Academic Year 2008/2009 (version 08 Dec 2008)

Topics for placement and project work in MSc Cognitive Neuroscience and Neuroimaging

Members of Academic Staff in the School of Psychology and other departments contributing to the lecture program would be willing to supervise research in the areas listed below (sorted alphabetically by supervisor's last name).

Please note: this list is preliminary and may be updated during the next few weeks. For students registered on an MSc/PhD programme, the PhD supervisor will offer placement and project. Students registered on the "stand-alone" MSc programme may want to choose a topic of interest from the list below and then contact the respective member of Academic Staff (for email address etc please see http://www.nottingham.ac.uk/psychology/people/index.php).

Dr Sygal AMITAY (MRC Institute of Hearing Research, Auditory Learning Group)

HOW TO IMPROVE YOUR HEARING: AUDITORY TRAINING EFFECTS ON PSYCHOPHYSICAL TUNING CURVES. Auditory training can work like sports training – if you practice a listening task you get better at it. Training can induce long-lasting changes in performance on almost all auditory tasks. We have previously shown (e.g. Amitay et al., 2006) that high-level cognitive skills such as attention play a crucial role in learning even a simple auditory discrimination. However, the extent to which bottom-up processes contribute to learning is still unclear. In this project we propose to investigate whether training in auditory frequency discrimination changes the shape of the auditory filter. We predict that an improvement in frequency discrimination will be accompanied by a narrowing of the psychophysical tuning curve (PTC) for frequency, reflecting changes in the shape of the auditory filter. We will measure the width of the auditory filter before and after training using psychoacoustic techniques, and correlate it with the improvement in frequency discrimination. Amitay, S., Irwin, A. & Moore, D.R. (2006) Discrimination learning induced by training with identical stimuli. Nature Neuroscience, 9, 1446-1448.

Dr Henry CHASE and Dr Lee HOGARTH (School of Psychology)

The concept of prediction error is central to associative learning models (e.g. Rescorla and Wagner, 1972) and has been integral for the understanding of reward- and punishment-related neural activity (e.g. Schultz, 2006). An event related potential (ERP) called the feedback-related negativity (FRN) has been associated with negative prediction errors (Holroyd and Coles, 2002) i.e. when the obtained outcome is worse than expected.

This ERP has been intensively studied: however, it remains unclear exactly what psychological aspect of negative prediction error it represents. Two aspects may be distinguished: surprise and updating. The first, surprise, is the psychological consequence of an unpredicted event, leading to behavioural effects such as increases in attentional orienting. The second, updating, reflects the fact that prediction errors are used to modulate the strength of associations between stimuli.

In typical neuroscientific experiments, no attempt is made to distinguish these two possibilities. However, by exploiting the learning set phenomenon – in which learning performance improves with successive learning problems – it is possible to modulate learning rate and hence the relative contribution of surprise and updating following a given feedback event. Specifically, as learning rate increases, updating of associations is faster but surprise decreases. Consequently, if the FRN is associated with updating, it should be larger with successive discrimination problems, whereas if it is associated with surprise, it should get progressively smaller.

This study may be also relevant for understanding addiction, as a related waveform, the error-related negativity (ERN) is reduced in addicted patient groups (e.g. Franken et al., 2007). It is also reduced in impulsive subjects (e.g. Martin, Potts and others. 2006/2008): impulsivity being a risk factor for addiction. Two groups of subjects would be recruited for the present study: daily cigarette users (who have made the transition into drug dependence) and non-daily cigarette users (who have not), and FRN amplitudes will be compared between the two groups. I you would like any further information about the study, please contact Henry Chase (lpzhwnc@nottingham.ac.uk).

Dr Antonia HAMILTON (School of Psychology): The role of ostensive signals in imitation

People tend to imitate each other and learn by imitation. This project will examine how ostensive signals (e.g. eye contact) modulates what individuals learn from watching another person's actions.

The project will use video stimuli and behavioural measures to see if eye-contact enhances adult's imitation of simple, goal directed actions. Eye tracking measures could also be used if desired. Reading - Southgate, Chevallier & Csibra (in press), Developmental Science. Available at http://www.cbcd.bbk.ac.uk/people/scientificstaff/gergo/index_html/pub/index.html

Prof Georgina JACKSON and Prof Stephen JACKSON in co-operation with Dr Martin SCHÜRMANN

MEG for studies of cognitive control in response and task selection. Humans can override or suppress reflexive or habitual actions in favour of forms of response that are more likely to achieve our behavioural goals. Disorders of this function are observed in mental illnesses such as Tourette's syndrome where individuals exhibit unwanted behaviour that they find difficult to control. The mechanisms of cognitive control and their neural correlates were addressed by G.J. and S.J. in numerous earlier studies [1-3] that used behavioural measures, event-related potentials (ERPs), and fMRI.

The project requires evaluation of data from MEG experiments with tasks that are similar in cognitive control demands but different in response modes – either oculomotor or manual. A particular aim is to use the good spatiotemporal resolution of MEG for closer analysis of the parietal brain activity during task switching which has been observed in ERP studies [3,4]. The project is well suited for a student who is interested in MEG data analysis, both in source space (using distributed source models) and in sensor space (using the Fieldtrip toolbox [5] within Matlab scripts part of which the student will develop under guidance).

1. Swainson R. et al. (2003). Journal of Cognitive Neuroscience 15, 785-799.
2. Mueller SC et al. (2006) Current Biology, 16, 570-573.
3. Astle DE et al. (2006) Brain Res. 1125: 94-103.
4. Rushworth MFS et al. (2002) Journal of Cognitive Neuroscience 14: 1139-1150
5. http://www.ru.nl/neuroimaging/fieldtrip/

Prof Stephen JACKSON (School of Psychology): 1. Neural basis for unwanted thoughts and actions

Understanding the nature of the brain mechanisms that allow us to regulate our behaviour is a fundamental problem for neuroscience and is of considerable clinical importance in understanding and treating the consequences of mental illness. This is because behavioural dysregulation and/or disorders of cognitive control are strongly associated with a number of common mental illnesses including: Attention Deficit Hyperactivity Disorder [ADHD]; Tourette syndrome [TS]; and Obsessive Compulsive Disorder [OCD]. In this project we will use magnetic resonance imaging to investigate the functional anatomy of unwanted actions.

Prof Stephen JACKSON: 2. Neural circuits involved in the suppression of tics in Tourette syndrome

Tourette syndrome (TS) is a developmental neuropsychiatric disorder characterised by the presence of chronic vocal and motor tics. Tics are involuntary, repetitive, stereotyped behaviors that occur with a limited duration. The neurological basis of TS is unclear at this time however it is agreed that the basal ganglia, including circuits that link the striatum to the frontal lobes, are dysfunctional. It has been suggested that individuals who learn to successfully control their tics do so by recruiting an enlarged or enhanced network of cortical areas that are involved in the cognitive control f behaviour. In this project we will use neuroimaging techniques (e.g., functional MRI, diffusion tensor imaging, transcranial magnetic stimulation) to investigate and quantify this hypothesis.

Prof Stephen JACKSON: 3. Brain plasticity and functional re-organisation in the ageing brain

Both normal ageing and age-related neurodegenerative disorders such as Parkinson’s disease (PD) are associated with specific forms of cognitive deficit: most particularly impairment in executive function and the cognitive control of behaviour. These cognitive impairments have been linked to neurobiological changes affecting the operation of the cortico-striatal circuits of the human brain. Recent studies have shown that the neurobiological changes and age-related cognitive decline associated with normal ageing can be significantly slowed, or even reversed, by regular cardiovascular [CV] exercise, and studies using a rat model have demonstrated that a cardiovascular exercise intervention can attenuate dopamine depletion in the striatum of hemi-parkinsonian rats, indicating that exercise may be neuroprotective. The aim of this project would be to investigate this hypothesis using behavioural measures of performance and neuroimaging techniques (e.g., functional MRI, diffusion tensor imaging, transcranial magnetic stimulation).

Prof Stephen JACKSON: 4. Neural representation of movement and updating of the ‘body-schema’

Damage to the posterior parietal cortex can lead to a disorder of visually guided reaching movements known as optic ataxia (AO). We have previously suggested that the brain area most often associated with optic ataxia – the medial aspect of the posterior parietal cortex -- is important for maintaining a dynamic, up-to-date, representation of the postural configuration of the body [i.e., the body 'schema']. We will investigate this hypothesis by studying reaching movements to visually defined and posturally defined targets in neurologically healthy individuals and patients with optic ataxia. This project will make use of kinematic analyses of reaching movements and fMRI. My lab is equipped with 2-joint robot arm for measuring movement and also an MRI-compatible 2-joint robot for measuring movements in the MR scanner.

Prof Stephen JACKSON: 5. Mechanisms of functional re-organisation of sensorimotor function after stroke

Stroke is the leading cause of disability in the UK and one half of those surviving a stroke will be significantly disabled and require help with activities of daily living, either at home or in an institution. This project will investigate neural plasticity and functional re-organisation of sensorimotor function following a stroke. Current projects include the use of robot-based therapy to rehabilitate upper-limb function after stroke, and, the use of somatosensory stimulation to promote recovery of swallowing post stroke. The project will utilise one or more of the following techniques: magnetic resonance imaging; transcranial magnetic stimulation; motor learning/movement analysis using a 2-joint robot arm.

Prof Stephen JACKSON: 6. Neural basis for the modulatory effects of motor intention on perception

Psychophysical studies have repeatedly demonstrated that visual stimuli presented close to the onset of a saccadic eye movement are mislocalised spatially and temporally. Similarly, psychophysical and electrophysiological studies have demonstrated that the intention to execute a limb movement leads to reduced tactile sensitivity on the limb that is about to be moved. This project will use magnetic resonance imaging and/or transcranial magnetic stimulation techniques to investigate how motor intention influences tactile perception.

Dr Jon PEIRCE (School of Psychology)

Understanding conjunction detectors in mid-level vision. My lab focuses on how the outputs of V1 might be combined by later visual areas. We study this using a variety of techniques, including psychophysics, fMRI, computational modelling and patient work. The psychophysical methods are generally most productive and easiest to learn for a short-term project. The following describes one possible theory to test (using psychophysics), but others are easily possible (and, potentially, using other methods).

We have previously shown that conjunction detectors can be demonstrated in the visual system using aftereffects such as the curvature aftereffect (Hancock & Peirce, 2008). We know that, at some point in the visual pathway, recognition of objects becomes 'translation invariant'; you can still recognise your mother regardless of where the image of her face falls on your retina. Are curvature detectors, as measured by the curvature aftereffect, translation invariant, or does this invariance occur at a later stage in the visual stream?

Dr Denis SCHLUPPECK (School of Psychology)

Comparing single and multi-echo fMRI data acquisition for mapping topographic areas in occipital, temporal and parietal cortex

(Background) In most fMRI experiments only one echo is acquired to form an image for each time point in a time series. However, measurements and theory predict that combining data from multi-echo EPI sequences can increase sensitivity and provide better signal in areas that commonly show susceptibility artefacts e.g. in temporal and frontal lobe (see Gowland & Bowtell, 2007).

(Things you would do/learn in this project)
• help acquire functional MRI data on the 3T Philips scanner
• use standard topographic mapping techniques to measure maps in different parts of cortex (e.g. occipital, parietal, and inferior temporal)
• learn matlab-based tools for analyzing data from 'traveling wave' (topographic mapping) paradigms.
• write a detailed report that would be useful to anyone wanting to acquire data in this way in future
• learn about the physics rationale for optimally combining two echoes to create better images

(Things you need) To prevent disappointment and frustration on your part, you should have an interest in quantitative methods and some experience with computers in general, possibly Matlab and Unix. If you don't have those skills, yet, you could spend some time learning and teaching yourself basics of computer programming / scripting. If you are interested, but have concerns, don't hesitate to come and see me.

References:
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http://www.ncbi.nlm.nih.gov/pubmed/17964252

Larsson & Heeger (2006) JNeurosci
http://www.ncbi.nlm.nih.gov/pubmed/17182764

Schluppeck, Glimcher & Heeger (2005) J Neurophysiol
http://www.ncbi.nlm.nih.gov/pubmed/15817644

(theory) Gowland & Bowtell (2007) Physics in Medicine and Biology
http://www.ncbi.nlm.nih.gov/pubmed/17374912

Dr Martin SCHÜRMANN (School of Psychology) and Dr Sue FRANCIS (Sir Peter Mansfield Magnetic Resonance Centre)

Brain basis of audiotactile interaction. Many perceptual events in everyday life are multisensory. For example, the sounds arising when the hand explore a surface contribute to the explorer's haptic percepts. As a possible brain basis of such phenomena, functional brain imaging has identified activations specific to audiotactile interaction in secondary somatosensory cortex, auditory belt area, and posterior parietal cortex, depending on the quality and relative salience of the stimuli. This project focuses on the role of auditory cortex in the perception of vibrotactile stimuli. Given that auditory perception depends on fine analysis of temporal structures, the question is whether auditory cortex is activated when vibrotactile stimuli with certain temporal properties are processed. The project comprises psychophysical pilot experiments and fMRI measurements.

McGlone F, Kelly EF, Trulsson M, Francis ST, Westling G, Bowtell R. Functional neuroimaging studies of human somatosensory cortex. Behav Brain Res. 2002, 135:147-158.
Schürmann M, Caetano G, Hlushchuk Y, Jousmäki V, Hari R. Touch activates human auditory cortex. Neuroimage 2006, 30: 1325-1331.