictures and had to produce verbal responses in both tasks, this early activity, thought to stem from left frontal cortex, was present only in picture naming where lexical selection is required. The fact this activity seemed modulated by semantic context is consistent with the idea that the left frontal cortex is involved in lexical selection as early as 200 ms after stimulus onset. These findings provide a direct link between recent electrophysiological investigations of the time course of lexical access in speech production and anatomo-functional correlations of the contextual semantic interference effect investigated here.

95. 4:45 p.m. - 5:45 p.m.

Factors influencing the loci of dysfluency in neurogenic and persistent developmental stuttering

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Introduction Acquired neurogenic stuttering (ANS) and persistent developmental stuttering (PDS) share similarities in symptomatology although the two disorders differ in other aspects such as the degree to which symptoms can be reduced with altered auditory feedback (Balasubramanian et al. 2003, Balasubramanian et al. in press). Interestingly, ANS and PDS have never been carefully compared with regard to one of the most fundamental characteristics of stuttering—namely the loci of dysfluencies within spoken utterances (Ringo & Dietrich 1996). Therefore, the current study compares the two disorders in terms of the distribution of stuttering moments within utterances as quantified by Brown's (1945) word weights. Thus, we investigate the influence on stuttering of a word's initial consonant, position within the utterance, word length, and grammatical class. Method Twenty-five adults with PDS and four adults with ANS participated. Two ANS cases had a history of childhood stuttering from which they had recovered. Developmental stutterers read a passage from the SSI-3. Neurogenic stutterers read a passage appropriate for their reading level and cognitive status. Brown's word weights were calculated for each subject's stuttered and fluent words. Weights for fluent words were calculated once based on all fluent words and once based on a random subset (equal number of fluent and stuttered words). Given that the two methods yielded similar results, all further analyses were based on the subset method. First, per Brown's descriptions, weights (total 0-4) were attributed to words that started with a consonant, occurred within the first three words of the sentence; were five or more letters long; or were a verb, noun, adjective, or adverb. Second, all analyses were repeated with word length based on number of sounds and with word length based on number of syllables. Third, for each of the four factors separately, we determined the proportion of stuttered and fluent words loaded by that factor. Results and Discussion As expected, adults with PDS showed greater total word weights for stuttered versus fluent words. The ANS group, however, showed an almost identical pattern. Results were largely unaffected by the definition of word length in terms of letters, sounds, or syllables. Examining each factor separately, results for ANS were again highly similar to those for PDS. Both groups showed a difference between stuttered and fluent words for the length and grammatical factors. In sum, the influence of the factors under investigation on the loci of stuttering appears similar in developmental and neurogenic stuttering. Such similarities in the symptoms may be informative for current neural models of both normal speech production and stuttering. Balasubramanian V, et al. (2003) Acquired stuttering following right frontal and bilateral pontine lesion: a case study. Brain Cogn 53:195-189 Balasubramanian V, et al. (in press) Dysfluency levels during repeated readings, choral readings, and readings with altered auditory feedback in two cases of acquired neurogenic stuttering. J Neuroling Brown SF (1945) The loci of stuttering in the speech sequence. J Speech Disord 10:181-192 Ringo CC, Dietrich S (1996) Neurogenic stuttering: An analysis and critique. J Med Speech Lang Pathol 3:111-122.

96. 6:00 p.m. - 7:00 p.m.

To listen and to talk: Auditory M100 response shifts posteriorly when perceiving phonemes before speaking

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One of the most fundamental questions in speech perception research is how properties of the acoustic speech signal are mapped to linguistic elements such as phonemes. Distinct theories have been proposed to answer this question. A crucial distinction among these theories can be put in the form of a simple question: does the speech motor system have a role in speech perception? From this view, recent studies postulate that the anterior auditory cortex "what" processing pathway would be involved in acoustic-phonetic decoding while posterior auditory cortex "where/how" stream would underlie a sensorimotor mapping between auditory representations and articulatory motor representations. In return, this motor-related activity is hypothesized to constrain phonetic interpretation of the sensory inputs through the internal generation of candidate articulatory categorizations. Consistent with such perceptual-motor interactions in speech perception, we hypothesized that the "where/how" processing pathway would be more engaged when perceiving speech stimuli before producing them compared to passively listening to the same stimuli. Using magnetoencephalography we tested whether equivalent current dipole (ECD) source location estimate (which approximates the center of gravity of neural activity) of the so-called M100 response recorded about 100 ms from the auditory speech stimulus onset would shift posteriorly when subjects are perceiving phonemes and subsequently perform a speech production task, compared to a pure passive perception task. Ten healthy volunteers were presented the same syllables with two levels of ambiguity (presented with or without auditory noise) in four different conditions: passive perception, passive perception and overt repetition, passive perception and covert repetition, and passive perception and overt imitation. In the three last 'motor' conditions, the task of the subjects was to perceive the phoneme first, then wait for visual signal, and perform the speech production task. Compared to the passive speech perception condition, results showed a significant shift of the ECD-estimated location of M100 response to the phoneme sounds to a more posterior position in the left hemisphere during the motor tasks. This demonstrates that perceiving speech before speaking induces a stronger involvement of the "where/how" processing pathway and therefore suggests that sensorimotor interactions during speech perception are dependent on the exact content of the task.

97. 4:45 p.m. - 5:45 p.m.

Tell me a story: Continuous speech production, fMRI, and correlational analyses

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When compared to other levels of language processing (e.g. single word), neuroimaging research on discourse has been limited. Blood oxygen level dependent functional magnetic resonance imaging (BOLD fMRI) research in this area has been largely limited to discourse comprehension, primarily because of susceptibility artifact produced by continuous movement of the articulators, that has beset discourse production studies. Here we apply BOLD fMRI to a discourse production task, using novel preprocessing methods, which combine global mean regression and independent components analysis (ICA) to separate the BOLD fMRI signal from artifact. After seeing a drawn picture cue, healthy participants had 30 seconds to retell in their own words a narrative on which they were previously trained; narratives were recorded and transcribed off line. In post hoc analyses, the transcripts were scored on an array of linguistic features: acoustic (pitch variation), lexical (type-token ratio), syntactic (verbs/t-unit), and discourse (inclusion ratio). These measures were correlated with the BOLD signal across subjects on a voxel-by-voxel basis. The results show that brain regions in both the right and left hemispheres are correlated with these measures. We found correlations between pitch variation and BOLD signal in left superior temporal gyrus, superior temporal sulcus and inferior frontal gyrus (IFG) and in inferior parietal lobules bilaterally. Type token ratio correlated with activity in the right middle frontal gyrus, medial prefrontal cortex, and insula. The number of verbs per t-unit correlated with activity in the left dorsal IFG, insula, anterior and posterior middle temporal gyrus and supplementary motor area. In addition, we found that inclusion ratio and percentage of maze words, independent measures of fluency and dysfluency, correlated with activity in the left and right IFG and middle temporal gyrus respectively. The benefits of this approach are twofold: first, we demonstrate a method that makes it possible to evaluate connected speech production using BOLD fMRI; second, we present an analytic approach which provides quantitative estimates of the neural correlates of speech and language production in a more naturalistic and relatively unconstrained setting.

98. 6:00 p.m. - 7:00 p.m.

Bilingual and monolingual brains compared: An fMRI Investigation of social interference in lexical selection

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Abstract: It's well known that the cognitive and neural mechanisms of language processing are affected by background information. As a kind of background information, however, there has been little research into the role of social information in language processing. Using fMRI technique, the present study explored the role of social information in lexical selection by comparing brain activation patterns for English-Chinese bilinguals and English monolinguals under different social conditions. The results showed that, relative to congruent social information, incongruent social information induced activation in the left frontal executive regions for both bilinguals and monolinguals. However, compared to monolingual subjects, bilingual individuals showed increased activations in several brain regions related to executive functions (i.e., left putamen and bilateral frontal gyri) for both congruent and incongruent social conditions. These results suggest that the social information plays an important role in lexical selection, and the effect of social information on lexical selection depends on language experience.

99. 4:45 p.m. - 5:45 p.m.

Sensorimotor adaptation in speech production: A TMS study

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Manipulation of auditory feedback has been shown to alter speech production. Moreover, auditory feedback is instrumental in the acquisition of speech and an integral component of speech motor learning. The goal of the present study was to determine if speech motor adaptation is mediated by a multisensory integration area in the posterior parietal lobe (supramarginal gyrus or Brodmann area 40), resulting from short-term reorganization of an existing neural network. This hypothesis was tested by applying repetitive transcranial magnetic stimulation (rTMS) over the posterior inferior parietal area to see if speech motor adaptation to acoustic perturbations was altered under conditions of stimulation. Experimental subjects (n=10) received offline stimulation (600 pulses of 1 Hz rTMS) in the posterior parietal inferior area (MNI ICBM 152: $x = -52$, $y = -40$, $z = 36$, $p < .05$ FDR corrected) at 110% of their RMT. Meanwhile, control subjects (n=10) received sham stimulation. All subjects produced the word ëheadí for 200 trials while receiving auditory feedback manipulated by a digital signal processor. Subjects received unaltered feedback for the fi rst 30 trials, followed by a gradual upward shift in F1 of 40 trials until the signal became similar to subjects' production of ëhad.í This level was then held for another 100 trials. Finally, feedback returned to baseline for the last 30 trials. The change in compensation of F1 was assessed using a two-way mixed design ANOVA, with a between subjects factor of group (sham versus rTMS) and a within subjects factor of phase (compensation versus after effect). The ANOVA yielded a significant main effect of group, $F(1, 18) = 15.29$, $p < .005$, with no significant main effect of phase or significant interaction. Overall, rTMS applied over the posterior inferior parietal area significantly reduced speech motor adaptation. Thus, this area may mediate sensorimotor adaptation by undergoing reorganization of its neuronal network following auditory changes during speech motor learning.

100. 6:00 p.m. - 7:00 p.m.

A distributed network for speech motor adaptation

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Speech motor adaptation refers to changes in motor output in response to short but intensive periods of practice under feedback altering conditions. Speech motor adaptation has been evaluated behaviorally in response to manipulations of auditory and orosensory feedback, yielding indirect evidence of short term neural plasticity. In a recent behavioral study, we reported compelling evidence for a strong sensorimotor coupling evidenced by simultaneous changes in both speech motor output and speech perception. Here we focus on the neural changes associated with sensorimotor adaptation. Functional MRI data were acquired while subjects produced single words in the scanner. After acquiring baseline trials, auditory feedback was gradually altered (3 semitone shift) over thirty trials and then maintained for 120 trials. Changes in neural activation and acoustic speech output were assessed following the initial feedback manipulation, and over the course of the practice period. Comparison of initial and adapted periods revealed increased activations in the inferior frontal gyrus extending to the ventral premotor and primary motor cortex, in the anterior part of the insular cortex and in the superior and middle temporal gyri bilaterally. These increases gradually subsided over the course of the practice while the acoustic evidence suggested maintained compensation for the altered feedback. These

results reflect the interactive nature of speech production and speech perception and suggest that speech motor adaptation results in a change in synaptic weights over the course of a single experimental session. Sensorimotor adaptation provides a robust means to assess the dynamics of brain plasticity for speech.

101. 4:45 p.m. - 5:45 p.m.

Functional integration changes following intensive SFA therapy in chronic aphasia

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Objective: It is generally accepted that optimal recovery relies upon the reactivation of premorbid language circuits. Most studies on therapy-induced aphasia recovery have focused on brain activations; thus, only two studies have reported on functional connectivity (FC) (Abutelabi et al., 2009; Vitali et al., 2007). However, these studies have used a Dynamic causal modeling (DCM) approach, which requires the predefinition of seed regions. With no a priori hypotheses of the functional network supporting a given task, spatial independent component analysis (sICA) decomposes blood oxygenation level-dependent (BOLD) signals of the whole brain into spatial networks. Also, sICA provides information on the degree of integration within and between network(s). The present fMRI study uses sICA to describe therapy-induced FC changes following Semantic Feature Analysis (SFA) in a group of participants with chronic aphasia, as compared to a group of healthy volunteers. Methods: Ten healthy volunteers (control group; mean age 70,2 ± 3,99 years old) and nine participants presenting chronic aphasia (PWA: mean age 61,66 ± 6,42 years old; 4 to 25 years post-onset) participated in the present study. Both groups underwent an overt naming task during fMRI. The control group was seen at T1, and three weeks later (T2), whereas the PWA group was examined before (T1) and after (T2) intensive SFA. Preprocessing consisted of slice timing and realignment, followed by a sICA analysis (Perlbarg et al., 2008). Representative functional large-scale networks were extracted within the control group at T1, and gathered in the PWA group at T1 and T2. Measures of integration for each network (Marrelec et al., 2008) were calculated and at each time of measure, and within either group. Results: Four different networks were identified in the control group: the default-mode network (N1), an attentional network (N2), and two language-processing networks including temporal areas in both hemispheres (N3 and N4). At T1, the control group showed higher within-system integration measures than the PWA group across N1,N2 and N3 (probability of difference (PofD)= between 0.0000 and 0.0260, maximum = 0 and 1). However, when comparing the control group at T1 and the PWA group at T2, higher integration levels were observed in the PWA group for N1 and N4 (PofD = respectively 0.0320 and 0.0000). Furthermore, when comparing pre-post therapy, post-therapy showed maximal levels of within and between systems integration in all four networks (PofD = 1.0000). Discussion: The present results show that behavioural improvement following SFA therapy was associated with dynamic within and between integration changes in normal networks sustaining an overt naming task. These results are in line with previous evidence that relates better recovery to a ënormalizationí of cerebral activity. Moreover, intensive SFA therapy induced FC changes in both specific and non-specific to normal language networks, as reflected by maximal integration post-therapy levels. Conclusions: sICA opens new avenues to quantify and characterize therapy-induced modifications of brain networks sustaining recovery in chronic aphasia. This approach reflects the dynamic interactions between specific-to-language and non-specific-to language networks, and therapy-induced changes in brain plasticity that sustain the recovery from aphasia. References: Abutalebi, J. Della Rosa, P.A., Tettamanti, M., Green, D.W. and Cappa, S.F. (2009). Bilingual aphasia and language control: A follow-up fMRI and intrinsic connectivity study. Brain and Language, 109 (2-3), 141-156. Marrelec, G., Bellec, P., Krainik, A., Duffau, H., PÈlÈgrini-Issac, M., Lehéricy, S., ... Doyon, J. (2008). Regions, systems, and the brain: hierarchical measures of functional integration in fMRI, Medical Image Analysis. 12 (4), 484ñ496. Perlbarg, V., Marrelec, G., Doyon, J., Pelegrini-Issac, M., Lehericy, S. & Benali, H. (2008). NEDICA: Detection of group functional networks in fMRI using spatial independent component analysis. IEEE International Symposium on Biomedical Imaging: From Nano to Macro, 1246-1250. Vitali P, Abutalebi J, Tettamanti M, Danna M, Ansaldo AI, Perani D, Joanette Y, Cappa SF. Training-induced brain remapping in chronic aphasia: A pilot study. Neurorehabil Neural Repair 2007;21:152-160.

102. 6:00 p.m. - 7:00 p.m.

The neural underpinnings of phonological training in pure anomia: An fMRI case study

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Objective: Failure to retrieve words in the face of spared conceptual knowledge about the same words (pure anomia) is frequent in aphasia. Behavioral studies show that pure anomia is ameliorated by speech therapy, but the neural substrate underlying recovery is unclear. In particular, the relative role of ipsilesional and contralesional areas is still debated. We investigated the neural underpinnings of phonological training in subject CAF, by means of BOLD-fMRI. Methods:

CAF is a 56-year old, right-handed aphasic. He is 2 years post onset of a left prefrontal stroke (inferior and medial frontal gyri, insula and putamen), and presents with moderate anomia, in the absence of comprehension deficits. Three-hundred black-and white drawings were presented 3 times for oral naming. Sixty drawings were selected: 20 easy (E) stimuli, always named correctly; 40 difficult (D) stimuli, always named incorrectly. The latter stimuli were divided in two fully matched subsets: a 20-item, difficult/trained subset (D/T), used for phonological training, and a 20-item, difficult/untrained (D/U) subset, serving as control. Phonological training of D/T stimuli was administered for 10 consecutive days, in 1-hour sessions. During each session, stimuli were presented 10 times, in different randomizations. CAF was asked to name each stimulus. When he failed to do so, a phonemic cue was provided (initial sound, then initial syllable, then first two syllables, and so forth), until the correct response was produced. The 60 drawings were presented during three event-related, BOLD fMRI naming sessions, performed with a 4T scanner. Sessions took place 1 month before training (T0), immediately before (T1), and immediately after training (T2). During each session, CAF named the 60 stimulus drawings (naming task) or pronounced a pre-learned pseudo-word in response to a squiggle (control task). Activations yielded by the E, D/T and D/U subsets at T0, T1 and T2 were contrasted. Results: No differences between trained (D/T) and untrained (D/U) difficult stimuli were observed at T1 and T0, when contrasting either behavioral or neuroimaging data. By contrast, the same comparisons yielded significant differences at T2. Behavioral results: Naming accuracy at T2 was significantly greater for D/T than for D/U stimuli ($p<.01$). Performance on D/T at T2 was significantly more accurate than at either T0 or T1 ($p<.01$), whereas performance on D/U remained unchanged across sessions. Neuroimaging results: Contrasting D/T and D/U stimuli at T2 yielded strong activation in multiple perilesional loci, and in lateral occipito-temporal areas (BA37). These latter areas were also activated by easy (E) stimuli at T0 through T2, but never by untrained (D/U) stimuli. Sparse foci of moderate activation were observed at T2 in prefrontal regions, in response to all stimulus subsets. Discussion: In a subject with pure anomia, phonological training specifically resulted in the activation of perilesional neural tissue, and of ipsilesional temporo-occipital regions subserving spared naming abilities. Such changes only occurred in response to trained items. Right prefrontal activations were observed after phonological training but, since they occurred in response to all stimuli (trained and untrained, easy and difficult), they are probably an aspecific result of phonological training.

103. 4:45 p.m. - 5:45 p.m.

Abnormal developmental trajectory of cortical thickness in the left pars opercularis in people who stutter across the lifespan

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The speech characteristics associated with developmental stuttering are proposed to be the result of an aberrant brain mechanism caused by the interaction of genetic and environmental variables (De Nil, 2004).Despite the fact that stuttering is a lifelong affliction, no study has examined the potential neurodevelopmental signatures of the disorder across a paediatric and adult population of people who stutter.The current study aimed to fill this gap in the knowledge base.The acquisition and mastery of speech movements requires years of practice spanning the course of development (Goffman & Smith, 1999; Green et al., 2000).People who stutter (PWS) are known to perform poorly on speech oriented motor learning tasks (Namasivayam and Van Lieshout, 2008; Smits-Bandstra et al., 2006).These neural processes are thought to be represented in the interior frontal gyrus (IFG), specifically BA44 (Guenther, 2006).Consequently, various theories of stuttering posit that the disorder is related to a breakdown in formation of the neural processes supporting speech production, specifically in BA44(Brown et al., 2005; Kell et al., 2009; Sommer et al., 2002; Watkins et al., 2008).We hypothesized that the development of cortical thickness in PWS would differ across the lifespan in BA44, or other regions related to speech processing, relative to a group of control participants. Methodology: 116 right-handed males with English as their primary language and a normal developmental and medical history participated in this study.The 55 PWS ranged in age from 7 to 47 years ($x = 25.59$, s.d.= 11.17) and the 61 control participants from 6 to 48 years ($x = 26.54$, s.d.= 10.56).The two groups did not differ in age ($t(114)= .43$ $p = .67$).Stuttering severity ranged from very mild (5) to very severe (49) ($x = 21.50$, s.d.= 9.13). T1 images for 51 participants (23 PWS) were collected on a 1.5-T MRI at the Toronto Western Hospital in Toronto.T1 images for 47 participants (23 PWS) were collected on a 1.5-T MRI system at the Hospital for Sick Children in Toronto.The images for the remaining 18 participants (9 PWS) were collected on a 3-T MRI system at the Haskins Laboratories in New Haven. T1 images were registered to the ICBM 152 template with a 12-parameter linear transformation (Collins et al., 1994), RF inhomogeneity corrected (Sled & Pike, 1998), skull stripped (Smith, 2002) and tissue classified (Tohka et al., 2004).Deformable models were used to fit the white matter surface for each hemisphere separately, followed by an expansion outward to find the grey matter/CSF intersection (MacDonald et al., 2000), resulting in 4 surfaces of 41,962 polygons each.From these surfaces the distance between the white and grey surfaces in native space was used to measure cortical thickness (Lerch & Evans, 2005).The individual surfaces were non-linearly aligned to the ICBM 152 template using surface-based registration techniques (Robbins et al., 2004).All analyses were performed using native cortical thickness.Since individual

cortical thickness measures and brain volume are unrelated (Ad-Dab'bagh et al., 2005) no normalization similar to VBM is necessary. ROI Analysis: Differences in cortical thickness across ages between PWS and controls were investigated in 8 specific brain regions of interest (ROIs) based on our hypothesis separately for each hemisphere: pars opercularis (BA44), pars orbitalis and rostral IFG (BA47), anterior cingulate gyrus, posterior cingulate gyrus, transverse gyrus, ventral precentral gyrus, posterior parasylvian region (extended planum temporale), Wernicke's area. Using the average grey surface of all subjects the ROI delineations were back projected onto the individual surfaces using the surface transformation and the average ROI thickness computed for each individual.For each ROI a linear mixed effect model was calculated with the intercept allowed to vary between scanners to correct for possible scanner effects and.a Bonferoni-correction was used. Results: A significant interaction between age and group was found for the left pars opercularis ($p = .02$).Grey matter in this region was thinner in the younger stutterers relative to their same aged peers but this relationship changed with age such that grey matter was thicker in older stutterers relative to their same age peers.By contrast, the developmental trajectory of thickness for the other ROIs was similar for both groups.The current findings support the idea that the developmental trajectory of grey matter thickness in left pars opercularis (BA44) is abnormal in people who stutter.This suggests that children who stutter may have deficient neural resources for establishing the motor processes underlying speech.This deficiency may contribute to the overt speech characteristics that are prominent in the disorder.Neural pruning for efficient processing does not appear to transpire in this region in PWS.Our findings show that PWS may have deficient neural resources for for speech.

104. 6:00 p.m. - 7:00 p.m.

Application of semi-quantitative rating of speech samples to primary progressive aphasia and frontotemporal dementia

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Background: Language impairment may be one of the most prominent symptoms in frontotemporal dementia (FTD), but one of its hallmarks is variability between patients. That is, a variety of types of speech and language deficits can be present. Although numerous methods have been developed for the assessment of language impairments in FTD, there has been relatively little quantitative investigation of the characteristics of speech. Moreover, speech assessment tools developed for stroke aphasia have shortcomings in this population. Objective: To develop a method for the semi-quantitative rating of a variety of types of speech samples (both constrained and unconstrained), with the goal of enabling the efficient quantification of multiple features of speech in patients with primary progressive aphasia (PPA), FTD, and related disorders. Methods: Drawing upon prior research in stroke aphasia and PPA, we developed a method for using an ordinal rating scale (0 through 3) for the clinician-based rating of a) main concepts, b) gist, c) word expression, d) grammar/syntax, and e) fluency. These ratings are made on several speech samples, including spontaneous speech during a structured clinical interview as well as picture description with probed questioning. Reliability of this rating system is being determined with multiple separate blinded raters. Validity of the system is being determined against standard psycholinguistic performance-based instruments, caregiver ratings of symptoms, and quantitative MRI-based measures of regional brain atrophy. Results: In a series of FTD patients of different subtypes, the ratings distinguished several major abnormalities in speech that are congruent with caregiver ratings of symptoms in daily life and with blinded clinician diagnostic impressions. For example, behavioral variant FTD patients failed to understand the gist of pictures but described the objects and actions accurately and with fluent speech with intact grammar and word expression. PPA patients exhibited a variety of abnormalities of language, but were able to communicate the concepts and gist of the pictures reasonably clearly. Preliminary analyses of reliability are in progress, as are analyses of a larger number of FTD and PPA patients. Conclusions: The semi-quantitative clinician-based rating of speech samples in FTD is feasible and will likely provide an important complement to fully quantitative speech analysis and qualitative clinical observations. We hope that it will augment the dataset on patients such as this that can be shared between clinicians, and also serve as a potential marker for diagnostic and monitoring purposes.

105. 4:45 p.m. - 5:45 p.m.

Comprehension is not the basis for error detection: A conflict-based account of monitoring in speech production

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Although speech errors are common, verbal communication is generally successful; errors are detected and repaired in a fast and efficient manner. How might such a speedy error detection system work? The standard theory of speech-error detection, the perceptual-loop account (Levelt, 1983), posits that the comprehension system monitors production output, detecting any deviation between that output and what was intended. A comprehension-based monitor such as the perceptual-loop, however, cannot explain why some aphasic patients with poor comprehension have no difficulty detecting their own errors, while some with good comprehension cannot. Here, we verify that aphasic error

detection is unrelated to comprehension, and propose a new theory of error detection which is, instead, based on the production process itself. We then test our theory using computational simulations. Patient analysis. The picture naming errors of 40 aphasic patients given the 175-item Philadelphia Picture Naming Test were examined for evidence of error-detection. An attempt to correct or otherwise reject a wrong response was coded as successful detection and was determined separately for semantically-related and phonologically-related errors. We then assessed whether detection rate was more strongly associated with production or comprehension. Two production measures, the strength of the semantic (s) and phonological (p) weights as estimated by the interactive two-step model of word production (Foygel & Dell, 2000) and three comprehension scores (Pyramids and Palm Trees, Synonym Judgment Test: Nouns, and Phonological Discrimination) were determined for each patient. Semantic-error detection was strongly associated with s-weights ($r = 0.68$, $p < 0.001$), as was phonological-error detection with p-weights ($r = 0.51$, $p < 0.001$). Error detection, however, was not correlated with any of the comprehension measures. We conclude that error detection reflects production, but not comprehension, ability. Computational model. Based on the correlations between error detection and the model-derived production measures, we introduce a production-based account of monitoring, in which conflict internal to the production system is the basis for error detection (e.g. Botvinick et al., 2001). We present two simulations using the interactive two-step model. In the first, we show that the amount of conflict within the word and phoneme layers is a good predictor of the occurrence of a semantically and phonologically-related errors, respectively. Therefore, by detecting conflict, the model can successfully detect errors. In the second simulation, we show that the model correctly predicts the relationship between the strengths of the s and p weights and the ability to detect semantic and phonological errors. Conflict is only strongly associated with modelís errors if the relevant weights are relatively good. Thus the model successfully explains how production-based monitoring can occur and the variation in patient's ability to monitor for particular kinds of errors. Conclusion. The conflict-based model of speech-error detection successfully explains the error detection behavior of aphasic patients. We further propose that, although representational conflict arises at all linguistic levels in the system, the brain may contain modality general mechanisms for registering (e.g. anterior cingulate cortex) and reducing (e.g. left inferior frontal gyrus) this conflict.

106. 6:00 p.m. - 7:00 p.m.

From reference to sense: An fMRI adaptation study on semantic encoding in language production

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Introduction: Speaking is a complex, multilevel process, in which the first step is to compute the message that can be syntactically and phonologically encoded. Computing the message requires constructing a mental representation of what we want to express (the reference). This referent is mapped onto linguistic concepts stored in memory, by which the meaning of the utterance (the sense) is constructed. We used fMRI adaptation to investigate brain areas sensitive to reference and sense in overt speech. fMRI adaptation is a phenomenon whereby repeating a stimulus property changes the BOLD-response in regions sensitive to that property. By independently manipulating repetition of reference and sense across subsequently produced sentences in a picture description task we distinguished sets of areas sensitive to these steps in semantic encoding in speaking. Methods: In a picture description paradigm, the described situation (the reference) and the linguistic semantic structure (the sense) of subsequently produced sentences were independently repeated across trials. Participants described pictures depicting events involving transitive verbs such as hit, kiss, greet, and two actors colored in different colors with sentences such as ëThe red man greets the green womaní. In our factorial design, the same situation involving the same actors could subsequently be described by two different sentences (repeated reference, novel sense) or the same sentence could subsequently be used to describe two different situations (novel reference, repeated sense). For reference, we controlled for the repetition of actors and for sense for the repetition of individual words (fig. 1). We alsol performed a control experiment with the same stimuli and design but without the description task. To correct for increased artefacts due to speech, we scanned using 3T-fMRI parallel-acquired inhomogeneity-desensitized fMRI (Poser, Versluis, Hoogduin et al., MRM, 2006, Buur, Poser and Norris, MRM, 2009). Results: In the fMRI analyses we looked for areas sensitive to only sense, only reference, or showing a conjunction of both factors. Encoding reference involved the bilateral inferior parietal lobes (BA 39), both in the production and control task. Left inferior frontal gyrus (BA 45) showed suppression to repetition of sense in the production but not control task. , Left middle frontal gyrus (BA 6), bilateral superior parietal lobes and bilateral posterior temporal gyri (BA 37)) showed repetition suppression to both sense and reference processing (conjunction analysis with conjunction null), again only in the production task. Discussion: The input to semantic encoding is construction of a referent, a mental representation that the utterance is about. The bilateral temporo-parietal junctions are involved in this process as they show sensitivity to repetition of reference but not sense. Semantic encoding itself requires mapping of the reference onto the sense. This involves large parts of the language network: bilateral posterior temporal lobes and upper left inferior frontal gyrus were sensitive to both reference and sense. Finally, sense recruits left inferior frontal gyrus (BA

45). This area is sensitive to syntactic encoding (Bookheimer, An. rev. Neurosci, 2002), the next step in speaking. These results reveal the neural architecture for the first steps in producing an utterance.

107. 4:45 p.m. - 5:45 p.m.

Picture naming: Neural dynamics of sequence and priming

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Picture naming is a fundamental linguistic process that includes all stages of speech production (Levelt et al. 1999). Consequently, the task is frequently used to study language function. However, despite a growing understanding of the brain areas and time windows of activation that reflect the different processing stages in picture naming (e.g., Levelt et al. 1998) the description is not complete. The semantic aspects, in particular, have remained elusive at the neural level (e.g., Maess et al. 2002; Vihla et al. 2006). In receptive language, priming studies with word sequences have been successfully used to track the neural timeline of semantic and phonological processing (e.g., Vartiainen et al. 2009). In language production, pictures have been most often primed with words (e.g., Caramazza & Costa, 2000), although priming with pictures would seem to more directly probe the process of picture naming. Here, using magnetoencephalography (MEG), we tracked the cortical dynamics of object naming for sequences of three pictured items that were unrelated (MIX) or related by their meaning (SEM; e.g., castle, hospital, tent) or sound form (PHON; e.g., castle, camera, carrot). Data was recorded from 10 Finnish-speaking volunteers. The stimuli were line drawings of 116 objects that formed 21 semantic categories (e.g., buildings, musical instruments) and 24 phonological categories (initial phonemes e.g., /ka/, /pa/). Blocks of MIX, SEM and PHON sequences (~50 per block, in total 104 per category) were presented in a randomized order. The task was to covertly name each picture, but in 30 % of the trials (targets) the final picture was drawn in red to prompt overt naming. The MEG data for the non-target sequences was analyzed using both minimum norm estimates (MNEs) and equivalent current dipoles (ECDs), and the activation strength and timing were quantified. A significant effect of picture order was detected at the group level. The activation strength was increased with the progression of the sequence, regardless of the stimulus category, in the bilateral occipital, inferior occipitotemporal, middle temporal, and frontal cortex. The occipital, temporal and left frontal areas also showed decreasing peak activation latency. Priming effects (SEM vs. MIX, PHON vs. MIX) were evaluated for the sequence-final picture. In the individual subjects, significant differences of neural activation were observed most consistently in the left occipitotemporal (N=5) and right posterior temporal (N=5) cortex, but these did not translate to spatiotemporally consistent group-level effects. Picture naming may be theoretically fairly straightforward and well-described, but its neural implementation is complex. The sequential presentation, even with unrelated items, had a strong effect on the neural activation, which should be kept in mind when using pictures as stimuli. References: Caramazza A & Costa A (2000) The semantic interference effect in the picture-word interference paradigm: does response matter? Cognition, 75, B51 - B64. Levelt WJM, Roelofs A & Meyer AS (1999) A theory of lexical access in speech production. Behavioral and Brain Sciences, 22, 1 - 38. Levelt WJM, Praamstra P, Meyer AM, Helenius P & Salmelin R (1998) An MEG study of picture naming. Journal of Cognitive Neuroscience, 10, 553 - 567. Maess B, Friederic AD, and Damian ASM, Levelt WJM (2002) Semantic category interference in overt picture naming: sharpening current density localization by PCA. Journal of Cognitive Neuroscience, 14, 455 - 462. Vartiainen J, Parviainen T, Salm.elin R (2009) Spatiotemporal convergence of semantic processing in reading and speech perception. Journal of Neuroscience, 29, 9271 - 9280. Vihla M, Laine M & Salmelin R (2006) Cortical dynamics of visual/semantic vs. phonological analysis in picture confrontation. Neuroimage, 33, 732 - 738.

108. 6:00 p.m. - 7:00 p.m.

Transcranial direct current stimulation modifies automatic and controlled verbal fluency

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Background and Objective: Overt human behaviors are generally acknowledged to be the result of a variable admixture of automatic and controlled mental processes. Clustering on verbal fluency tasks (the generation of contiguous words, within semantic or phonemic subcategories) seems to originate from automatic processes. Switching from one subcategory to another seems to reflect elements of cognitive control, such as self-monitoring and self-cuing. Convergent evidence from behavioral, imaging, and lesion studies suggests that, in individuals left-hemisphere dominant for speech, automatic functions in this task rely upon left posterior temporal-parietal regions; the controlled functions, upon left prefrontal regions. Transcranial direct current stimulation (tDCS), which involves passing a weak, direct electrical current through the cortex, may enhance or inhibit the functions of underlying cerebral tissues, depending upon the polarity of the applied current. Here, we present preliminary data showing that tDCS may modify automatic and controlled aspects of word retrieval in healthy adults. Methods: In this single-blind experiment, 57 healthy right-handed adults (ages 18-70 years [mean 34.4 years], education 12-20 years [mean 17.8 years]) were randomly assigned to re-

ceive 1 mA of active (either anodal [excitatory] or cathodal [inhibitory]) stimulation, plus sham stimulation, in counterbalanced order. Stimulation was delivered for 30 minutes via a constant current stimulator through 7.6x7.6-cm sponge electrodes. The ìactiveî electrode was placed over the left prefrontal region (F3), the ìindifferentî electrode over the vertex or right supraorbital region. At the end of each period of stimulation, subjects completed 60-second trials of two different verbal fluency tasks (letter [S or P] and category [animals or supermarket items]). Productions were scored as to the number of words generated, switches, number of clusters, and percent words in clusters. Results: Between-groups analyses revealed that, compared to cathodal stimulation, anodal stimulation was associated with the production of more clusters and a greater percentage of words within clusters on letter-cued fluency tasks (ps = 0.02 and 0.04, respectively). For the category-cued fluency tasks, on within-group analyses, anodal stimulation showed a trend towards the generation of more clusters (p = 0.06) and a greater percentage of words within clusters (p = 0.03) compared to sham stimulation. The opposite pattern was found for cathodal stimulation ñ participants produced fewer clusters and a smaller percentage of words in clusters compared to the sham condition. Males and older adults tended to show larger tDCS-related alterations in productivity. Conclusions and Significance: To our knowledge, this is the first demonstration that tDCS can selectively alter a component process of lexical retrieval. Specifically, left frontal anodal stimulation facilitated and cathodal stimulation impeded the production of clustered word retrieval on both letter- and category-cued verbal fluency tasks in healthy adults. Subgroups that might be expected to show less-efficient verbal productivity, namely males and older adults, were most responsive to the tDCS intervention. These preliminary findings provide an empirical foundation for future studies on the investigational and therapeutic uses of tDCS in disorders of language production.

109. 4:45 p.m. - 5:45 p.m.

Aphasia, anxiety, and beta-adrenergic antagonists

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Background: The role of anxiety has not been sufficiently explored in aphasia. In 2007 Beversdorf et al demonstrated improved naming ability in patients with Brocaís aphasia following treatment with the centrally acting beta-adrenergic receptor blocking agent, propanolol. In a subsequent pilot study (Tanaka et al 2009) we found that propanolol provides short term improvement of naming in Brocaís and Wernickeís aphasia, and improvement of auditory comprehension in Wernickeís aphasia. We hypothesized that the beta blocker might benefit persons with aphasia by reducing anxiety. The current project extends the results of our previous study, and further evaluates the relationship between aphasia and physiologic measures of anxiety, following treatment with propanolol. Subjects and Methods: 11 patients with mild to moderate aphasia; 4 with Brocaís aphasia (mean age 67.3; range 56-78), 4 with Wernickeís aphasia (mean age 69.3; Range: 45-79) and 3 with amnestic aphasia (mean age 64.7; Range: 44-74). The test battery consisted of the Boston Naming Test (BNT), Action Naming Test (ANT), two tests of auditory comprehension (yes/no and response to oral commands), FAS (word and vegetable), and the Cookie Theft Description from the Boston Diagnostic Aphasia Battery. Physiologic measures of autonomic function consisted of heart rate, blood pressure (both supine and standing), coefficient of variation of R-R intervals in the electrocardiogram (CV-RR100), and sympathetic skin response (SSR). The Beck Anxiety Inventory was used as the measure of anxiety. All participants received baseline testing on all tests, and then were given 10 mg of propanolol daily for 4 weeks. A second test session was carried out after the 4 weeks of administration of propanolol; and a third test was carried out one month after propanolol was discontinued. Results: On the second testing four weeks after administration of propranolol, scores on the BNT, ANT, FAS (category) and auditory comprehension tests were significantly improved for all subjects. CV-RR100 was significantly reduced. There were no significant changes on the Beck Anxiety Inventory. There was no significant correlation between any test score and CV-RR100 change. The initial CV-RR100 was not related to percent change of any test score. There were no significant differences among the three groups. Conclusion: Treatment of aphasia with the putative anti-anxiety agent propanolol produces significant improvement on a range of language tests, regardless of aphasia diagnostic category, coupled with predictable, significant changes in physiologic measures of autonomic function. In contrast, however, no changes were produced on a scale designed to measure anxiety.

110. 6:00 p.m. - 7:00 p.m.

Syntactic deviance or delay? A study of the production of relative clauses in individuals with Down Syndrome

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The central question in the study of language development in people with Down Syndrome (DS) is whether their linguistic ability is merely "delayed" or "deviant". Recent studies (Perovic 2006, Ring & Clahsen 2005) brought to light the issue of modularity in language, providing evidence for a specific syntactic deficit in the language of DS, related to the

inability to comprehend structures displaying A-dependencies, such as bound variable anaphoras and passive construction in English. The aim of the present study is to investigate the area of A'-dependencies in Italian (subject (SR) and object (OR) extracted relative clauses), to determine whether the linguistic deficit of DS extends to these type of structures. 6 italian adults with DS (aged 19-29) with a mean IQ of 60, were asked to perform two elicitation tasks adapted from (Novogrodsky & Friedmann 2006), where the target structures were SR and OR. 100 Italian typically developing children (TD) aged 3;5 to 8;10 were matched to the experimental subjects. The results of participants with DS can be summarized in three main points: 1) The mastery of SRs vs. the poor production on ORs. Individuals with DS show a celing level performance on SRs' production (Picture Description task: 92.5%), that is significantly higher than younger control children (3 y.o.: Two-tailed Fisher's Exact Test, $p<.0098$) and comparable to the other age groups (4-8 y.o.). Their performance on SRs strongly constrasts with their overall production of ORs (50% of the expected contexts) which is significantly lower than that of children from 3 to 7 ($p<.0001$), but significantly higher than children of 8 years of age ($p<.0001$). 3) The absence of passive to avoid ORs (Belletti 2009). When adults with DS do not produce an ORs, they often resort to declarative clauses. They never adopt SRs with passive to avoid ORs, while children of 6, 7 and 8 years old consistently use it when an OR is expected. The absence of passive in DS's production confirm the difficulty of DS subjects with verbal passive, previously observed in the comprehension of English individuals with DS (Ring & Clahsen 2005). 4) Participants with DS adopt different strategies to alleviate the production of ORs (Belletti 2008, Utzeri 2007). Subjects with DS sometime use ORs with resumptive DPs (25%), as TD children. However, they never produce ORs with 3rd person resumptive clitics, which are frequently used by TD children of all age groups (mean of the ORs produced: 21%). Beside confirming for DS the well known asymmetry between SR and OR observed in TD children (Guasti & Cardinaletti 2005, Belletti & Contemori, 2010) with the latter much harder to produce than the former, we argue that syntactic competence of our subjects with DS on SR and OR does not parallel in any systematic way a clear stage of TD children's syntactic development, in line with the deviant (and not simply delayed) view of the nature of DS's grammar (Perovic 2006, Ring & Clahsen 2005).

111. 4:45 p.m. - 5:45 p.m.

Neural dynamics of using newly learned grammar and vocabulary

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The combination of grammar and vocabulary gives the human language an unlimited power of expression. Grammar and vocabulary may be supported by different memory systems (for a review see Ullman, 2004), but within the natural sentence context the two components are intimately linked. In the present study, we set out to elucidate the neural processes of grammar and vocabulary from a language learning perspective. Using magnetoencephalography (MEG), we examined processing of sentences (with grammar) and sequences of words (without grammar) in a newly learned miniature language and in the native language. Ten native Finnish speakers were trained, with the help of cartoon-like images, on a miniature language (Anigram) that consisted of simple subject-verb-object sentences employing 20 nouns (animal names) 10 transitive verbs, and novel object-marking rules. The object marker was determined by the phonology of the subject; this form of object marking does not exist in the languages mastered by the participants. After four days of training, MEG data were recorded while participants performed a modified picture naming task on a novel set of images (Figure 1A). The task was performed in both the new and native language, with the order counterbalanced across participants. The images depicted either one animal doing something to another (sentence) or two animals standing together (word sequence). The task was a cloze test where participants were prompted to overtly name the final animal in the appropriate inflected object form (sentence) or in its base form (word sequence). The MEG data was analysed using both minimum norm estimates (MNEs) and equivalent current dipoles (ECDs). The presentation of the image, prior to the appearance of any words, resulted in a neural differentiation between the languages (Figure 1B). In the left angular gyrus, sustained activation from ~300 ms onwards was stronger for the new than the native language; stronger activation to sentences than word sequences approached significance. When words were superimposed on the picture, activation was monotonically decreased with the progression of the sentence or word sequence in multiple areas in both hemispheres, similarly for the two languages. In the bilateral inferior occipitotemporal and left middle temporal cortex (Figure 1C), activation additionally differentiated between the stimulus types: for the final inflected object form word of the sentence (but not for the base form of the word sequence) the activation remained at the same level as for the second word or was even increased. This study provides a new perspective on the methodologically challenging topic of sentence-level speech production. We propose that presentation of the first picture initiated lemma-level access to all depicted words. In the sentence condition, thematic roles are also assigned and stored in the working memory. Our results indicate that this stage was more taxing in the newly acquired than native language. As the task progressed, the descending activation suggests global effects of priming and confirmed expectations. The enhanced left-hemisphere activation in generation of the sentence-final word may reflect the combined retrieval of word form (Jobard et al., 2003) and inflectional morphology (Newman et al., 2010). References: Jobard G, Crivello F, Tzourio-Mazoyer N (2003) Evaluation of the dual route theory of reading: a metanalysis of 35 neuroimaging studies.

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112. 6:00 p.m. - 7:00 p.m.

Impairments of speech in Parkinson's disease

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Few studies have examined connected, spontaneous speech in demented and non-demented patients with Parkinsonís disease (PD). It is generally thought that PD does not affect language per se, although some work suggests difficulty with grammatical comprehension. PD patients nevertheless may exhibit difficulty with communication. Beyond language, this difficulty may be attributable to cognitive functions such as memory, attention, or executive resources. The effects of dementia on language performance in PD are relatively unstudied. We assessed the speech production of non-demented PD patients (n=19), demented PD patients (n=14) and healthy seniors (n=16) in a semi-structured speech sample. This involved narrating a story from a wordless childrenís picture book. The narrations were assessed for appropriateness and correctness of syntax, semantics, morphology, and phonology, including abnormal silences in the stream of speech. Standard neuropsychological tests were also conducted. We found that demented PD patients were deficient compared to both controls and non-demented PD patients at the level of sentence structure (production of well-formed sentences and absence of required determiners) and demented PD patients were also impaired in the production of complex syntax compared to controls. Aspects of sentence structure correlated with executive measures of mental search. Fluency (false starts, speech rate, and total number of words produced) also was reduced in demented PD patients compared to non-demented PD patients and controls. Speech rate and overall output correlated with sentence comprehension. Word-level dysfluency measures were correlated with each other but not with executive functioning. Demented PD patients also produced more phonemic errors than non-demented PD patients and controls. In addition, all patients produced long pauses between and within sentences. In non-demented PD patients, this correlated with several measures of executive functioning and also with semantic categorization. We conclude that demented PD patients have significant impairments in language performance that cannot easily be explained by their motor disorder. This particularly involves speech fluency and grammatical expression, and the latter appears to be related at least in part to poor executive functioning. Abnormal pausing is an early feature of speech impairment in PD.

113. 4:45 p.m. - 5:45 p.m.

Intra-cranial electrophysiology (ICE) of language: Chronicling spatiotemporal stages and connectivity from visual input to motor output

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Language is uniquely human, so neuroscientists have so far been unable to study its basis in the brain with the high-resolution (but invasive) methods that are possible in animals. This is one of the reasons that spatiotemporal neural models of speech production have been notoriously difficult to assemble, and why regions like Broca' area have been associated with so many different aspects of language. Using intra-cranial electrophysiology (ICE) in pre-surgical patients, I found separate language processing stages for the meaning, structure and sound forms of words. These were nearly overlapping in space and all within Broca's area, but were clearly separable in time (peaks at ~200, 320, and 450 ms) (Sahin, NT, et al, Science, 326: 445 (2009)). The spatiotemporally distinct circuits fell within the volume of a typical fMRI voxel and would not have been distinguishable with conventional neuroimaging. The results indicated a serial rather than parallel or single-stage structure to language processing, and demonstrated a type of multi-processing in cortical regions that needs to be considered as a possibility when studying neural correlates of other cognitive systems. In another group of patients, I found that oscillating brain circuits at a given time and location process different information at different spectral frequencies, and could identify a flow of information from early visual input (~60ms) all the way to articulatory output (~600ms and beyond) with multiple waves of systemwide activity suggesting distinct computations. Transient periods of long-distance neural synchrony appeared to bracket the period of cognitive processing, suggesting that task information is distributed to the various expertise centers for processing, then later the results are collected and bound together for the final output. Overall, the findings give a glimpse into a complex level of brain organization in time, space, and physiology, which is not visible with fMRI or MEG and must be probed much further to understand how the human brain computes language.

Prosody, social and emotional processing

114. 6:00 p.m. - 7:00 p.m.

Adapting a tool to assess communication following right brain damage (Protocole MEC de Poche): A special focus on psycholinguistic criteria

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Traditional taxonomy of aphasia does not include the description of communication impairment after right brain damage (RBD). With the development of new psycholinguistic models, including pragmatics and discourse, as well as of cognitive psychology and neuroimaging techniques, the "aphasia of the right hemisphere" has been the focus of clinical research, which has initially been proposed in the 1950s. In general 50% to 70% of adults with RBD present deficits in at least one of these four communicative processes – lexical-semantic, pragmatic, prosodic and discursive processes. This impairment may affect social interactions causing several functional difficulties. In this context, a Canadian battery was designed for briefly assess communication after neurological disorders, mainly a RBD, and was adapted to be administered to Brazilian Portuguese speakers. This study aims at presenting an important phase of the adaptation process of this clinical tool to Brazilian Portuguese. Brazilian public health is characterized by a great demand of clinical evaluations which contributes to the first diagnosis hypotheses. The Protocole MEC de Poche (Joanette, Ferré, Ska & Côté, in press) is the first instrument of brief assessment of communication comprising the evaluation of four communication components. Aim: to present one of the main phases of the adaptation process of the Protocole MEC de Poche to its Brazilian Portuguese version, the Bateria MAC Breve (Fonseca, Casarin, Scherer, Parente, Côté, Ferré, Ska & Joanette, in press). Method: The sample was composed by 200 non-expert judges, of three age and two education groups, who judged the level of familiarity (metaphors, conversational and narrative discourse, semantic judgement), or the grade of plausibility (reading), or the level of directiveness (speech acts). Their judgment guided them to choose the level of a psycholinguist criterion in an analogic scale from 0 (conpletely unfamiliar) to 10 (completely familiar). Then they were invited to write the meaning of each sentence. Quantitative data were descriptively analyzed, and the qualitative data were judged by two experts who categorized the answers to be quantified. Results: Medians of familiarity judgements ranged from 2.0 to 10.0, guiding the authors to exclude the non-familiar stimuli and keeping the familiar ones (7.0 or more). Discussion and conclusion: After this adaptation phase, experts' judgments and a pilot study always ending up with the authors analyses will be taken into account, generating an adapted version of Protocole MEC de Poche to be administered in 30 minutes, assessing neurological impaired people, mainly with right hemisphere stroke, aiding the diagnosis and prognosis of patients with a possible "right hemisphere aphasia". Finally, it is important to stress the necessity of taking into account the psycholinguistic criteria collected from the population to select the stimuli which will comprise the adapted version.

115. 4:45 p.m. - 5:45 p.m.

Early processing of audiovisual emotional information from body language and interjections

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Perception of congruent information from different modalities tends to facilitate processing compared to perception of information from a single modality. One situation in which this benefit becomes especially prominent is the perception of other peopleís emotions. While the processing of emotional facial expression and semantics has been amply investigated, other, equally important information sources such as body language have been largely understudied. In the current study, we therefore investigated the time course of multimodal perception of emotional body language and interjections. During EEG recording participants were presented with stimuli in different modalities. In the audio condition, participants listened to angry, fearful, or neutral interjections. In the visual condition, participants saw short video clips of angry, fearful, or neutral body language. By using video clips instead of photos we ensured high ecological validity of the stimulus material. In the audiovisual condition, participants were presented with video clips accompanied by matching interjections. In this approach, we focused on the early time course of multimodal perception including the N1-P2 complex of the event-related brain potential (ERP; e.g. Stekelenburg & Vroomen, 2007). Comparing the audio to the audiovisual N1 component we report a decreased amplitude of the N1 in the audiovisual condition. Furthermore, comparing the sum of the visual and the audio condition to the audiovisual condition, a smaller N1 amplitude is observed in the audiovisual condition. Thus, the reduction of the N1 component in the audiovisual condition cannot result from mere summation of the underlying unimodal processes. The reduction rather suggests an early integration process. Comparing the ERP responses to different emotions, a clear difference occurs for emotional and neutral stimuli,

showing larger N1 amplitudes for neutral than for emotional stimuli. Therefore, both, audiovisual as well as emotional information result in an amplitude reduction, suggesting facilitated information processing. In the P2 response, a component often associated with emotional salience detection (e.g. Paulmann & Kotz, 2008), an interaction between modality and emotion type is seen: while a clear distinction between emotional and neutral stimuli is found in the audiovisual condition, this effect is much smaller in the audio condition. Hence, audiovisual perception seems to play an important role in the detection of emotional information at an early point in perception. Overall, our findings show an early facilitatory effect of multimodal perception for ecologically valid emotional stimuli.

116. 6:00 p.m. - 7:00 p.m.

Speech rhythm and brain rhythms: An MEG study

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This study aimed to understand the functional significance of low-frequency brain rhythms -particularly theta (4-8 Hz) and alpha (8-13Hz)- in relation to the rhythm of a subvocally rehearsed utterance. A variety of studies have found that prosodic aspects of speech, including rhythm, are more strongly associated with right-hemisphere (RH) areas, and this has been argued to arise from a bias for theta-frequency oscillation in RH auditory cortex (Giraud et al., 2007; Poeppel, 2003; Robertson & Ivry, 1998, 2000). However, it is unknown how low-frequency oscillations relate to behavioral performance. A subvocal rehearsal/working memory task was used to probe the effects of speech rhythmicity on behavioral and neural measures. On each trial, speakers were visually presented a sequence of four trisyllabic nonwords, and then subvocally rehearsed the sequence for three seconds prior to producing it. The experiment contrasted highly rhythmic utterances (with a sww.sww.sww.sww pattern of syllable prominence) against phonologically-matched less rhythmic utterances (with a sww.wsw.wsw.sww pattern). Data were obtained from 8 participants using a 275-channel whole-head biomagnetometer (CTF Systems, Vancouver BC) and analyzed in the time-frequency domain using Nutmeg (bil.ucsf.edu/nutmeg). Behavioral analyses showed that speakers have slower rates of production and produce more errors in less rhythmic speech. MEG source power analyses in low-frequency power bands during the rehearsal phase showed a hemispheric dissociation in posterior middle temporal gyrus (pMTG): theta- and alpha-band desynchronization was associated with highly rhythmic utterances in LH pMTG, but with less rhythmic utterances in RH pMTG. Additionally, L/RH inferior frontal gyrus (IFG, BA44/45) showed significant theta desynchronization in less rhythmic utterances. This suggests that RH pMTG and L/RH IFG theta oscillations support syllabic-timescale, rhythmic coordination of utterances, while LH pMTG oscillations support subsyllabic, segmental-timescale coordination of speech sounds, which is facilitated in highly rhythmic speech. A nonlinear dependence measure (Pereda et al., 2005; Quiroga et al., 2002) was used to probe between-condition differences in synchronization between voxels in temporal, frontal, and parietal areas associated with dual-stream models of speech processing (Hickok & Poeppel, 2007; Rauschecker & Scott, 2009). The nonlinear dependency measure was calculated during the rehearsal phase on each trial using 4-13Hz bandpass-filtered source activation time-series. Repeated measures ANOVA with condition and error occurrence as factors revealed greater synchronization in highly rhythmic speech between LH IFG (BA45) and a more inferior/frontal site (BA47). In contrast, greater synchronization was observed between LH central-MTG and -STG voxels in less rhythmic speech and with the occurrence of production errors. Interestingly, non-errorful production was associated with greater synchronization between posterior and anterior RH MTG sites. These results suggest that speech rhythmicity is indexed by between-area coordination of low-frequency oscillation in the RH MTG and LH IFG, while facilitation of segmental processing involves low-frequency desynchronization in LH MTG. Taken together, the results support theories which attribute hemispheric asymmetries in speech processing to biases in oscillatory frequency, and show that during subvocal rehearsal, the effects of such biases manifest in areas beyond primary auditory cortex, as well as prefrontal areas implicated in speech motor planning.

117. 4:45 p.m. - 5:45 p.m.

Emotional interference: The magnitude and time-course of automatic emotional language processing

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An important question in language processing is what factors influence lexical access. Emotionally arousing words increase lexical access, as lexical decision time is faster to emotional words than to neutral words[1]. Arousal may increase lexical access in this case by drawing attention to potentially threatening stimuli. This account is supported by the emotional Stroop paradigm, in which negative emotional words and taboo words delay color naming relative to neutral words, indicating increased activation of task-irrelevant lexical properties[2,3,4]. However, the nature of task interference depends on the precise stimuli and experimental design, thereby making comparisons between taboo and emotional word interference effects difficult. Specifically, researchers report delayed reaction times reaction time (RT) to

emotional words only in a blocked design, where emotional and neutral words are presented in separate blocks, whereas taboo words also delay RT in a mixed design, where taboo and neutral words are intermixed within a block. Researchers have attributed this effect to lingering interference persisting beyond the word itself, thus masking interference relative to neutral words. This suggests that highly arousing taboo words elicit immediate, fast interference, whereas less arousing emotional words elicit slow interference that maps onto subsequent stimuli[4]. However, previous studies have often confounded the effects of arousal and emotional valance, and have never directly compared interference to taboo and emotional stimuli within the same design. We hypothesize that arousal will mediate the nature of Stroop interference, with increased arousal leading to more immediate interference. Our study used a novel design to isolate immediate from lingering interference, while differentiating between the effects of arousal and valence. Following a norming study, we grouped items into four length and frequency matched stimuli classes, Taboo (e.g., shit), High-arousal Emotional (HE, e.g., stab), Low-arousal Emotional (LE, e.g., sad) and Neutral (e.g., spoon). Participants completed the emotional Stroop, where they indicated the color of each stimulus as quickly and accurately as possible via button press. Stimuli were presented pseudorandomly with several trials of non-word asterisk strings (AS) occurring between word trials. Lexical interference was calculated on correct trials for words and AS occurring one (AS1) and two (AS2) trials after word presentation. To measure interference, average AS RT (not including AS1 or AS2) was subtracted from average stimuli RT. Data showed that lexical interference differed between word types, with the longest RT to Taboo, followed by HE, LE and Neutral words, respectively. AS1 interference was significantly greater following Taboo than any other word type, but was equivalent for Emotional and Neutral words. Additionally, AS2 following Taboo stimuli trended towards larger interference. The results of our study provide important insights into the processing of emotional and taboo stimuli. In contrast to prior work showing that emotional words produce only delayed interference, our research suggests that taboo and emotional words produce immediate interference, but only taboo produces lingering effects. We suggest that interference effects are due to the strength rather than the speed of interference. Increased arousal may lead to stronger, sustained lexical access, influencing the magnitude of the emotional interference effect. 1. M. Nakic et al., NeuroImage 31, 1752 (2006). 2. D.G. MacKay et al., Memory and Cognition 32, 474 (2004). 3. F.P. McKenna et al., Journal of Experimental Psychology: Learning, Memory, and Cognition 21, 1597 (1995). 4. F.P. McKenna et al., Journal of Experimental Psychology: Learning, Memory, and Cognition 30, 382 (2004).

118. 6:00 p.m. - 7:00 p.m.

Who ate the candy? Neural processing of prosodic contrastive focus

Marcela Perrone (1), Marion Dohen (2), Hélène Loevenbruck(2), Marc Sat (2), Cédric Picht (1), Gaëtan Yvert (1), Monica Baciu (1) 1 Laboratoire de Psychologie et NeuroCognition, UMR CNRS 5105, UPMF, Grenoble, France 2 Département Parole & Cognition, GIPSA-lab UMR CNRS 5216, Grenoble Universités, France

Introduction. Considered as the melody of speech, the neural processing of prosody has long been assumed to be right-lateralized (Ross, 1981; Zatorre et al., 1992; Mayer et al., 2002). However, prosody often brings linguistic information and likely involves left-sided language areas (Baum & Pell, 1999; Astésano et al., 2004). One fine example is prosodic contrastive focus which is used to emphasize a constituent in an utterance as opposed to another using a specific intonational contour ('THOMASF mangeait le bonbon' / 'THOMASF ate the candy'). Previous studies have analyzed the processing of prosodic focus but either in an interlinguistic perspective (Tong et al., 2005) or in a framework of affective vs. linguistic comparison (Wildgruber et al., 2004). The aim of the present fMRI study is to clarify the neural network involved in the processing of prosodic contrastive focus in French and to examine potential hemispheric specialization. Methods. 22 French adults participated in the experiment. Two conditions were compared: Focus (F; utterances with narrow contrastive focus on the subject or the object) and Neutral (N; neutral broad focused utterances). The auditory sentences all had the same syntactic and syllabic structure (e.g., 'Thomas mangeait le bonbon' / 'Thomas ate the candy'). The task consisted in determining whether each auditory sentence contained contrastive focus or not. Responses were recorded and performance of task execution was evaluated. A random-effect group analysis was performed on the F vs. N contrast images ($p < 0.001$, uncorrected). In order to test possible hemispheric lateralization, Regions of Interest (ROI) analyses were carried-out. To this aim, ROIs were based on the whole-brain activation obtained by contrasting F vs. N in all subjects and delineated in the left and right hemispheres symmetrically. For each ROI, a repeated ANOVA was performed on the parameter estimates with the hemisphere as a within-subject factor. Results. Analysis of the correct responses confirmed that the tasks was perfectly performed (Focus: M = 92.99%, SD = 6.73%; Neutral: N = 97.72 %, SD = 3.85%). Compared to the neutral sentences, the processing of prosodic focus involved activations in the left premotor cortex, the inferior frontal gyrus bilaterally, the left superior and right middle temporal gyri, the supramarginal gyrus bilaterally, and the left superior parietal lobule (Group analysis; Figure 1-Panel A). In addition, left dominant activations were observed in the inferior frontal gyrus, the supramarginal gyrus and the anterior insula (ROi analyses; Figure1-Panel B). Conclusion. Altogether, these results demonstrate that the perception of prosodic focus is not strictly right-lateralized but rather involves bilateral processes in order to detect focus cues. The strong right middle temporal activation likely suggest that the melodic processing of the intonational contour rather takes place in the right hemisphere whereas the associative processes towards a linguistic decision would rather be left-lateralized (left dominance of supe-

rior temporal, parietal and frontal regions). This study provides evidence that that both hemispheres participate in the auditory perception of prosodic contrastive focus, with a left-dominant contribution for morpho-syntactic processes and thematic role monitoring. References. Astésano et al.,2004, Cognitive Brain Research, 18, 172-184 Baum, & Pell, 1999, Aphasiology, 13, 581-608 Mayer, J., et al. Proc. Speech Prosody 2002, Aix-en-Provence, France, 487-490 Oldfield,1971, Neuropsychologia, 9, 97-113. Ross, E.D., 1981. Archives of Neurology 38(9), 561– 569. Zatorre, R. J. et al., 1992. Science, 256, 846–849.

119. 4:45 p.m. - 5:45 p.m.

Brain correlates of speech rhythm and semantic processing

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Rhythm is a multidisciplinary phenomenon which is fundamental in motor behavior, music and language. In language, we define rhythm as the temporal structure that underlies the perception and production of utterances. In contrast, meter is defined as the alternation of stressed and unstressed syllables in the rhythmic structure of a given language. This alternating pattern provides a structural and temporal grid for speech processing that can be employed to boost speech comprehension. We assume that default stress patterns create implicit predictions about when a next stressed syllable occurs in an acoustic signal. Consequently, the unfolding speech signal comprises perceptual regularities that lead to facilitated information processing. The current study investigates lexico-semantic processing in metrically regular and irregular sentence contexts. We tested lexico-semantic integration by means of semantic expectancy violations with EEG and fMRI to examine whether (1) the N400 ERP component (indexing lexico-semantic integration) is influenced by metric context and if (2) brain activations in response to semantic expectancy violations differ as a function of metric context. We predict decreased activation in expected brain regions for lexico-semantic processing (IFG and STG/STS) in metrically regular compared to irregular context. Our results confirm that semantic expectancy affects amplitude modulations of the N400 component. Furthermore, the N400 amplitude is reduced in metrically regular context. fMRI results support the ERP results. We find the classical lexico-semantic network consisting of the STG and IFG in metrically irregular context, but bilateral IFG/insula only in metrically regular context. Our results show that regular speech rhythm induced by alternating stressed/unstressed syllables facilitates lexical-semantic integration.

120. 6:00 p.m. - 7:00 p.m.

Upregulation of non-language brain areas in response to syntactically ambiguous sentences heard without supporting speech prosody

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Neuroimaging has been used to examine patterns of neural activation when reading sentences with a temporary syntactic ambiguity requiring probabilistic decision-making, but little attention has been paid to effects of speech prosody as an aid to syntactic resolution when sentences are aurally presented. Extant imaging data has suggested that dorsolateral prefrontal cortex (DLPFC) activation supports syntactic probability estimation in reading. In the case of speech, imaging data has suggested that bilateral frontal and anterior-superior temporal activation supports prosodic processing. To our knowledge there has yet to be a systematic imaging evaluation of the role of prosody during the course of probabilistic decision-making related to verb compatibility and sentence structure. We conducted two experiments. Experiment 1, a behavioral study, investigated the utility of syntactically-tied prosody in facilitating the interpretation of sentences with syntactic ambiguities. Experiment 2, a fMRI study, investigated the associated patterns of neural activation. In both cases, the spoken stimuli were sentences with a temporary syntactic ambiguity. The sentences contained an embedded verb that was either more compatible with its sentence structure, such as ìThe newspaper editor printed the article gleefullyî (both the verb and the sentence structure are associated with a direct object); or less compatible with its sentence structure, such as ìThe newspaper editor printed the article was slanderousî (here the verb is associated more often with a direct object but is embedded in a sentence structure with a sentence complement). The sentences were digitized and processed to reduce the three major acoustic features associated with normal sentence prosody: pitch variation, timing variation, and amplitude variation. Behavioral results from Experiment 1 show that the removal of ordinarily available prosody exacerbates the processing difficulty associated with less compatible relative to more compatible stimuli. Imaging results from Experiment 2show significant right DLPFC involvement when listeners must resolve the structure of a sentence with less compatible compared to more compatible stimuli, and this activation is augmented in the absence of normal prosody. Taken together these findings support the position that syntactically-tied prosody facilitates online syntactic parsing in the presence of temporary syntactic ambiguity in spoken material. Moreover, sentence processing without natural syntactic prosody recruits brain areas associated with executive resources that are not ordinarily activated during core-syntactic processing.

121. 4:45 p.m. - 5:45 p.m.

Electrophysiological evidence for metrical expectancy during silent word reading

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Objective: Speech rhythm is an important aspect of language processing. In particular, several studies have shown its role in language acquisition and the segmentation of the continuous speech stream. The event-related brain potential (ERP) method has recently been used to investigate the electrophysiological correlates of perception of speech rhythm, as well as the interplay between metrical expectancies and other aspects of language, such as syntax and semantics. While most of that body of work has investigated the perception of metrical stress patterns expressed through variations in acoustic cues, the goal of the present study was to investigate to what extent metrical structure in English plays a role in silent word reading, using the ERP method. Methods: ERPs were recorded in 14 participants while they were visually presented with sequences of five bisyllabic words that had the same frequency of occurrence in English. The first four words were either all trochaic (i.e., stress-initial) or all iambic (i.e., stress-final). Metrical expectancy was manipulated by varying the stress pattern of the last word of each list, so that it had either the same or different stress pattern as the previous four words. After each sequence, a sixth word was presented and participants were required to decide whether it was a new word or a repetition of one of the previous words. Results: A comparison of the ERP elicited by visually presented trochaic and iambic words did not reveal any significant difference. However, final words that did not match the stress pattern of the previous words (i.e., a trochaic in an iambic sequence, or an iambic in a trochaic sequence) elicited a larger negative component between 250 and 600 ms following the word presentation, over the fronto-central regions of the scalp (See Figure 1). Moreover, this negative effect was larger for unexpected trochaic words than unexpected iambic words. Discussion and Conclusion: The present results suggest that word sequences with a regular stress pattern elicit expectancies about the stress pattern of upcoming words even during reading, as demonstrated by the presence of a larger negative component to unexpected than expected stress patterns. Moreover, this increased negativity shares a similar latency and scalp distribution as the N400 component. This finding is also in line with previous studies showing that interactions between rhythmic and lexico-semantic processing in the auditory modality are reflected by a modulation of the N400 effect. Overall, these results extend the literature suggesting that implicit prosody plays a role in the understanding of written language.

122. 6:00 p.m. - 7:00 p.m.

Task-dependent involvement of frontal and temporal cortices during prosody processing

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Evidence from neuropsychology and neuroimaging suggest that regions in frontal and temporal cortices are involved in both the production and perception of speech. However, whether these regions play similar or different roles in the production and perception of prosodic speech is not well understood. Using multivoxel pattern analysis of functional neuroimaging data, we tested the hypothesis that, while frontal and temporal cortices are recruited during both prosody production and perception, the ability of these regions to discriminate between different prosodic conditions differs depending on the task (production vs. perception). We found that while frontal and temporal regions were able to classify between different prosodic conditions at a better-than-chance level during the production task, classification performance was poor during the perception task. These results show that frontal and temporal cortices are involved in different types of processing depending on the task. In addition, these findings suggest that frontotemporal activation during prosody production does not reflect processing of auditory feedback from produced speech, and that frontotemporal activation during prosody perception is not involved in low-level processing of acoustic features, but is instead subject to higher-level modulation. Our findings contribute to the current understanding of the commonalities and differences, at the neural network level, between the production and perception of speech processes.

Registration

Categories	Early May 1st – July 31st at 11:59 pm (CST)	Late August 1st – November 7th at 11:59 pm (CST)	Onsite November 8 – November 12
Student	$50	$100	$150
Postdoc	$75	$150	$200
Regular	$175	$300	$350

Registration fees include access to all conference sessions, coffee and breakfast in the morning, coffee breaks during the day, a welcome reception on Wednesday November 10, an evening reception on Thursday November 11, and all conference material.

Student Registration

To register for the conference as a student (graduate students, medical students, residents, and fellows), you must submit a letter from your department to confirm your student status and expected date of graduation. Letters can be mailed to the NLC2010 Registrar (address appears below), emailed to registration@neurolang.org or faxed to (773) 702-2482.

Cancellation policy

Written requests for refunds are subject to a cancellation fee of $10 before the end of the early registration period (July 31st 2010). Between August 1st and November 30th 2010, a cancellation fee of 50% will be applied. No refunds will be processed after November 1st 2010.

Registration Inquiries

NLC2010 Registrar, Department of Neurology, The University of Chicago, 5481 S. Maryland Ave. MC-2030, Chicago IL, USA, 60637. Fax: (773) 702-2482. Email: registration@neurolang.org

Conference venue

The Second Annual Neurobiology of Language Conference (NLC 2010) will be held at the beautiful southern California style Rancho Bernardo Inn Golf Resort & Spa, 17550 Bernardo Oaks Drive, San Diego, CA 92128.

As a guest at the Rancho Bernardo Inn you will enjoy a complete Resort-Style experience: luxury accommodations, award-winning dining, championship golf, resort spa, etc. In addition, Rancho Bernardo Inn is located just minutes away from many of San Diego's top attractions: Wild Animal Park, Legoland, SeaWorld, San Diego Zoo and Southern California Beaches.

In order to make your NLC 2010 experience a memorable one, we are delighted to offer an unbeatable room rate for single or double occupancy of US $170, which includes **complimentary kids Club** for all attendees staying at the Rancho, **free transportation back to downtown San Diego on Saturday, November 13**, **30% discount on published golf prices** (good for individual or tournament play and includes rental cart), a **10% discount on spa services**, and **complimentary self parking.**

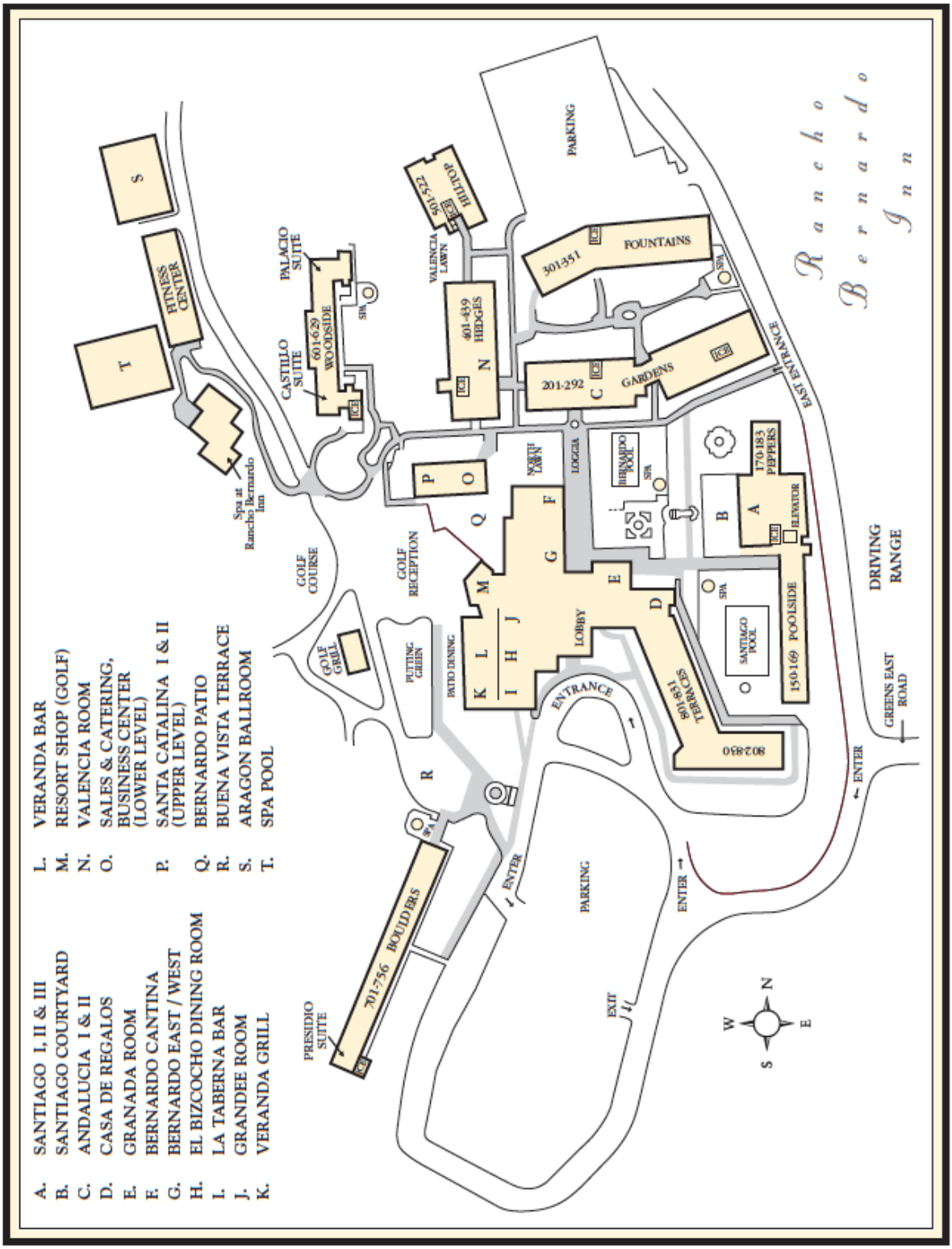
The group rate is available throughout the conference, (i.e. November 10-12), and can be extended 3 days prior to and after the conference.

To reserve a room online, visit the Rancho's website at and use the following code: **1011ANNUA**. Please note that the online reservation system will only accept reservations that are within the Conference dates. To reserve additional dates at the group rate, call the Rancho's reservation's team Monday-Friday from 7am-9pm, and Saturday and Sunday from 7am-7pm at **800-542-6096.**

If you wish to reserve a place at the kids Camps, please mention it when you call to make your reservation.

We strongly encourage you to reserve your room at the Rancho as soon as possible because space is limited!

Site Map


A. SANTIAGO I, II & III
B. SANTIAGO COURTYARD
C. ANDALUCIA I & II
D. CASA DE REGALOS
E. GRANADA ROOM
F. BERNARDO CANTINA
G. BERNARDO EAST / WEST
H. EL BIZCOCHO DINING ROOM
I. LA TABERNA BAR
J. GRANDEE ROOM
K. VERANDA GRILL
L. VERANDA BAR
M. RESORT SHOP (GOLF)
N. VALENCIA ROOM
O. SALES & CATERING, BUSINESS CENTER (LOWER LEVEL)
P. SANTA CATALINA I & II (UPPER LEVEL)
Q. BERNARDO PATIO
R. BUENA VISTA TERRACE
S. ARAGON BALLROOM
T. SPA POOL
Rancho Bernardo Inn
FITNESS CENTER
PALACIO SUITE
CASTILLO SUITE 601-629 WOODSIDE
601-639 HEDGES
VALENCIA LAWN
201-252 GARDENS
301-351 FOUNTAINS
PARKING
EAST ENTRANCE
Spa at Rancho Bernardo Inn
GOLF COURSE
GOLF RECEPTION
GOLF GRILL
PUTTING GREEN
PATIO DINING
NORTH LAWN
LOGGIA
BERNARDO POOL
LOBBY
ENTRANCE
SANTIAGO POOL
SPA
170-183 PEPPERS
ELEVATOR
150-169 POOLSIDE
801-851 SEQUOIA TERRACE
802-850
DRIVING RANGE
GREENS EAST ROAD
ENTER
PRESIDIO SUITE
701-756 BOULDERS
EXIT
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Driving directions

From San Diego International Airport:
Take Harbor Drive south (toward downtown)
Turn left at Grape Street
Go east to the top of the hill, then take Interstate 5 south
Stay in the right lane and follow Route 163 north toward Escondido
(Route 163 becomes Interstate 15)
Take the Rancho Bernardo Road exit east to Pomerado Road (4th light)
Turn left on Pomerado Road
Turn left onto Greens East Road
Follow the signs to the resort entrance

From Interstate 15:
Take the Rancho Bernardo Road exit east to Pomerado Road (4th light)
Turn left on Pomerado Road
Turn left onto Greens East Road
Follow the signs to the resort entrance

Kids camp

The kids camp is available from Wednesday, November 10, at 4pm until Friday, November 12, in the evening. It is complimentary to all participants staying at the Rancho. To make a reservation, or request additional information, please call the Rancho Bernardo Inn.

November 10th- Wednesday
Arrival: Each kid will receive a welcome totes. It will be filled with arts and craft supplies, snacks, disposable camera, stickers, and much more
Wii Lounge: It will be open from 12PM-3PM. The kids can come relax on bean bag chairs, bust a move at the Dance Dance Revolution, be a Guitar Hero, create their own Rock Band and join in the fast paced Wii Tournaments.
Activities with the Pros:
3PM-4PM: Mini Golf-Kids can aspire to be their favorite player on the putting green.
4PM-5PM: Fun Fitness- Kids can play with hula hoops, jump ropes, and have a soccer tournament.
Dive-In Movie: at the Santiago Pool. S'mores by the fire pit will start at 7PM. Kids can watch a family rated movie on the big screen while roasting a marshmallow and enjoying popcorn and lemonade!

November 11th – Thursday
Get Up and Go Breakfast: 8AM-9:30AM Wake up to build a waffle breakfast. Bacon, sausage, hash browns, mike, juice and more waffle toppings than you can name! Top homemade waffles with: assorted fruits, chocolate chips, whipped cream, syrups, nuts, and "chefs choice" toppings!
Fun Fitness: 10AM-11AM. The kids can start their day energized!
Wii Lounge: It will be open from 12PM-4PM. The kids can come relax on bean bag chairs, bust a move at the Dance Dance Revolution, be a Guitar Hero, create their own Rock Band and join in the fast paced Wii Tournaments. Enjoy Pizza, popcorn, and build your own ice cream sundae station.
Create your own Facial: 4PM-5PM- Kids can be creative and have fun with a spa professional.
Dive-In Movie: at the Santiago Pool. S'mores by the fire pit will start at 7PM. Kids can watch a family rated movie on the big screen while roasting a marshmallow and enjoying popcorn and lemonade.

November 12th – Friday
Get Up and Go Breakfast: 8AM-9:30AM Wake up to build a waffle breakfast. Bacon, sausage, hash browns, mike, juice and more waffle toppings than you can name! Top homemade waffles with: assorted fruits, chocolate chips, whipped cream, syrups, nuts, and "chefs choice" toppings!
Fun Fitness: 10AM-11AM. The kids can start their day energized!
Wii Lounge: It will be open from 12PM-4PM. The kids can come relax on bean bag chairs, bust a move at the Dance Dance Revolution, be a Guitar Hero, create their own Rock Band and join in the fast paced Wii Tournaments. Enjoy Pizza, popcorn, and build your own ice cream sundae station.
Tennis: 4PM-5PM. The kids can aspire to be their favorite player while playing on the tennis courts.
Dive-In Movie: Dinner and a movie at the Santiago Pool starting at 6PM! Enjoy pizza, popcorn, nachos, and more snacks while watching your favorite movie on the big screen. We will keep the fun going with S'mores at the Santiago Fire pit.

Dinner & lunch

The Rancho Bernardo Inn offers two choices for the Dining. The restaurant El Bizcocho was recently named the Critic's Choice for "Best of the Best" by San Diego Magazine and voted the city's "Highest-Rated Restaurant" by the Zagat Survey. Locally grown Organic Produce and handcrafted Artisan Products provide the perfect backdrop for the innovative, Contemporary Cuisine served at El Bizcocho. The Veranda is the perfect place to meet for a snack, dine under the stars or gather around the fire with a cocktail. Serves Breakfast, Lunch and Dinner. Nearby you'll find Veranda Bar, Rancho Bernardo Inn's Sports Bar featuring Plasma Televisions, Billiards and Darts along with a selection of Beers, Cocktails and Appetizers.
In addition, the Cafe Granada is is just off the lobby. Your morning Starbucks™ , a quick breakfast or lunch on the go is just a few steps away. House-Made Pastries Baked Fresh Daily | Fresh, Crisp Salads | Grab-and-Go Sandwiches | Business Center with High-Speed Internet.
In addition, we have organized special onsite lunch options (from $6 to $16) for our participants. No need to worry about rushing out for a quick bite! We will serve wraps, tacos, burgers, BBQ ribs, salads and more!

If you would like to go out for lunch or dinner, here are some options near the Rancho (also see map next page):

A. Bernard'o Restaurant: 12457 Rancho Bernardo Road, San Diego, CA (858) 487-7171 (.9 mi/1.45KM)

B. Barrel Room: 16765 Bernardo Center Drive, San Diego, CA, (858) 673-7512 (1.9 mi/ 3.06 KM)
C. El Bizcocho (onsite)

D. Carvers Steaks & Chops: 11940 Bernardo Plaza Drive, San Diego, CA, (858) 485-1262 (1.7 mi / 2.74 KM)

E. Elephant Bar Restaurant: 17051 West Bernardo Drive, San Diego, CA, (858) 487-7181 (.9 mi/1.45)

F. Stir Fresh Mongolian Grill: 17120 Bernardo Center Drive, San Diego, CA, (858) 385-0020 (.6 mi / .97 KM)

G. Spices Thai Cafe: 16441 Bernardo Center Drive, San Diego, CA, (858) 674-4665 (1.5 mi / 2.9 KM)

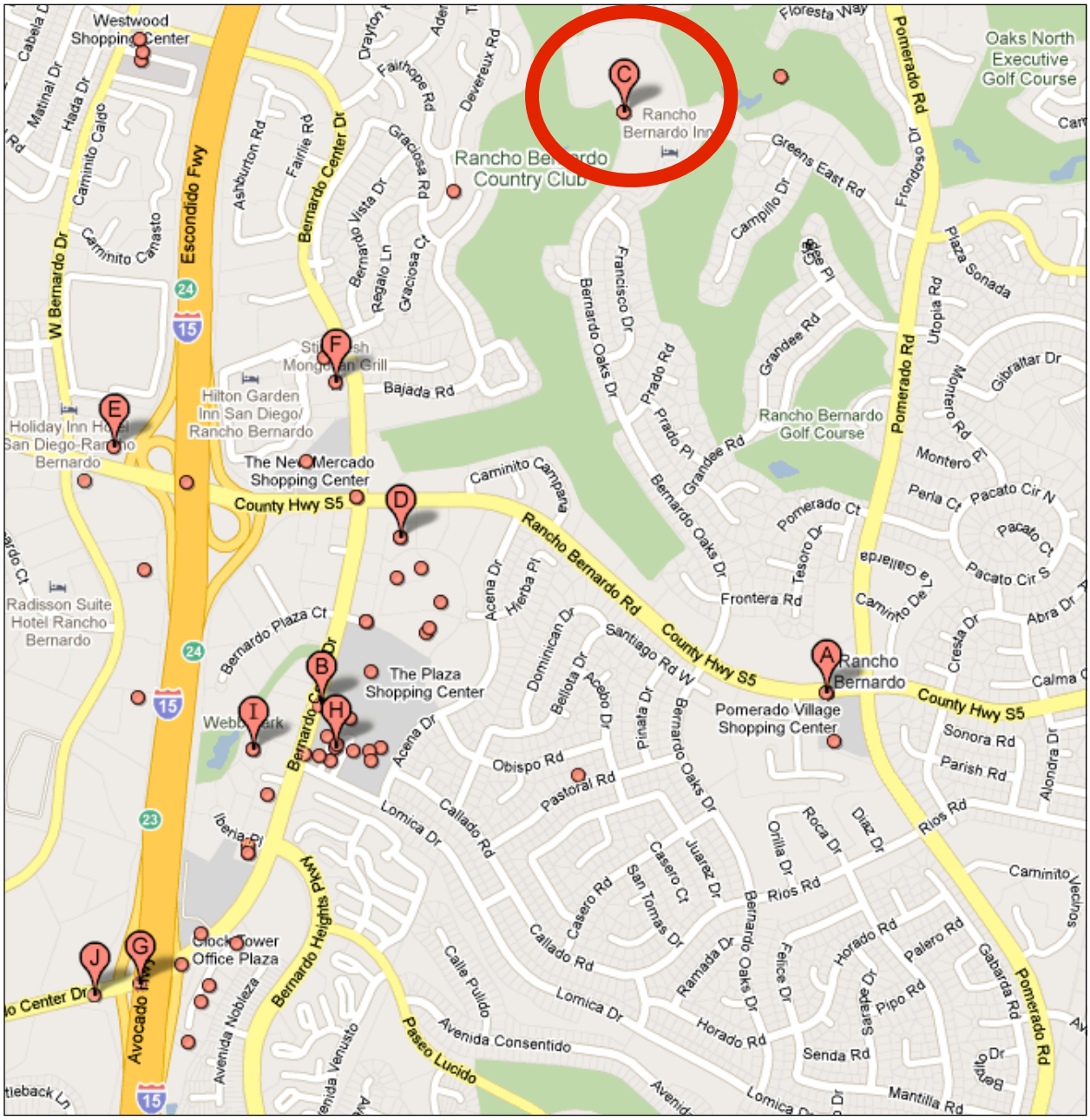
H. Hunan Restaurant: 16719 Bernardo Center Drive, San Diego, CA, (858) 487-8131 (1.8 mi / 1.77 KM)

I. Pearl Chinese Cuisine: 11666 Avena Place, San Diego, CA, (858) 487-3388 (1.1 mi / 1.77 KM)

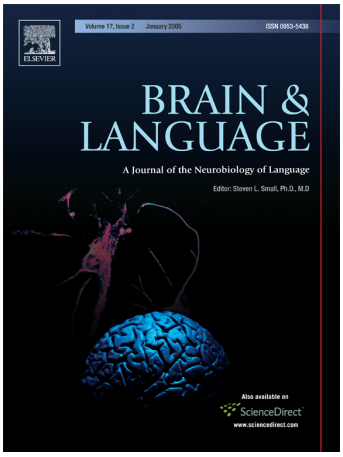
J. Rb Sushi Japanese Restaurant: 16405 Bernardo Center Drive, San Diego, CA, (858) 613-9000 (2.3 miles / 3.8 KM)

Area map with nearby restaurants

(The Rancho Bernardo is circled in red on the map)



Exhibitors



Brain & Language The international journal Brain and Language focuses on the neurobiological mechanisms underlying human language and is a proud sponsor of the Neurobiology of Language Conference.

Cortech Solutions: Innovative solutions for research in electrophysiology and behavior - EEG / ERP, fNIRS, sEMG and more. A single source for sales and support for all the tools a neuroscientist needs for advanced brain research. We identify best-in-class solutions, work with the manufacturers to ensure compatibility and offer the total solution with a single source for technical support. Leave the technical solutions to us -- you concentrate on the science!"

Rogue Research Inc. is the developer of the Brainsight neuronavigation family of products, including TMS navigation, veterinary neurosurgery tools and more recently, NIRS imaging. Rogue Research is also a founding member of Rogue Resolutions, a company dedicated to the development and support of integrated neuroscience solutions, including interoperability between Brainsight and the neuroConn family of EEG and tDCS products.

Organization

The second annual Neurobiology of Language meeting is being developed by **Steven L. Small** (small@neurolang.org) and **Pascale Tremblay** (tremblay@neurolang.org) of The University of Chicago, and by the NLC2010 international Organizing Committee.

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Peng Zhou, Macquarie Centre for Cognitive Science, Macquarie University

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Juliana Baldo, VA Northern California Health Care System
Christopher Barkley, UC San Diego
Blythe Buchholz, The University of Chicago
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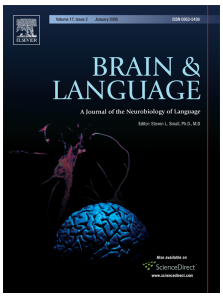

Brain & Language (Elsevier)

Author Index

Legend: P = Poster, S = Slide session, K= keynote lecture, D = Discussion panel, Th = Thursday, November 11, Fr = Friday, November 12. Examples: Th-S2: Slide presentation #1 on Thursday, November 11. Fr-P1: Poster #1 on Friday, November 12.

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