

DAY 1: PRESENTATIONS

For what do you need a left temporal lobe?

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Objectives: This is a single-case study of an aphasic patient, 'Fred', whose stroke destroyed all of his left temporal lobe, caudal to rostral, medial to lateral, and inferior to superior except sparing the superior temporal gyrus. The case afforded a rare opportunity to advance our understanding of the functions of this large section of brain. More specifically, because most aetiologies affecting the rostral and inferior temporal lobe (such as semantic dementia) involve bilateral damage, our objective was to assess semantic memory in the case of an extensive but unilateral temporal lesion.

Methods: In addition to structural and functional imaging of Fred's brain, we administered a range of tests of language and semantic memory.

Results: Fred's major chronic-aphasic symptom was anomia: he scored 0/30 on the difficult Graded Naming Test, 28/64 on the substantially easier naming test from the Cambridge Semantic Battery, and had very poor category fluency. He benefited from phonological cueing, but typically required more than the initial phoneme of the target word. He was significantly impaired on both verbal and non-verbal assessments of semantic memory, and demonstrated surface dyslexia and dysgraphia. His performance on tests like lexical and object decision was impaired but lacked the strong sensitivity to stimulus familiarity and typicality that is so characteristic of semantic dementia. **Conclusions:** Fred's profile of language and semantic impairments resembles something mid-way between more typical semantically-impaired stroke aphasic patients (Jefferies & Lambon Ralph, *Brain*, 2006) and patients with semantic dementia (Patterson et al., *Journal of Cognitive Neuroscience*, 2006).

Left frontal anodal tDCS during spoken picture naming elicits neural and behavioral priming in Broca's area.

Holland, R., Leff, A.P., Josephs, O., Galea, J., Desikan, M., Price, C. J., Rothwell, J., Crinion J.

Objectives: Using functional magnetic resonance imaging (fMRI) we assessed if concurrent anodal transcranial direct current brain stimulation (A-tDCS) applied over left frontal cortex (LFC) would facilitate picture naming and modulate local neural activity.

Methods: 10 healthy participants (mean: 69 years) completed a single-blind, sham-controlled cross-over fMRI study. Spoken picture-naming responses and imaging data were acquired before (sham), during and after (carryover) 20-min 2mA bipolar A-tDCS delivered to LFC.

Results: Naming was significantly faster (primed) during and after A-tDCS, compared to sham stimulation ($F(2,18)=10.17$, $p<0.001$), with no difference between A-tDCS and carryover. A-tDCS significantly reduced BOLD response (neural priming) within LFC compared to sham (ANOVA, $P = 0.05$), which was retained for at least 20 minutes after stimulation. Furthermore, there was a significant correlation between A-tDCS neural and behavioral facilitation effects. Faster naming was associated with increased neural priming in LFC involving Broca's area, but not with activity in left postcentral gyrus a motor speech region, also in the vicinity of the anode electrode, indicating a regionally-specific rather than global cortical facilitation effect of A-tDCS.

Conclusions: A-tDCS delivered over LFC concurrently with a picture-naming task had significant and sustained regionally-specific neural and behavioural priming effects, involving Broca's area. This suggests that A-tDCS may facilitate naming through a neural priming mechanism in word retrieval rather than motor speech networks. Concurrent tDCS and fMRI is feasible and may provide new insights into causal effects in brain regions ultimately leading to the development of new therapeutic tDCS applications for aphasia and anomia treatment.

Verbal and Non-Verbal Fluency Tasks and the Frontal Lobes

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Objective: Fluency tasks have been widely used to tap the voluntary generation of responses, thought to be a frontal 'executive' process. However, there is debate regarding the localisation within the frontal lobes of fluency tasks and whether these tasks are sensitive to damage beyond the frontal region. This study aims to investigate a series of fluency tasks in patients with focal frontal and posterior lesions.

Method: Patients with unselected focal frontal and non-frontal lesions were included on the basis of their imaging. Patients and educational, age and sex matched controls were administered background cognitive tests and verbal and non-verbal fluency tasks including word, design, gesture and ideational fluency. Lesions were analysed by traditional anterior/posterior and left/right frontal subdivisions as well as a more fine-grained frontal localisation. Thus, patients with right and left Lateral lesions were compared to patients with superior and inferior Medial lesions.

Results: A selective frontal impairment was found only for phonemic and design fluency tasks. The severest deficits for Lateral patients were along material specific lines (i.e., Left – phonemic and Right – design). Interestingly, a Superior Medial deficit was observed on all fluency tasks regardless of material type. A Left Inferior Frontal Gyrus deficit was observed on fluency tasks greater selection requirements (e.g., phonemic fluency).

Conclusion: Frontal lobe damage results in a wide range of fluency impairments specific for word (constrained by phonology) and design generation, with some support for material specific lateralisation. The Left Inferior Frontal Gyrus plays a crucial role in selection and the Superior Medial region in energization.

Cognitive enhancement and neurobilingualism: Selective effects of brain stimulation on language switching but not manual response-conflict

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Objectives: Recent high-profile reports have argued that the need for bilingual speakers to continuously switch between languages leads to an enhancement of cognitive control mechanisms that extends into the non-language domain. It has been suggested that these enhanced cognitive control mechanisms are associated with the function of dorsolateral prefrontal cortex (DLPFC). We used non-invasive brain stimulation techniques to test this proposal directly by investigating whether brain stimulation to the left and right DLPFC has similar effects on executive function in the linguistic and non-linguistic domains for bilingual speakers.

Methods: Prior to stimulation Korean–English bilingual participants completed two demanding cognitive control tasks: a language-switching task in which bilingual speakers had name stimuli in their first or second language, and were required to continuously and randomly switch between languages; and a manual response-conflict task in which participants made spatially congruent or incongruent, speeded, manual responses according to a randomised colour cue. All participants then underwent either 15 minutes of *cathodal* stimulation to the left or right DLPFC, or 15 minutes of *sham* stimulation. Following stimulation all participants repeated the language-switching and manual response-conflict tasks outlined above.

Results: First, contrary to the predictions of a generalized increase in cognitive control in bilingual speakers, we show that baseline (i.e., pre-stimulation) performance on the language-switching and manual response-conflict tasks is uncorrelated. Second, we show that cathodal stimulation of the **left** DLPFC but not the right DLPFC abolishes the beneficial effects of practice on the language-switching task relative to the sham condition. Third, we show that cathodal stimulation of the **left** DLPFC has no effect on the manual response-conflict task relative to sham.

Conclusions: These results provide evidence that recent demonstrations of enhanced cognitive control in bilingual speakers, that have been linked to DLPFC function based upon correlational brain imaging studies, may not in fact generalise very widely to non-linguistic executive function.

From Sensation to Semantics: Convergent Connectivity and Graded Specialization in the Temporal Lobe as Revealed by Diffusion Weighted Imaging Probabilistic Tractography

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Objectives: Damage to unimodal association cortices in the posterior temporal cortex results in modality-specific disorders. Anterior temporal lobe atrophy results in multimodal comprehension deficits. This suggests that information converges gradually along the caudal-rostral axis of the temporal such that representations become increasingly modality-invariant. However, little is known about the in vivo connectivity of the entire human temporal lobe. By using diffusion-weighted imaging (DWI) tractography, we attempted to characterise temporal lobe intra-connectivity and also regional connectivity to frontal and parietal areas classically associated with language processing.

Methods: Whole brain, distortion-corrected DWI was acquired from thirteen healthy subjects. Seed regions were defined as the white matter of each gyri within an anterior, a middle and a posterior cross-section of the temporal lobe. Probabilistic tractography was performed using the PICO Monte Carlo streamline approach and q-ball. Group-wise connection values between each pair of regions were extracted from the resulting probability maps.

Results: Convergence of sensory information is graded and occurs along both the longitudinal (caudal-rostral) and lateral axes of the temporal lobe. In contrast, temporal lobe connectivity to frontal and parietal language regions is non-graded and dissociates across the caudal, mid and rostral temporal cortices.

Conclusions: The human temporal lobe displays a pattern of graded convergent connectivity which would result in the emergence of increasingly modality-invariant representations towards the temporal pole. Furthermore, an anteroventral temporal region displays limited connectivity to areas outside the temporal lobe - which aligns with recent evidence that this region underpins the extraction of modality- and context-invariant semantic representations.

ABSTRACT FOR SYMPOSIUM

“Re-considering language as the function of a large-scale neural network: Towards a new understanding of normal language and aphasia” *Organised by Matt Lambon Ralph*

Multiple neuroscience and clinical studies now demonstrate that language function - like other forms of higher cognition - is supported by multiple, wide-spread, interconnected cortical regions. As such, a key challenge for contemporary studies is to measure, not only the contributions that each region makes to overall language function, but also the pattern of structural and functional connections that license the regions to act as a coordinated network. Such studies are critical to our understanding for the neural basis of normal language function. In addition, they offer new insights about the nature of impaired and recovered language function in patients with aphasia after stroke, neurosurgery and neurodegenerative disease. This symposium will present recent and novel findings on this topic. Multiple methods, perspectives and method combinations will be covered including DTI, functional connectivity, TMS, cortical stimulation and computational modelling.

The bits in here and here that go when you're losing your wordage: atrophy, metabolism and connectivity changes in semantic dementia.

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Semantic dementia (SD) has been arguably the most fruitful lesion model informing understanding of human semantic memory over the past two decades. From the outset, it was recognized that the syndrome was associated with severe, focal temporal lobe degeneration. Volumetric studies offered the first refinement by showing that the rostro-ventral temporal lobe, particularly the peri-fusiform region and pole, but also parahippocampal gyrus and hippocampus were sites of severe atrophy while the superior temporal gyrus was relatively preserved. Metabolic studies then highlighted that the lesion of SD could be completely restricted to these regions—in other words, this lesion was not simply the tip of a diffusely abnormal iceberg but, rather, it could be the only affected brain region. Nevertheless, debate continued on whether the substrate for the cognitive syndrome was the whole lesion, a sub-region, or even subtle damage elsewhere. Recent work with FDG-PET has highlighted that the rostral fusiform gyrus (subjacent to the hippocampal head) is the critical lesion locus and that there is a strong lateralization according to test material—left rostral fusiform: verbal (naming); right rostral fusiform: visual associative. Finally, understanding how this lesion interacts with “classic” language areas has been illuminated through a multi-modal imaging approach combining metabolism, structure and diffusion imaging of white matter tracts. These results indicate that pathways leading from posterior sensory areas into the ventro-rostral temporal lobe are preserved but that the ventro-rostral lesion causes degeneration of efferent fibres projecting to caudal superior temporal, and supramarginal, gyri (respectively STG and SMG), as well as into the uncinate and arcuate bundles. In summary, imaging evidence in SD highlights that the rostral fusiform is a

critical node in semantic knowledge processing, and, that this lesion has a direct impact on spared lateral temporo-parietal language areas (STG and SMG).

Why white matter matters in understanding chronic stroke aphasia: Evidence from tractography

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Objectives: Language deficits demonstrated by chronic stroke aphasics can only be partially accounted for by cortical lesion site. Differences in damage to dorsal and ventral white matter (WM) pathways involved in language processing may play an important role in explaining variation in language deficits. Using tractography-based methods we aimed to determine the condition of WM tracts of stroke aphasics, and relate this to their performance on language tasks.

Methods: Chronic stroke aphasics were assessed on a battery of language tests and had a high-resolution T1 MRI scan and diffusion-weighted scan. A recently developed method, wherein probabilistic tractography streamlines are launched from every brain voxel, was used to process diffusion data. This method produces Anatomical Connectivity Maps (ACMs), which allow visualisation of WM pathways throughout the entire brain. These were related to participants' language profiles.

Results: Data are presented from a preliminary case series of patients and controls. Patients whose ACMs showed damage to WM in the extreme capsule were anomic, whilst patients with arcuate/superior longitudinal fasciculus damage were impaired on all tasks requiring spoken output. Interestingly, patients whose behavioural profiles diverged despite largely overlapping lesions showed evidence of WM damage in differing locations on ACMs.

Conclusions: In this group damage to ventral WM pathways was associated with anomia, whilst damage to dorsal pathways was associated with phonological output deficits. Examination of WM path damage can explain more variation in the language impairments of stroke aphasic patients than cortical damage alone. ACMs represent a new and useful tool for looking at WM changes after stroke.

DAY 2: PRESENTATIONS

TMS reveals two critical and functionally distinct time periods for early face and body perception

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Objectives: Neuropsychological patients exhibiting category-selective visual agnosias have provided unique insights into the cognitive functions of the human brain but such patients are exceptionally rare. One way to address this paucity of patients is via the use of transcranial magnetic stimulation (TMS), which can be used to transiently disrupt object perception in neurologically normal experimental subjects.

Methods: Across a series of experiments TMS was delivered over the face-selective right occipital face area (OFA) or the body-selective right extrastriate body area (EBA) at different latencies after stimulus onset while subjects performed a range of face, body and eye gaze discrimination tasks.

Results: Results demonstrated that TMS disrupted performance for the face and body tasks during two temporally distinct time periods, the first at 40-50ms and the second at 100-110ms. A follow up experiment revealed that these two time periods exhibit functionally distinct patterns of discrimination impairments. Specifically that TMS delivered during the first time period (at 40-50ms) disrupted both preferred (faces at OFA and bodies at EBA) and non-preferred (bodies at OFA and faces at EBA) task performance. By contrast TMS delivered in the second time period (at 100-110ms) disrupted preferred task performance only.

Conclusions: These results reveal two early and functionally distinct time periods for visual face and body perception. The first period at 40/50ms is category-general and may reflect the disruption of a preparatory signal in visual cortex. The second period at 100/110ms is category-specific and most likely reflects the first feed-forward sweep of visual information.

Semantically-driven re-activation of visual cortex during object recognition and naming: An MEG study

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Objectives. 1. To reveal the neural basis of faster processing of early than late acquired objects, not only in naming tasks but also in visual identification tasks. 2. To follow up the fMRI findings of Ellis, Burani, Izura, Bromiley, & Venneri (2006; *Neuroimage*, 33, 958-968) showing stronger responses to early than late acquired objects in visual and semantic (anterior temporal pole) cortex.

Methods. Right-handed participants seated in a MEG scanner named pictures of familiar objects covertly. MEG data were acquired and co-registered with structural MR scans for each participant.

Results. Whole head beamforming for a 0-600 ms time window showed extensive activation including occipital, occipitotemporal and left anterior temporal responses. The response in visual cortex occurred in two phases, with an initial (primarily evoked) response from 50-200 ms followed by a second (primarily induced) response from 300-400 ms. There was a significantly stronger response to early than late from 200-600 ms in the 15-30 Hz frequency band. The left temporal pole response was primarily induced, lasting from around 100-400 ms in the 10-20 Hz range.

Conclusions. We propose that the initial processing of visual objects in the first 200 ms is indifferent to age of acquisition, but that this is followed by a semantically-driven re-activation of visual representations which is modulated by age of acquisition and gives rise to the advantage for early over late acquired objects in visual identification tasks.

Why is ventrolateral prefrontal cortex interested in abstract words? Convergent neuropsychological and rTMS evidence

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Objectives: Neuroimaging studies reliably reveal ventrolateral prefrontal cortex (VLPFC) activation for processing of abstract relative to concrete words but the cause of this effect is unclear. We tested the hypothesis that abstract words require VLPFC because they depend heavily on the semantic-executive control processes mediated by this region. Specifically, we hypothesised that accessing the meanings of

abstract words require more executive regulation because they have variable, context-dependent meanings.

Methods: Comprehension of concrete and abstract words was tested in a) aphasic patients with multimodal semantic deficits following VLPFC lesions and b) healthy subjects following rTMS to left VLPFC. Half of the trials were preceded by a sentence cue that placed the word in particular context and half had no context.

Results: a) Patients exhibited impaired comprehension of abstract words, but this deficit was ameliorated by contextual cues. Concrete words were better comprehended and showed more limited benefit from the cues. b) TMS slowed reaction times to abstract but not concrete words, but only when words were presented out of context. TMS had no effect when words were preceded by a contextual cue.

Conclusions: These converging results indicate that VLPFC plays an executive regulation role in the processing of abstract words. This role is less critical when words are presented with a context that guides the system towards a particular meaning or interpretation. Regulation is less important for concrete words because their meanings are constrained by their physical referents and vary less with context.

Do scholastic difficulties in children with early cerebellar injury arise from specific or general impairments?

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Objective: Poor scholastic performance has been reported following early cerebellar injury, but no previous studies have attempted to investigate if these difficulties arise from a general cognitive impairment. It is thus difficult to target rehabilitation effectively. We investigated the extent of scholastic difficulties, above and beyond general cognitive processing, following cerebellar injury sustained through tumour during the preschool years (<5 years), and the impact of tumour histology/treatment on outcome.

Method: Eleven children (aged 5-15 years) with varying tumour histology/treatment were given comprehensive standardised tests of academic achievement (WIAT- II) and cognitive functioning (WISC-IV). This enabled individual performance on academic subtests of the WIAT-II to be predicted from IQ scores on the WISC-IV.

Results: IQ-achievement test discrepancy analyses revealed significantly poorer performance than expected on the basis of FSIQ in 6/11 children for Reading and Mathematics, 7/11 children for Written Language, and 3/11 children for Oral Language. Most of these children had malignant tumours treated with chemotherapy and/or radiotherapy. For the remaining children, academic performance was either in line with, or was significantly above, that expected on the basis of FSIQ. Most of these children had benign tumours treated with surgical resection only.

Conclusions: These results suggest that early injury to the cerebellum has a generic effect on cognitive processing that underpins development of scholastic skills. Additional academic difficulties are likely to occur in children with invasive tumours requiring more aggressive treatment probably because chemotherapy and radiotherapy are known to affect attentional processing which is critical for scholastic progression.

What can making funny faces tell us about language? Developmental and Neural Correlates of Oral Motor Control and Vocabulary

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Objectives: Oral motor control and language may be linked during development. There is suggestive evidence from clinical (Alcock, et al, 2000), genetic (Bishop, 2002), neuroimaging (Wilson, et al, 2004), and normative developmental studies (Alcock & Krawczyk, 2010). The current study aims to investigate these links in school age children (7 – 12 years). Additionally, recent brain imaging studies suggest that developmental and behavioural changes are accompanied by changes in functional cerebral organization (Brown, et al, 2005; Toga, et al, 2006). Thus, for a sample that we could characterize on a broad behavioural spectrum, we used functional imaging to characterize this group's neural organization on a task involving oral-motor movement. We also used structural imaging to investigate potential individual differences in cortical thickness associated with oromotor skills.

Methods: Non-word repetition (Wagner, Torgesen, & Rashotte, 1999), speeded single word reading (Wagner, Torgesen, & Rashotte, 1999) and measures of grammatical comprehension (Leech, Aydelott, Symons, Carnevale, & Dick, 2007) were compared to oral motor imitation scores. Picture naming was used as the task in the scanner.

Results: There were significant relations (even when age was accounted for) between all of these measures and oral motor control, and more specifically, the sequential component of the oral motor task. Neuroimaging results suggest that there are age-related increases in activations at the level of the sub-central gyrus bilaterally, and age-related decreases in temporal and occipital regions.

Conclusions: These results fit in well with the neuro-constructivist and perspective (Elman, et al, 1996), where lower-level audio-motor skills play an important role in determining higher-level linguistic performance.

Functional neuro-anatomy of self-awareness in Alzheimer disease and Mild cognitive impairment

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Objective: To study the functional neuroanatomy of self-awareness in patients with mild cognitive impairment (MCI) and Alzheimer's disease (AD).

Method: Seventeen healthy elderly, 17 patients with MCI, and 17 patients with a clinical diagnosis of AD took part in a fMRI study. Each participant was accompanied by a study partner. In the MRI scanner, participants were presented with questions regarding them or their study partner ("Are you/Is [study partner] [adjective]?") and asked to give a "yes" or "no" answer. The study partner was asked to complete a paper questionnaire answering the same questions so the responses of participant and study partner could be compared and "discrepancy" scores calculated, for each of the 2 conditions (Self and Other).

Results: AD patients had significantly higher discrepancy scores when judging themselves ($t_{16} = -2.16$, $P = 0.05$), whereas there were no significant differences between discrepancy scores for Self and Other for MCI and controls. Comparison between Self and Other conditions in either the control and MCI groups did not reveal significant activations, suggesting that in these groups self- and other- appraisal share similar networks. Instead, in the AD group, the comparison between the two conditions showed greater activation for Other relative to Self in medial prefrontal and anterior temporal regions.

Conclusions: Differences in functional activation of medial prefrontal and anterior temporal cortex reflect the decreased self-awareness in AD patients. This dysfunction occurs specifically when AD patients are required to judge themselves and not when they have to judge others, may be the basis of anosognosia in dementia.

Confabulation reflects a pathological functioning of Temporal Consciousness: A case study

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Confabulation is a symptom, observable in amnesic patients who are unaware of their memory deficit. According to the Memory, Consciousness and Temporality theory (MCTT) (Dalla Barba, 2002) confabulation is not a pure memory disorder, but a disorder involving Temporal Consciousness (TC). TC allows individuals to become aware of something (episodes, information) as part of a personal past, present or future. In this study we describe a patient, TA, who developed a chronic amnesic-confabulatory syndrome, following rupture of a right internal carotid siphon aneurysm. Our aim was to elucidate as fully as possible the nature of TA's impairment and to test the hypothesis of confabulation as reflecting a dysfunction of TC. Confabulations were collected with the Confabulation Battery (Dalla Barba, 1993, 2008), which includes 169 questions tapping various aspects of semantic knowledge and TC. TA's confabulations were present in answers to questions tapping TC, i.e. autobiographical episodic memory, orientation in time and place, and foresight of personal future. In contrast, confabulations were not observed in answers to questions tapping semantic knowledge, including foresight of impersonal future. TA's brain MRI showed lesions involving the right hippocampus, parahippocampal gyrus, fornix, mammillary bodies, and thalamus. Moreover TA showed sub-cortical lesions involving the caudate nucleus bilaterally, a lesion site not previously described in amnesic-confabulatory syndrome. In addition, there was no evidence of structural damage to the frontal lobe, usually considered as crucial in the production of confabulation. We suggest that this pattern of results is better accounted for within the framework of MCTT, and reflects a specific dysfunction of Temporal Consciousness.

ELIZABETH WARRINGTON PRIZE LECTURE

The Affective Neuropsychology of Confabulation and Anosognosia

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What is more 'counter-intuitive' than someone who is unaware of the fact that they can no longer move half their body? Or, someone who claims her arm belongs to her granddaughter? What is more thought-provoking than someone who persistently recalls personal memories that never happened? To date, such striking neuropsychological symptoms represent one of the best windows of insight into different facets of 'the self', including a minimal or, bodily self and an extended or, autobiographical self. The talk will focus on memory-related confabulation following ventromedial frontal lobe lesions and anosognosia for hemiplegia and other somatic delusions following right perisylvian lesions. These syndromes include positive, productive symptoms, such as confabulations and delusions about the self. In addition to presenting evidence in favour of specific hypotheses and theories, I will try to argue in favour of three main theses: (1) Experimental studies in productive neuropsychological symptoms are possible and fruitful; (2) Academic polarisation between psychodynamic and neurocognitive traditions and rigid distinctions between psychogenic and neurogenic explanations have obscured the role of emotion and motivation in the pathogenesis of both confabulation and anosognosia. Emotional influences are in a dynamic balance with other cognitive functions and they may be instigated directly by neural dysfunction or indirectly by life changes and altered social circumstances, or by a combination of the above; (3) Contrary to traditional neuropsychology in which deficits result entirely from irreversible damage to specialized brain modules, I will argue that for a *dynamic view* of symptoms, regarding them as arising from short-term functional alterations that are potentially reversible and 'plastic', i.e. they can be experimentally and clinically treated with either neurological or psychological interventions. Ultimately, the presented studies pave the way for (1) acquiring an unprecedented 'on-line' experimental 'handle' over dynamic changes in self-awareness; (2) understanding the dynamic relation between conscious and unconscious processes in the mind and brain; (3) effectively managing and treating historically treatment-resistant disorders; (4) addressing in a genuinely interdisciplinary manner one of the oldest questions in psychology, philosophy and medicine; *how mind-body processes affect ailment and healing.*

DAY 2: POSTER PRESENTATIONS

Exploratory approach to semantic processing during reading: Introducing combined TMS & Eyetracking into neurolinguistic research

Imke Franzmeier, Sam Hutton & Evelyn Ferstl

Objectives: For the first time single-pulse transcranial magnetic stimulation (TMS) is linked to eyetracking to explore semantic processing in a sentence context. The left motor cortex has been linked to action word processing using lexical decisions on single words (e.g. Pulvermüller et al., 2005), providing information about the lexical access but not about processing action-words in context. Motor representations for actions, however, strongly rely on subsequent object nouns (e.g., open a bottle/door). This study investigates how the reading behaviour changes when the motor cortex is stimulated during action word processing on a sentence level.

Methods: Sentences with hand-actions were presented to 18 participants, who were asked to read the sentences and answer comprehension questions. At the time of fixation on the verb or the subsequent object noun, a single TMS pulse was applied over the left motor cortex (LMC) or the right temporal lobe. Eye movements were recorded for all words in each sentence.

Results: Trial dwell times were longer when stimulation was applied to the LMC. Stimulation (left and right) of the verb increased fixation durations and dwell times for verbs and nouns. An increase of regressions out of the verb was observed for left side stimulation.

Conclusion: Stimulation of the LMC affected the reading process due to rereading and backtracking (regression). Where the regressions are directed at is still unclear and will be focused on in further analysis. Combining Eyetracking with TMS allows us to observe how cortical malfunctioning affects reading. This promising and new combination has a great potential for neurolinguistic research.

Neuropsychological and spontaneous speech assessment of syntactic function in Primary Progressive Aphasia

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Objective: The insidious nature of language decline in primary progressive aphasia (PPA) poses a major challenge to accurate early diagnosis. Agrammatism is considered an important dimension of PPA, yet there is no consensus on its definition. It is often identified simply by clinical opinion, which is impossible to quantify; meanwhile, the few neuropsychological tests devised to objectify agrammatism have not been validated against the pattern and frequency of errors in spontaneous speech. The aim of this study was to contrast PPA patients' performance on a detailed grammatical test battery against grammatical errors in spontaneous speech.

Method: 10 patients with PPA were assessed in a longitudinal study of PPA. Production and comprehension of syntax were assessed using standard and novel neuropsychological tests. Spontaneous speech was recorded during a semi-structured interview and evaluated for frequency of grammatical errors and syntactic complexity.

Result: Compared to controls, the PPA group had significant impairment in syntactic function. There was a significant correlation between test scores and spontaneous speech measures of agrammatism. The PPA subjects' spontaneous speech also revealed a significant decline in syntactic complexity measures that did not correlate with either grammatical test scores or grammatical errors in speech.

Conclusion: The results suggest that the syntactic deficit in spontaneous speech can be captured with neuropsychological tests in PPA. Decline in syntactic complexity is also a feature of PPA that, interestingly, appears to be independent of grammatical errors suggesting a different neural mechanism.

Why is a word a word? Investigating interactive processing in the word recognition network

Evans, Lambon Ralph & Woollams

Objectives: We investigated the differential consequences of damage to orthographic and semantic processing within the visual word recognition network using a case-series comparison of pure alexia (PA) and semantic dementia (SD).

Methods: Performance of PA patients, SD patients and matched controls was assessed using lexical decision tasks that manipulated real word semantic properties (imageability and semantic priming) and nonword foil properties (consonant strings and pseudohomophones).

Results: When real words were presented with illegal consonant string foils, all groups could discriminate between them. In the context of orthographically legal pseudohomophone foils however, both patient groups performed less accurately than controls with SD patients performing below chance. The speed and accuracy of controls showed imageability and semantic priming effects with pseudohomophone foils but not consonant string foils. In contrast, SD patients did not show semantic effects in either foil context and PA patients showed semantic effects across both foil contexts.

Conclusions: Although both PA patients and SD patients were impaired at lexical decision with pseudohomophone foils, consideration of imageability and semantic priming effects revealed the different bases for the deficit: SD patients failed to show any semantic effects, whereas PA patients showed semantic effects irrespective of foil context. Controls provide the middle ground between these groups, in that semantic effects were apparent only in the more difficult foil context. Taken together, these results indicate that normal visual word recognition is supported by an adaptive blend of orthographic and semantic information.

Using *in vivo* probabilistic tractography to reveal connectivity and parcellation of the human inferior parietal cortex.

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Objectives: Brain function strongly depends upon both anatomical microstructure and connective architecture. The current study used in vivo probabilistic tractography to examine the relationship between parcellations of the left inferior parietal cortex (LIPC) derived via white matter connectivity profiles and those by cytoarchitecture.

Methods: Probabilistic tractography was performed from seven LIPC cytoarchitectonic seed regions identified by recent parcellations. Similarities and differences in the long-range connectivity patterns between the seven cytoarchitectonic regions were used to tractographically parcellate the LIPC via a hierarchical cluster analysis.

Results: The current tractographic parcellation defined four distinct regions within the LIPC: inferior, superior and anterior-superior sub-regions in the supramarginal gyrus, as well as the angular gyrus. The connectivity patterns of these parcellations provide key insights about the neural basis of the numerous higher cognitive and language functions ascribed to the LIPC. Specifically, (a) the angular gyrus - associated with multimodal integration and cognitive control - shows widespread occipito-temporo-parietal interconnection; (b) inferior SMG - implicated in acoustic-motor speech interfacing - exhibited strong connectivity between superior temporal structures and insular/inferior prefrontal regions; (c) superior SMG - a core region for controlled object use and other aspects of cognitive control - demonstrated strong connectivity from middle and inferior temporal lobe representations to frontal motor regions; and (d) the anterior SMG subregion had dedicated connectivity suitable for specific integration of somatosensory and motor information.

Conclusions: The four identified tractographic regions aligned closely with the differentiation of various higher cognitive and language functions associated with LIPC.

Differentiating subitizing and counting: a voxel based correlational study

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Objectives: There is an ongoing debate about whether the contrast between efficient visual enumeration of small number (subitizing) and the relatively inefficient enumeration of larger numbers (counting) is subserved by separable processes. All the neuropsychological evidence for distinct subitization and counting processes to date has emphasised behavioural differences between patients, and there is a paucity of data on the underlying neural correlates of any impairments. The present study provides a first lesion-based analysis of the relations of these different aspects of enumeration.

Methods: We examined subitization and counting across a case series of brain lesioned patients with chronic deficits, correlating any behavioural deficits with data from whole-brain analyses of high resolution MRI scans. We related the range of behavioural performances on visual enumeration to a continuous measure of neural integrity using an observer independent voxel-based approach, separating out gray and white matter.

Results: Severe impairments in subitizing were associated with damage to the early visual areas and white matter in the occipito-parietal region, even with visual field defects accounted for in the modelling, while later visual areas were associated with less severe subitizing impairments. In contrast, impairments in counting efficiency were associated with damage to a larger fronto-parietal network, including the left angular gyrus as well as higher visual areas.

Conclusions: The data support the argument for distinctive processes, and neural areas, supporting subitization and counting.

Heterogeneity of the left temporal lobe in semantic representation and control: Priming multiple vs. single meanings of ambiguous words

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Objective: Understanding words involves both representations of word meaning plus executive mechanisms that guide knowledge retrieval in a task-appropriate way. These two components of semantic cognition – representation and control – are commonly linked to left temporal and prefrontal cortex, respectively. This simple proposal, however, remains contentious because in most functional neuroimaging studies to date, the number of concepts being activated and the involvement of executive processes during retrieval are confounded.

Method: Using fMRI, we examined a task in which semantic representation and control demands were dissociable. Words with multiple meanings like *bank* served as targets in a double-prime paradigm, in which multiple meaning activation and maximal executive demands loaded onto different priming conditions.

Result: Left anterior inferior temporal areas (ITG) were sensitive to the number of meanings that were retrieved, suggesting a role for this region in semantic representation, while left posterior middle temporal gyrus (pMTG), inferior parietal and inferior frontal cortex showed greater activation in conditions that maximised executive demands.

Conclusion: These results support a functional dissociation between left ITG and pMTG, consistent with a revised neural organization in which left prefrontal and posterior temporo-parietal cortex work together to underpin aspects of semantic control.

Exploring the temporal and spatial characteristics of auditory word comprehension using EEG

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Objectives: Two opposing theories have been proposed to explain word comprehension; the serial (Friederici, 2002) and parallel (Marslen-Wilson, 1987) processing streams. Additionally, neuropsychological and neuroimaging studies have shown that a hierarchy exists, propagating down the temporal lobe (Binder et al, 2000). Here, electroencephalography (EEG) was used to investigate changes in neurophysiological activity for intelligible and unintelligible auditory presentations of single words. The aim was to identify event-related potentials corresponding to phonological and semantic processing and determine their neural source.

Methods: EEG data was collected from subjects passively listening to auditory words. Four conditions were used: 1) high imageability 2) low imageability 3) rotated and 4) rotated vocoded speech. Conditions 1-3 were contrasted with condition 4 to outline phonological processing, whereas conditions 1-2 were contrasted with condition 3 to outline semantic processing.

Results: Conditions with phonetic features produced higher amplitudes around 100ms, which suggests phonological processing. Conditions with semantic content produced larger negative amplitudes around 500ms, which suggests semantic processing. Phonological processing was localised between bilateral posterior and middle inferior temporal regions, whereas semantic processing was localised to the bilateral anterior temporal lobes (ATL). Additionally, both contrasts revealed bilateral inferior frontal activity (IFG).

Conclusions: Auditory word comprehension is suggested to be processed within a serial framework, where the stream propagates from intermediate temporal regions to ATL. This hierarchical structure is inline with evidence showing increasingly complex speech being processed down the processing stream. The IFG activity could reflect a general language role for speech comprehension and not just semantic control.

Near and far space attention: A VBM corelation study

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Objectives: Neglect in near and far space has been mainly investigated with line bisection paradigms and there is limited evidence supporting such a dissociation in visual search tasks. In addition, neuroimaging findings in health individuals do not fully reconcile with the lesion data reported in clinical studies in patients with spatial neglect restricted to either near or far space. The aim of the present study was to clarify whether line bisection and visual exploration in near and far space are supported by distinct neuronal substrates specific to the processing of these two space sectors.

Method: We investigated the structural anatomical correlates of near and far space attention deficits in a group of 18 unselected right brain damaged patients who performed a line bisection and a visual search paradigm in near and far space.

Results: Impaired performance in far space was found to be correlated with grey matter loss in the middle temporal and inferior temporal gyrus for both types of tasks. In contrast, impaired cancellation was associated with grey matter loss in the temporal and inferior frontal gyri, and in the insula while performance on line bisection was correlated with structural loss in the lingual gyrus.

Conclusions: The results suggest that neglect deficits in far space are more associated with damage to brain structures within the ventral visual stream irrespective of task. In contrast attention deficits in near space seem to be associated with damage to a wider network of task-specific structures outside to the dorsal visual pathways.