PhD Projects in the School of Psychology at The University of Nottingham

Behavioural Neuroscience

Dr Tobias Bast

Behavioural Neuroscience projects – Hippocampo-prefrontal-subcortical circuit in cognition and behaviour

My research focuses on how a brain circuit consisting of the hippocampus, prefrontal cortex and connected subcortical sites mediates and integrates important cognitive functions, including everyday-type memory (e.g., memory for places and events) and attention, and other behavioural processes (emotional, motivational, sensorimotor). In addition, I study how dysfunction in this neural circuit causes cognitive and behavioural deficits. To address these questions I mainly combine sophisticated behavioural testing with a wide range of in vivo neurobiological methods to analyse and manipulate brain function in rat models (although, recently, we have also begun some studies involving human participants and 'translational' tests similar to our rat paradigms).

More details on my current main lines of research and some key references can be found here at http://www.nottingham.ac.uk/psychology/people/tobias.bast, under the 'Research' tab. If you are interested in this research and would like to work towards a PhD in this area, please email me. Suitable candidates would typically have some relevant research experience (e.g., from undergraduate or MSc projects).

Computational Neuroscience project – Neurocomputational models of hippocampus-dependent place learning and navigation (jointly with Steve Coombes, Mathematical Sciences)

Humans and other animals can readily remember significant places and associated events and return to these places as appropriate. From an experimental point of view, studies of the neuro-psychological mechanisms underlying place learning and navigation offer unique opportunities, because similar tests can be used in rodent models and human participants. Studies in rodent models have led to a detailed understanding of the neuro-psychological mechanisms of place memory, and the importance of the hippocampus for place learning and navigation in humans and other animals is well-established (Bast, 2011, *Curr Opin Neurobiol*; Hartley, Lever, Burgess, O'Keefe, 2014, *Phil Trans Roy Soc B*; also see 2014 Nobel Prize in Physiology and Medicine: http://www.nobelprize.org/nobel_prizes/medicine/laureates/2014/advanced-medicineprize2014.pdf).

In this project, we aim to develop quantitative models describing how neurons in the hippocampus and associated brain areas give rise to place learning and navigation, and construct an *in silico* model for testing ideas about functional mechanisms. The project brings together behavioural neuroscience expertise on hippocampal function and place learning (Tobias Bast, Psychology) with expertise in mathematical and computational neuroscience

(Steve Coombes, Mathematical Sciences). More specifically, we aim to adapt and further develop previous neurocomputational models of hippocampus-dependent place learning and navigation (e.g., Brown & Sharp, 1995, *Hippocampus*; Foster, Morris, Dayan, 2000, *Hippocampus*; Fremaux, Sprekeler, Gerstner, 2013, *PLoS Comput Biol*; Chersi & Burgess, 2015, *Neuron*), so that they accurately describe findings of recent and ongoing behavioural and neurobiological studies on the psychological characteristics and neurobiological substrates of hippocampus-dependent rapid place learning (e.g., Bast, Wilson, Witter, Morris, 2009, *PLoS Biol*; da Silva, Bast, Morris, 2014, *Learn Memory*). A particular emphasis will be on the hippocampal learning-behaviour translation: how place information (as encoded, for example, by hippocampal place cells) is related to decision making processes and, ultimately, translated into motor behaviour (for example, by way of interactions with prefrontal and subcortical circuits) (Bast, 2011, *Curr Opin Neurobiol*).

The project will be jointly supervised by Steve Coombes (Mathematical Sciences) and Tobias Bast (Psychology). Suitable candidates will have a strong mathematical background (preferentially a BSc or MSc in Maths, Physics, Engeneering or Computational Neuroscience) and a strong interest in applying mathematical tools to questions in neuroscience and psychology.

Dr Charlotte Bonardi

I am happy to consider proposals on any topic relating to associative learning, including in how associative learning is impaired in psychopathological conditions. My past research has examined this in schizophrenia, personality disorder, Alzheimer's disease and addictive behaviour.

Early cognitive deficits in AD

A crucial problem in Alzheimer's disease (AD) management is how to diagnose the disease at an early stage when treatments might be effective. Our previous work has examined, in a genetically modified mouse expressing the features of AD, learning abnormalities that develop prior to the onset of brain damage, and the potential mechanisms for these deficits. Future work could aim to identify the precise way in which learning in these animals fails, develop analogue tasks in human participants, and identify the underlying neural mechanisms. The ultimate aim is the development of sensitive predictive tests for early diagnosis.

Conditional learning

This project aims to investigate the function of conditional cues – stimuli which signal the presence of an associative (i.e., predictive) relationship between two further stimuli (for example, two beers only give you a hangover when you have been smoking). Explaining conditional learning is a challenge for associative theories, and disruption of performance on conditional tasks has also been implicated in schizophrenia. This project

could analyse the associative mechanisms underlying conditional learning, or use theories of conditional learning to explore how it is impaired in schizophrenia.

Associative learning and addiction

Human drug seeking has been analysed in terms of classical conditioning: the ability of environmental cues to become associated with the effects of the drug can make them provoke drug-seeking behaviour. The mechanism underlying this process has been modelled by an effect called Pavlovian-instrumental transfer (PIT): if you have two outcomes, chocolate and tobacco, each produced by a different (drug-seeking response), then a conditioned stimulus that signals e.g. chocolate, will increase the level of the chocolate-seeking response more than the tobacco-seeking response (and vv). However, there is still relatively little understanding of how this effect is mediated, and this project would address this.

Dr Helen Cassaday

I'm always interested to hear your ideas about associative learning processes, their underlying brain substrates and/or their role in psychological and psychiatric disorder. I'm also interested in the wider implications of what I do, and you're also very welcome to contact me about PhD options in any area in which I've published, see
http://www.psychology.nottingham.ac.uk/staff/hjc/

Brain substrates of associative learning

To investigate the underlying biology of associative learning mechanisms fundamental to normal cognition we use laboratory rats. The brain substrates under study are key to our understanding of addiction, age-related cognitive decline and schizophrenia. Currently available projects compare the effects of localised treatments within nucleus accumbens or medial prefrontal cortex on different aspects of associative learning and memory. For example, we are addressing the distinct roles of the dopamine D1 and D2 receptor families through the use of pharmacologically selective receptor agents.

Suggested reading (freely available online):

Pezze, M.A, Marshall, H.J. & **Cassaday, H.J.** (2015). Dopaminergic modulation of appetitive trace conditioning: The role of D_1 receptors in medial prefrontal cortex. *Psychopharmacology,* **232**, 2669-2680.

Pezze, M.A, Marshall, H.J., Fone, K.C.F. & **Cassaday, H.J.** (2015). Dopamine D_1 receptor stimulation modulates the formation and retrieval of novel object recognition memory: role of the prelimbic cortex. *European Neuropsychopharmacology,* **25**, 2145-2156.

Attitudes to animal use in relation to purpose

The use of animals for any purpose raises ethical concerns and the use of animals for basic science research is particularly controversial. The hypothesis to be examined is that public support for the use of animals in basic science research is less than the level of support which might be predicted based on public agreement with other forms of use. There are a number of scales which measure attitudes to animal use but none specifically designed to systematically compare attitudes to animal use across diverse purposes. The present project will address this gap by developing a scale to measure the levels of agreement/disagreement with the use of different types of animal for different purposes. As part of the validation process, the questionnaire will be used in outreach activities designed to promote the understanding of animal research.

Suggested reading (available via my web page):

Cassaday, H.J. (2015). What's special about the ethical challenges of studying disorders with altered brain activity? *In Ethical Issues in Behavioral Neuroscience:* G. Lee, J. Illes & F. Ohl (Eds.) *Current Topics in Behavioral Neurosciences,* **19**, 137-157. Springer-Verlag.

Davies, G.F., Greenhough, B.J., Hobson-West, P., Kirk, R.G.W., Applebee, K., Bellinghan, L.C., Berdoy, M., Buller, H., **Cassaday, H.J. et al. (LASSH network)**. (2016). Developing a collaborative agenda for humanities and social scientific research on laboratory animal welfare. *PLOS ONE, in press.*

Associative learning anomalies: individual differences and disease

Animal learning theories are applied to human diseases in which associative processes are disordered, as well as to our understanding of individual differences. For example, in cases of schizophrenia and in schizotypy, we find that learning occurs inappropriately, about stimuli that would normally be treated as irrelevant, redundant or in some other way indistinct. We have successfully established associative learning procedures suitable for use with human participants. Taking this work forward may involve testing participants with disorder of the dopaminergic system, in cases of ADHD, Tourette syndrome, schizophrenia or drug addiction. Another line of approach is to examine individual differences in learning in relation to personality measures and other scales designed to measure behavioural variation within the normal range.

Suggested reading (freely available online):

He, Z., **Cassaday, H.J.**, Park, S.B.G. & Bonardi, C. (2012). When to hold that thought: An experimental study showing reduced inhibition of pre-trained associations in schizophrenia. *PLoS ONE*, **7**, e42175.

He, Z., **Cassaday, H.J**., Bonardi, C. & Bibby, P.A. (2013). Do personality traits predict individual differences in excitatory and

inhibitory learning? *Frontiers in Psychology: Personality Science and Individual Differences,* **4**, Article 245.

Dr Mark Haselgrove

My research investigates the principles and properties of learning. In general, I am interested in examining whether learning in humans can be explained by the kinds of associative models that have been developed to understand conditioning in non-human animals. I welcome discussions with potential students who have research ideas in this broad field. More specifically, I have research interests in the following areas:

Learning and stimulus processing.

The amount of processing that is devoted to stimuli can change as a consequence of learning. Recent studies have begun to understand the circumstances in which this change takes place. For example, establishing predicative relationships between stimuli can result in a bias in the processing of these stimuli – as measured by their associability or the amount of overt attention that they capture. However, significant challenges remain, particularly in terms of understanding the relationship between uncertainty and learned changes in attention, as well as the influence of temporal variables in learned attention.

Suggested reading:

Haselgrove, M., Tam, S. K. E., & Jones, P. M. (2013). Enhanced unblocking from sustained post-trial surprise. *Journal of Experimental Psychology: Animal Behavior Processes, 39, 311-322.*

Esber, G. R. & Haselgrove, M. (2011) Reconciling the influence of predictiveness and uncertainty on stimulus salience: A model of attention in associative learning. *Proceedings of the Royal Society B*, *278*, 2553-2561

Navigation based upon environmental geometry.

There is now substantial evidence to show that the shape of an environment can serve as a salient cue for navigating towards a hidden goal. Experiments conducted in my, and other, laboratories have revealed that this form of learning is susceptible to the sorts of manipulations that influence associative learning (e.g. cue competition). However, the circumstances that favour one representation frame (e.g. global encoding) over another (e.g. local encoding) during navigation remains to be determined, despite emerging evidence that both play a role in navigation.

Suggested reading:

Buckley, M. G., Smith, A. D., & Haselgrove, M. (2016). Thinking outside of the box: Transfer of shape-based reorientation across the boundary of an arena. *Cognitive Psychology, 87, 53-87.*

Buckley, M. G., Smith, A. D., & Haselgrove, M. (2016). Blocking spatial navigation across environments that have a different shape. *Journal of Experimental Psychology: Animal Learning and Cognition,42,* 51-66

Interactions between learning and individual differences.

Learning provides individuals with the opportunity to understand the structure of their environment, and to adapt to changing situations. However learning can sometimes go wrong, and be less adaptive. For example, learning can promote anxiety and fear when events or actions cause aversive outcomes; learning can also support the acquisition of unusual beliefs in cases of schizophrenia. Studies conducted in my lab have investigated the relationship between individual differences (e.g. schizotypy, anxiety, AQ) and learning – in particular in terms of how individual differences may influence learned changes in attention and stimulus configuration. Further studies will better specify the relationship between learning and individual differences, and investigate their co-morbidity.

Suggested reading:

Haselgrove, M., Le Pelley, M. E., Singh, N. K., Teow, H. Q., Morris, R. W., Green, M. J., Griffiths, O., & Killcross, A. S. (2016). Disrupted attentional learning in high schizotypy: Evidence of aberrant salience. *British Journal of Psychology, In press*

Haselgrove, M., & Hogarth, L. (2012). *Clinical applications of learning theory*. Psychology Press.

Dr Paula Moran

Studies of learning and memory in patients with schizophrenia.

We have been investigating whether patients with Schizophrenia process information differently to healthy controls and whether these are related to their symptoms and their social function. A number of studies suggest that schizophrenia patients as a consequence of brain dopamine abnormality have learning and memory problems that might originate from abnormal prediction error calculations in the brain. We test this hypothesis behaviourally using a variety of neuropsychological tasks that measure learning and memory processes. We are particularly

interested in whether there is an association between the cognitive and the social problems that people with schizophrenia suffer from. If this is a general topic that interests you then do get in touch to find out more information about specific projects. paula.moran@nottingham.ac.uk.

Rispaud et al., (2016) The relationship between change in cognition and change in functional ability in schizophrenia during cognitive and psychosocial rehabilitation.Psychiatry Res. 244:145-50.

Al-Uzri MM, Reveley MA, Owen L, Bruce J, Frost S, Mackintosh D, Moran PM, (2006) The prevalence of memory impairment in schizophrenia: a case controlled study. *British J. of Psychiatry,* 189: 132-136.

Studies investigating the biological basis of schizophrenia symptoms using animal models.

We have been using a multidisciplinary approach to investigate how the symptoms of schizophrenia might arise from early developmental insults to the brain using mouse models. We investigate how early life manipulations of the dopamine system using genetics or drug challenges lead to behavioural and cognitive changes in adulthood associated with schizophrenia and other psychiatric disorders. We use this information to try and identify new treatment strategies for symptoms and to understand how existing treatments work. If this is a general topic that interests you then do get in touch to find out more information about specific projects. Paula.moran@nottingham.ac.uk.

Kabitzke PA, Simpson EH, Kandel ER, Balsam PD (2015) Social behavior in a genetic model of dopamine dysfunction at different neurodevelopmental time points. Genes Brain Behav.14(7):503-15.
Moran PM, O'Tuathaigh CMP, Pappaleo F, Waddington JL (2014) Dopaminergic function in relation to genes associated with risk for schizophrenia: translational models for psychotic illness. *Progress in Brain Research.* 211 79-112.

Bay-Richter C, O'Callaghan MJ, Mathur N, O'Tuathaigh CMP, Heery DM, Fone KCF, Waddington JL and Moran PM (2013) D-amphetamine and antipsychotic drug effects on latent inhibition in mice lacking dopamine D2 receptors *Neuropsychopharmacology,* 38: 1512-1520.

Dr Jasper Robinson

I'd be delighted to discuss these projects (or your own ideas) with you. Please get in contact with me:
https://jasperrobinson.wordpress.com/.

New views on recognition memory

We are using eye tracking to investigate the mechanisms

underlying people's learning in different forms of recognition task. This is important because a theoretical conflict exists in explanations based on declarative- and associative-memory accounts of recognition (Robinson & Bonardi, 2015), which in turn affects our understanding of neurodegenerative diseases.

There are several variations in the tasks but all involve the presentation of stimuli on a computer screen (e.g., pictures of faces with adults or movie of pets with young children) during an exposure-learning stage. During a subsequent test, recognition memory can be assessed by eye-tracking measurement of a bias in gaze toward a new face/pet relative to the original face/pet.

The great majority of knowledge about recognition memory comes from experiments with visual stimuli. We have developed an auditory recognition task that can be used both to test competing accounts of recognition memory and to help to expand knowledge to better include the auditory domain.

Robinson, J., & Bonardi, C. (2015). An associative analysis of object memory. Behavioural Brain Research, 285, 1-9.

Acquired equivalence in elderly people

Acquired equivalence is impaired in healthy elderly people (Robinson & Owens, 2013). Such findings are interesting in that they inform us both on normal developmental changes and on basic mechanisms of learning and memory.

The acquired equivalence procedure can be understood like this: When two items predict the same outcome, we become prone to confuse them. If we learn that two people, Alice and Paul, will like ice cream and we later learn that Alice will dislikes bananas, we tend to (falsely) assume that Paul also dislikes bananas.

Acquired equivalence has been assumed to occur in many psychological processes, including perception and language. So the finding that healthy ageing affects acquired equivalence makes testable predictions about the effects of ageing on certain other tasks. These would make interesting topics for your PhD research.

Robinson, J., & Owens, E. (2013). Diminished acquired equivalence yet good discrimination performance in older

participants. *Frontiers in Psychology, 4,* 1-8. doi: 10.3389/fpsyg.2013.00726

Professor Ed Wilding

I am interested in human long-term memory. A fundamental challenge for our memory system is to select currently relevant memories from among many similar competing memories. We accomplish this in a variety of ways by using top-down control operations and knowledge of how our memories work. I am keen to supervise projects that fall broadly in this field of enquiry, which can be described loosely as 'cognitive control over memory'. In pursuing research into memory and memory control I use behavioural assessments alongside measures of neural activity. These neural measures include electroencehalography (EEG), magnetoencehalography (MEG) and functional magnetic resonance imaging (fMRI).

Students working with me will gain a deep knowledge of the psychology of human memory, as well as conceptual and practical skills in cognitive neuroscience approaches to understanding the neural and functional basis of human cognition. Examples of topics I am currently pursuing include: how unintentional retrieval has negative as well as positive consequences[1]; how preparation to retrieve influences subsequent retrieval processing[2]; the accuracy of dual-process accounts of recognition memory[3]; how we use our knowledge about our memories to guide behaviour (metacognition)[4], and how memory as well as memory control suffers when cognitive resources are compromised[5]. I am also interested in contributing to projects where memory problems are to be investigated, for example in studies of healthy or pathological aging, and in other conditions such as schizophrenia and depression.

Please do contact me should you wish to know more about these topics, or indeed any others that fall broadly within my interests.

1. Evans, L.H., Herron, J.E. & Wilding, E.L. (2015). Real-time neural evidence for task-set inertia. *Psychological Science*. 26, 284-290.
2. Evans, L.H., Williams, A.N. & Wilding, E.L. (2015). Electrophysiological evidence for retrieval mode immediately after a task switch. *Neuroimage*, 108, 435-440.
3. Evans, L.H. & Wilding, E.L. (2012). Recollection and familiarity make independent contributions to memory judgments*. Journal of Neuroscience*, 32, 7253-7257.
4. Skavhaug, I-M., Wilding, E.L. & Donaldson, D.I. (2013). Immediate judgments of learning predict subsequent recollection: Evidence from event-related potentials. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 39, 159-166.
5. 5. Elward, R.L., Evans, L.H. & Wilding, E.L. (2013). The role of working memory capacity in the control of recollection. *Cortex*, 49, 1452-1462.

Dr Matias J. Ison

My research focuses mostly on human declarative memory, the type of memory involved in remembering events like what we did last summer, how to find our way back home or the connection between our friends' faces and their names (Ison et al., Neuron 2015). Patients with pharmacologically intractable epilepsy are sometimes implanted with depth electrodes for clinical reasons. We have the extraordinary opportunity to collaborate with some of the few hospitals in the world capable of recording the simultaneous activity of several individual neurons while subjects (epilepsy patients) perform visual perception and memory tasks.

More broadly, I am also interested in other aspects of visual perception and memory using a variety of different techniques (computational modelling, multielectrode recordings, non-invasive EEG, concurrent EEG and eye tracking).

You are welcome to contact me about PhD possibilities that fall within my expertise and interests.

Declarative memories and single neuron recordings from the human brain

This project requires the use of a variety of tools essential to analyse in vivo extracellular brain recordings. For further information, please email me: Matias.Ison@nottingham.ac.uk

More info:
Rapid Encoding of New Memories by Individual Neurons in the Human Brain.
Matias J. Ison, Rodrigo Quian Quiroga and Itzhak Fried.
Neuron 87 (1), 220-230 (2015).

Selectivity of pyramidal cells and interneurons in the human medial temporal lobe
MJ Ison, F Mormann, M Cerf, C Koch, I Fried, RQ Quiroga
Journal of neurophysiology 106 (4), 1713-1721 (2011).

Selectivity and invariance for visual object perception
MJ Ison, RQ Quiroga
Front Biosci 13, 4889-4903 (2008).

Brain dynamics during free viewing

Brain signal recordings have been almost exclusively studied in situations where eye movements are precluded. This is because ocular movements produce large signal artefacts that can "hide" real brain activity. Yet, we have recently shown that it is possible to obtain robust brain potentials in situations including eye movements, thus paving the way for future studies. This project aims at characterising electrophysiological and eye tracking signals recorded simultaneously in a real-world task and examine

possible applications, such as target detection and its potential application to Human Computer Interaction.

More info:
Looking for a face in the crowd: Fixation-related potentials in an eye-movement visual search task
LN Kaunitz, JE Kamienkowski, A Varatharajah, M Sigman, RQ Quiroga, & MJ Ison
NeuroImage 89, 297-305 (2014).

Fixation-related potentials in visual search: A combined EEG and eye tracking study
JE Kamienkowski*, MJ Ison*, RQ Quiroga, M Sigman
Journal of vision 12 (7), 4-4. (2012) *Equal contribution.

Cognition & Language

Dr Peter Chapman

The Psychology of Driving

I am happy to supervise any research that looks at aspects of traffic and transport psychology, though my particular interests are in cognitive influences (perception, attention, memory, decision making) on car drivers' behaviour. The research group is currently developing an instrumented car and a full motion driving simulator that would be available for recording driver behaviour (including physiological responses and eye movements) both in simulated environments and while driving on real roads.

Emotion and Memory

I supervise PhD students with interests in cognitive aspects of emotion-memory interactions. Recent PhD students have looked at – Facial EMG as a predictor of autobiographical memory and laboratory-presented emotional material; Influences at encoding and retrieval on memory for emotional material; Directed forgetting of emotional material.

Visual Search and Memory in Dangerous situations

Memory for dangerous situations is systematically distorted in terms of the amount of information remembered, the type on information remembered, and in other ways such as memory for the duration of events. This research explores attention (e.g. via eye movements recordings) in dangerous situations and relates

this to subsequent memory. So far we have looked at memory in dangerous driving situations, and also for roller coasters.

Dr Claudia Danielmeier

My research is focused on various aspects of human errors, performance monitoring and cognitive control. I am interested in research questions investigating behavioural and neural consequences of errors, for instance addressing questions like "How do people adapt after having committed an error to ensure that the same mistake does not happen again?" Additionally, I am interested in exploring different types of errors (action slips, memory errors, etc.) and various contexts in which errors are committed.
To address these questions, I have been employing various neuroimaging (functional magnetic resonance imaging, diffusion-weighted imaging) and electrophysiological methods as well as behavioural experiments. Below are some examples for potential projects:

Attentional adjustments after errors

This project will aim to identify those brain structures that are involved in increasing selective attention after errors. To avoid further errors, individuals increase their selective attention after error commission. While we know which brain areas are associated with error detection, the mechanisms of how these error detection signals are translated into increased attention are unknown. This will be the focus of this project.

Effects of errors on memory performance

Errors might not always have detrimental effects. One previous study suggested that errors in an unrelated task can actually improve memory for words. This project will explore this effect further and try to identify circumstances under which memory improvements occur. Functional connectivity changes between relevant brain areas will be measured with fMRI and EEG.

Error awareness

Some errors are consciously perceived by individuals (aware errors) while other errors go unnoticed (unaware errors). This project will investigate differences between aware and unaware errors, especially with respect to subsequent behavioural and neural adjustments.

Electrophysiological correlates of different error types

The error-related negativity (ERN) is an event-related potential that can be observed after errors. However, the ERN has mainly been investigated in action slips that represent only one type of errors. This project will require to review different error types in everyday life and develop tasks to study these in a more controlled setting. We will also address the question whether the ERN and other electrophysiological measures are also associated with different error types. Results of this project will contribute to the ongoing debate about the functions of the medial frontal cortex.

Dr Ruth Filik

Investigating the cognitive and neural processes underlying language comprehension

I would be interested in supervising projects examining the comprehension of figurative language (such as irony and metaphor), or in the influence of context on language comprehension more generally. I am also interested in how readers construct a mental representation of what they are reading, in particular, in relation to the processing of emotional information in text, or the processing of anaphoric reference. Methods that could be used to investigate these issues include eye-tracking and cognitive neuroscience techniques (mainly EEG).

Applied issues in the Psychology of Language

I would also like to supervise projects investigating more applied issues. Recent topics that I have worked on include:

- Communication in a healthcare setting (e.g., in relation to medical errors).
- Understanding individual differences in language processing, and how these may relate to certain disorders (such as eating disorders).
- How people process textual devices such as emoticons.

Dr Elizabeth Sheppard

Autism spectrum disorders

I have a wide range of research interests relating to Autism Spectrum Disorders (ASD) and visual perception, and would consider proposals in this area. At the moment I am particularly interested in impression formation in ASD – how skilful are individuals with ASD in forming accurate impressions of others?

Conversely, how do typical adults form impressions of those with ASD? What type of perceptual information do people rely on to make these judgments? More generally, what kind of beliefs do people in the population hold about ASD, and does this differ across cultures?

Psychology of driving

I'm interested in cognitive processes involved in driving, including perceptual, attentional and decision-making processes. I'm particularly interested in how these processes differ between individuals who have learned to drive in environments where driver behaviour, accident and fatality rates dramatically differ: for instance, comparing drivers from the UK with drivers from Malaysia. I'm also interested in how other individual differences may influence performance within the driving domain, including how having an Autism Spectrum Disorder affects aspects of driving skill.

Dr Alastair Smith

My research is broadly concerned with how we process and understand the spatial world around us, encompassing perception, cognition, and action. The approach has been to study these processes in the range of spatial scales that we naturally encounter. At the level of small-scale construction, I conduct research on drawing behaviour and the processes that transform a mental representation into motor commands. As well as running behavioural experiments, this work has involved detailed individual case and group studies of neurological patients with acquired disorders of spatial representation in various functional domains (i.e. constructional apraxia, unilateral visual neglect). At larger scales, I am interested in the processes that allow us to search, navigate, and represent our position in an environment. This work has concentrated on the typical development of spatial abilities (in adults and children) and atypical development in individuals with Williams Syndrome and Autism Spectrum Disorder. I am willing to consider PhD proposals in any of these areas, and am particularly interested in addressing whether spatial behaviours are equivalent across scales or reference frames. There is also the potential to maximise on collaborative links with colleagues in Geography in order to utilise satellite tracking and virtual reality technologies to understand naturalistic navigational behaviour. Potential projects include:

Navigational behaviour in autism

Autism is associated with a pattern of strengths and weaknesses in spatial abilities, although there have been few attempts to study real-world navigation. This project will provide a comprehensive assessment of navigational abilities in autism (including laboratory and real world tasks) and will relate them to underlying cognitive abilities.

Spatial learning in search

Visual search studies show participants to be sensitive to probabilistic properties of target location, although this seems to operate differently in large-scale foraging. This project will closely examine the impact of scale, effort, and spatial reference frames on probability cueing, using a variety of different methods. Additional insights may be gained from the application of transcranial direct current stimulation (tDCS) during learning.

Rehabilitation of navigational impairment

Daily navigation can be adversely affected by a variety of factors, from normal ageing through to neurological damage. There are currently no established evidence-based interventions to assist people experiencing difficulties and this project will develop and test cognitive rehabilitation strategies with patients and older adults with navigational impairments.

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Dr Richard Tunney

The learnability of embedded hierarchical structures in artificial languages

The cognitive processes involved in artificial grammar learning (AGL) have long been a source of controversy. Nonetheless as a paradigm AGL remains appealing because it allows the researcher to examine selected aspects of language in isolation. A large literature from the mid 1960s to the turn of the century settled on a consensus that AGL recruited similarity processes based on episodic memory that were relevant to the study of natural languages only if one took the position that language acquisition is statistical rather than symbolic in form (Pothos, 2007). However, this literature was largely restricted to simple finite-state languages that have very few properties of natural languages. A second wave of interest using languages with centre-embedded structures (AnBn grammars) using EEG and fMRI has apparently revealed evidence for language abstraction involving Broca's area. These findings stand in stark contrast to the findings using finite-state grammars (Fitch & Friederici, 2012). Centre embedded structures are an important feature of natural languages because, unlike finite state grammars, they minimally require a context free grammar. However, a number of research groups have cast doubt on this interpretation and instead suggested that simpler non-linguistic mechanisms involving counting the number of A and B elements in each sentence might provide a more parsimonious model (de Vries, Monaghan, Knecht, & Zwitserlood, 2008). The aim of this project is to discriminate between these two models.

de Vries, M.H., Monaghan, P., Knecht, S., & Zwitserlood, P. (2008). Syntactic structure and artificial grammar learning: The learnability of embedded hierarchical structures. . Cognition, 106, 763-774.
Fitch, W. T., & Friederici, A. D. (2012). Artificial grammar learning meets formal language theory: An overview.

Philosophical Transactions of the Royal Society of London, 367, 1933-1955. Pothos, E. M. (2007). Theories of artificial grammar learning. Psychological Bulletin, 133, 227-244.

Can pro-social behaviour be primed?

A number of recent studies have claimed that pro-social or altruistic behaviour can be elicited by means of social-priming. One classic study appeared to show that participants were more generous in a dictator game after they had unscrambled sentences with spiritual content than participants who had unscrambled sentences composed of neutral words (Shariff & Norenzayan, 2007). However, studies similar to this have been criticized because they might be the result of demand characteristics or because they fail to replicate (Shanks et al., 2013). I would be interested in supervising a series of tightly controlled experiments that would determine the boundary conditions for these effects and explore potential mechanisms.

Shanks, D.R., Newell, B.R., Lee, E.H., Balakrishnan, D., Ekelund, L., Cenac, Z., Moore, C. (2013). Priming intelligent behavior: An elusive phenomenon. PLoS ONE, 8(4), : e56515.
Shariff, A.F., & Norenzayan, A. (2007). God is watching you: priming God concepts increases prosocial behavior in an anonymous economic game. Psychological Science, 18, 803-809.

Surrogate utility estimation

The aim of the project is to quantify the extent to which people are able to estimate another person's utility for a decision outcome. That is, how good are we at making decisions for other people (Ziegler & Tunney, 2012). The principle aim is to compare next of kins' predicted utilities for their partner with the partners' actual stated utilities. This study will determine whether health-based utilities differ when estimated on behalf of other people, by comparing what the other person would estimate compared to what the person would estimate for themselves when asked the same series of hypothetical health state questions (Wendler & Rid, 2011). The results will go beyond research that has been conducted before in that previous work on self-other decision-making has been restricted to binary end-of-life decision accuracy (Shalowitz, Garrett-Mayer, & Wendler, 2006), and there exists as of yet no research on health states in surrogate decision making. We will be able to quantify the extent to which utility estimation differs when compared between the surrogate and the wishes of the
recipient. This will allow some theoretical predictions about the cognitive processes that we use to estimate another person's utilities. For instance, whether we attempt to simulate the other person's decision or hypothetically place ourselves in their position, and to explore what factors affect the degree of error in surrogate decision-making.

Shalowitz, D.I., Garrett-Mayer, E., & Wendler, D. (2006). The Accuracy of Surrogate Decision-Makers: A Systematic Review. Archives of Internal Medicine, 166, 493-497.

Wendler, D., & Rid, A. (2011). Systematic Review: The effect of surrogates of making treatment decisions for others. Annals of Internal Medicine, 154, 336-346.
Ziegler, F.V., & Tunney, R.J. (2012). Decisions for Others Become Less Impulsive the Further Away They Are on the Family Tree. PLoS ONE, 7(11).

Dr Walter van Heuven

My research focuses on visual word recognition in monolinguals and bilinguals, linguistic and non-linguistic implications of bilingualism, the processing of subtitles, and the acquisition of foreign language vocabulary. I use in my research behavioural (RTs, eye-tracking), neuroimaging (EEG, fMRI) and computational modelling techniques. Please contact me to discuss project ideas that you have that fall within my research expertise.

Bilingual visual word recognition

Research has revealed that when bilinguals recognize words in one of their languages words of the other language also influence this recognition process. A key question is whether and how bilinguals can control their visual word recognition process in order to minimize the influence of the other language. Projects could, for example, focus on the role that script similarity of the two languages plays in bilingual visual word recognition.

Processing of subtitles

Subtitles are nowadays available for many films and television programs. A key question is to what extent subtitles are processed when these are transcriptions of the spoken language that viewers can hear. These intralingual subtitles are redundant for English native speakers watching an English spoken film. However, non-native English speakers might have more difficulties with processing the spoken English and therefore focus more on the subtitles. Projects could, for example, investigate the role of language proficiency on the processing of subtitles, foreign language vocabulary acquisition when people watch subtitled foreign language films, and on how people divide their attention between the visual action and the subtitles.

Human Development and Learning

Dr Harriet Allen

I research the links between vision, attention and ageing. How does an instruction to attend to an item get translated into the visual system? How do changes in goals (for example, to do with

food, or clinical state) change this? Attention might enhance vision in a number of ways. Attention might simply speed up how quickly we respond to a stimulus, it might make us more likely accept that a stimulus is present, it might reduce the noise associated with the stimulus or increase the signal perceived from the stimulus.
I'm particularly interested in what happens when we ignore things. Is 'attend to this' really the opposite to 'don't attend to that'? As well as being interested in the effects of attention on vision, I'm interested in how these change with age. If we try to look for our friend arriving at the station, we could enhance the representation of any new person arriving on the scene, we could suppress the representations of people and things already visible, or both.

As we grow older both our perceptual and attention systems change. There are changes at the level of the eye (glasses wearing gets more common), the visual system and the attention systems (ignoring distractions gets harder). Can attention be used to compensate for visual changes?

Dr Lucy Cragg

My main research interest is the typical and atypical development of executive functions which I study using behavioural and neuroimaging methods, particularly electroencephalography (EEG). Executive functions are the skills that allow us to regulate our thoughts and behaviour, also known as cognitive control. I am interested in how executive functions and the underlying brain systems change during childhood and adolescence as well as the relationship between executive functions and other areas of development such as social cognition, language and maths. I am open to any topic that falls within my research expertise - some possible topics include:

How do the brain systems for ignoring distractions develop?

Is it possible to improve children's proactive control?

Do you need good executive functions to be good at maths?"

Dr Shiri Einav

Trust and scepticism: Children's Selective Learning from Testimony

Young children learn about many aspects of the world from others. Although for the most part the information that people offer is true, testimony is not always reliable and some sources are more knowledgeable than others. So, to balance effectively the benefits and risks of accepting information from others, children need to evaluate the reliability of informants' testimony, rather than show blind trust. Moreover, given the huge amount of testimony that children encounter every day, an efficient learning strategy would be to assess the value of such information not only in terms of its likely accuracy but also in terms of its relevance or utility. I'm interested in how these critical skills develop in early childhood. Doctoral research in this area would involve experimental studies to investigate empirically a range of questions on children's trust and scepticism in the testimony of others and how this impacts on their learning from others.

Children's use of questions to obtain information

In order to benefit from the knowledge and experience of other people, we often have to ask questions to elicit information from others. We know that children begin to ask questions from an early age, and they ask lots of them! However, much less is known about how children use questions as a tool to acquire new knowledge. I'm interested in how questions function as a mechanism that help children move forward from one knowledge state to another more adult-like knowledge state. Some relevant lines of enquiry for empirical research are: How does question-asking develop with age? What cognitive skills are involved? Under what circumstances are children most likely to seek knowledge through questions? How does question asking impact on children's learning?

For further information please e-mail:
shiri.einav@nottingham.ac.uk

Professor Peter Mitchell

Mentalizing

How effective are people in guessing what others are thinking and feeling? Can people effectively interpret the clues in facial expressions and body language to guess another person's thoughts? Can people guess what happened to another person by observing facial expressions and body language? Can people guess another person's character from facial expressions and body language? What do we know about individual differences in these abilities? Specifically, are people with autism spectrum disorders severely disadvantaged in being able to interpret facial expressions and body language? When people succeed in making accurate inferences based on facial expressions and body language, how do they do it? What features in particular do they attend to? When people are not so effective in making accurate inferences, what features are they attending to? In other words, which are the informative features and which features are not so informative?

These research questions can be investigate in participants of various ages and with different kinds of clinical status. How do children develop in their ability to make educated guesses about the content of other people's minds? How does this ability change over the lifespan? What are the prospects in this area of socio-cognitive functioning for people with clinical disorders?

The illusion of transparency (Joint Supervised by Dr Claire Lawrence).

People tend to think their inner states are more 'visible' to others than they really are and this is known as 'the illusion of transparency'. For example, if we coax a participant into falsely describing the scene in a photo they are looking at, he or she will probably overestimate the likelihood that the listener will detect his/her lie. Similarly, people tend to think that their nervousness is more apparent than it really is when public speaking and they (especially boys) tend to overestimate how entertaining they are when relating an amusing story. Generally, people seem to think that their inner states are more accessible than they really are. However, there might well be individual differences here, where some traits may be less prone to this illusion. For example, there are theoretical reasons to suspect that those who score high on measures of psychopathy, narcissism and Machiavellianism (sometimes known as The Dark Triad) are less preoccupied with their apparent nervousness or feel more confident in their ability to deceive others. Being able to judge accurately that others can't detect when we are lying could help to explain why certain individuals are more capable of being manipulative.

Dr Nicola Pitchford

Using tablet technology to support development of early scholastic skills

Co-supervised with Anthea Gulliford

The use of tablet technology to support the development of early scholastic skills, such as literacy and mathematics, is increasing in schools across the developed and developing world. Hand-held tablets have many benefits that make them suitable for use with young children in a range of different contexts. When coupled with software that is grounded in a solid curriculum, and incorporates interactive child-centered features, tablet technology could be an effective classroom aide for delivering high-quality instructional education to all children, regardless of ability or location. Yet very few formal evaluations of tablet technology have been conducted in different educational settings/countries or with different pupil groups (e.g. typically developing pupils, low and high achievers, deprived backgrounds, multilingual speakers) or different methods of implementation (such as individual

interaction or collaborative learning pairs). Thus, it is currently unknown if tablet technology can effectively support early scholastic development better than conventional teaching/instructional methods. Doctoral research in this area will involve comparing the use of tablet technology to conventional teaching and learning methods in the early primary school years and determining the factors that are necessary for successful implementation.

Relationship between cognitive and motor functioning and social adaptation in children following tumour resection to the cerebellum

Co-supervised with David Walker

Tumour to the cerebellum in early childhood can have severe impact on neurodevelopmental outcome with marked problems in cognitive and motor functioning. Difficulties with social integration are also common within this patient group. This project will explore the association between cognitive and motor functioning and social adaptation following treatment for tumour to the cerebellum in childhood. It will study social adaptation from the perspective of the patient and receiver of social interchanges. Doctoral research in this area will involve experimental and clinical work with patients in their homes and/or clinical settings, coordinating staff involved with the research project (including families, academics, and clinicians), and working with healthy controls.

Long-term effects of childhood trauma on cognitive flexibility, resiliency, and wellbeing

Co-supervised with Laura Blackie

Trauma experienced in childhood, through extreme poverty or traumatic events (neurological, environmental, or psychological in origin), is known to negatively impact on functioning in many domains, including cognitive, social, emotional, physical, psychological and moral development. All of these factors are known to influence scholastic performance so children who have experienced trauma are at risk for underachievement at school. Response to trauma experienced in childhood differs greatly. While some that experience childhood trauma develop posttraumatic stress disorder others do not and some even flourish in spite their experience. This raises the question of factors that influence resiliency. Cognitive flexibility is known to be a protective factor in promoting resiliency, but executive skills develop at different rates and have a prolonged developmental trajectory, suggesting that age and maturational level at the time of trauma might be mediating factors in influencing outcome. Doctoral research in this area will focus on investigating factors that influence the association between cognitive flexibility, resiliency and wellbeing in later life in individuals that have experienced childhood trauma and in non-trauma controls.

Impairments to dorsal stream processing in the brain

Co-supervised with Tim Ledgeway and Neil Roach

The dorsal pathway in the brain projects from primary visual cortex to the parietal lobes and is often referred to as the "where" pathway, as it is involved in motion processing, spatial cognition and visual motor planning. The ventral pathway projects from visual cortex to the temporal lobes and has been termed the "what" pathway, as it is involved in shape perception, visual memory and recognition of familiar objects/faces. Impairments to dorsal pathway functioning have been suggested as a defining characteristic of many developmental disorders, as well as healthy ageing. However the selectivity of this deficit is equivocal and its underlying nature is currently unknown. Doctoral research in this are will involve psychophysical experiments and/or computational modeling with groups of people with specific difficulties, e.g. dyslexia, preterm birth etc.

Professor Stephen Jackson

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.

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 behaviours 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 of 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.

Brain plasticity and functional re-organisation in the adolescent brain

During adolescence the brain undergoes considerable change and may impact upon important behaviours such as impulse control, aggression, risk taking, etc. The aim of this project will be to investigate this hypothesis using behavioural measures and multimodal brain imaging and brain stimulation techniques (e.g., functional MRI, diffusion tensor imaging, transcranial magnetic stimulation, magnetic resonance spectroscopy).

Perception & Action

Dr Markus Bauer

The topics suggested here can easily be combined; they reflect different aspects of my work that can be studied in isolation or in various combinations. The particular PhD project can either be developed by the student (with the help of the supervisor) or can be more structured in advance.

Neuronal mechanisms of attentional selection

An abundance of empirical evidence shows that only a fraction of our sensory environment is actively processed. Instead, we select information according to their relevance for current goals, a process termed 'attentional selection'. It is well established that fronto-parietal brain areas are involved in the control of this selection process1 and these are thought to modulate activity in sensory brain areas to enhance the neuronal representation of attended stimuli. The goal of this project is to elucidate the neuronal mechanisms through which this occurs. Magnetoencephalography (MEG) or Electroencephalography (EEG) will be used to measure the activity in these brain regions and their mode of communication as a function of cognitive task demands. One focus will be on the analysis of oscillatory brain activity, thought to be instrumental in regulating the flow of information through the brain2,3,4. This will be pursued by using advanced source analysis and connectivity analysis techniques, also in collaboration with my colleagues at the Sir Peter Mansfield Magnetic Resonance Centre (SPMMRC). A particular focus could be the role of exogeneous vs endogeneous attention components and their potential relation to different frequency bands4,5.

1 Corbetta M, and Shulman GL (2002) Nat Rev Neurosci 3, 201-215.
2 Bauer M, Kennett S, Driver J (2012) Journal of Neurophys. 107, 2342-2351.
3Bauer M, Kluge C, Bach D, Bradbury D, Heinze HJ, Dolan RJ, Driver J (2012) Curr Biol 22,397-402.

4 Bauer M, Stenner MP, Friston KJ, Dolan RJ (in press) Journal of Neurosci.
5 Friston KJ, Bastos AM, Pinotsis D, Litvak V (2014) Curr Opin Neurobiol. 28;31C:1-6.

Pharmacological manipulation of brain oscillations and signal routing in the brain

In animal in-vitro studies particular cell-types and synaptic currents have been associated with the generation of brain rhythms at specific frequencies1. To date, relatively little is known about how these principles transfer to cortex or different cortical areas. Using non-invasive electrophysiological recordings (particularly MEG) in humans, recent studies have aimed to investigate these principles by using psychopharmacological interventions to probe the role of specific neuro-transmitter and -modulator systems in human cortex2,3. This has the advantage that the impact of the given drugs can be assessed on event related changes in oscillations whilst the participant performs a cognitive task and correlations to behaviour4 can be assessed simultaneously. A parallel approach is to combine electrophysiological and neurochemical measurements using Magnetic Resonance Spectroscopy (MRS)5 , enabled by the excellent facilities available at the SPMMRC.

A more advanced option is to relate this approach directly to accompanying studies with in-vivo animal preparations. These provide a window to study the neurobiological mechanisms underlying the pharmacologically induced changes more specifically. The University of Nottingham offers the unique opportunity to combine these different levels of experimentation in a translational research approach, in collaboration with Dr Tobias Bast6,7. The combination of the human and animal approach is facultative and depends on the student's preference.

1 Whittington MA, Traub RD, Kopell N, Ermentrout B, Buhl EH (2000) Int J Psychophysiol 38(3):315-36.
2 Bauer M, Kluge C, Bach D, Bradbury D, Heinze HJ, Dolan RJ, Driver J (2012) Curr Biol 22,397-402.
3 Muthukumaraswamy SD (2014) J Psychopharmacol 28(9):815-29
4 Vossel S, Bauer M, ... Friston KJ (in press) Journal of Neurosci.
5 Gaetz W, Edgar JC, Wang DJ, Roberts TP (2011) Neuroimage, 55(2):616-21.
6 Bast T, da Silva BM, Morris RG. (2005) J Neurosci 25(25):5845-56.
7 Pezze M, McGarrity S, Mason R, Fone KC, Bast T (2014) J Neurosci 34(23):7931-46

How predictions and prior information guide perception and behavior

In order to interact successfully with the world, humans rely heavily on making use of contextual information or prior knowledge1. This becomes evident in various scenarios from elementary perception to complex decision making under uncertainty. One aspect of such contextual information are prior probabilities. It has been shown that humans are (in certain circumstances2, but not others3) very capable of integrating these prior probabilities with available sensory information to draw optimal inferences about the state of the world. The aim of this project is to elucidate the neuronal mechanisms through which the integration of prior information and sensory driven information occurs4 (predominantly using MEG or EEG) and/or using behavioural paradigms to investigate the crucial criteria under which such 'Bayes-optimal cognition' applies or breaks down. The experiments can therefore involve behavioural/psychophysical studies or focus more on the neuronal aspects. With respect to the latter, one hypothesis to be tested is the presumed role specific brain rhythms play in conveying predictive top-down and sensory bottom-up signals5,6 and investigate their interaction.

1 Clark A (2013) Behav Brain Sci. 36(3):181-204.
2 Ernst MO, Banks MS (2002) Nature 15(6870):429-33
3Kahneman D (2003) Am. Econ. Rev. 93,1449–1475.
4 Lee TS, Mumford D (2003) J Opt Soc Am 20(7):1434-48.
5 Bauer M, Stenner MP, Friston KJ, Dolan RJ (in press) Journal of Neurosci.
6 Friston KJ, Bastos AM, Pinotsis D, Litvak V (2014) Curr Opin Neurobiol. 28;31C:1-6.

The impact of brain stimulation techniques on cognitive performance and brain waves

During recent years rhythmic brain stimulation has been used to alter brain waves (oscillations at specific frequencies) and thereby enhance cognition1,2. However, relatively little is known about the mechanisms how external brain stimulation interacts with ongoing brain activity. For instance, we have recently shown3 that applying TMS over motor cortex leads to classical resonance phenomena when stimulated at individual beta-frequencies, but these effects were surprisingly short-lasting, particularly when compared to the effects of entraining brain

rhythms through flickering stimuli4. Furthermore, for higher frequency gamma-oscillations, it is less clear whether enhancing these rhythms can alter cognitive performance5,6. The aims of this project will be to investigate on the one hand under which circumstances rhythmic brain stimulation leads to changes in cognitive performance and how precisely different brain stimulation techniques (TMS, tACS/tDCS and rhythmic sensory stimulation) affect ongoing brain activity. The student will be trained in the use of brain stimulation techniques as well as psychophysics and EEG or/and MEG recordings.

1 Marshall L, Helgadóttir H, Mölle M, Born J (2006) Nature 444(7119):610-3.
2 Romei V, Gross J, Thut G (2010) J Neurosci, 30(25):8692-7.
3 Bauer M, Romei V, Brooks J, Economides M, Penny W, Thut G, Driver J, Bestmann S (under review) Neuroimage.
4 Spaak E, de Lange FP, Jensen O (2014) J Neurosci. 34(10):3536-44.
5Bauer F, Cheadle SW, Parton A, MŸller HJ, Usher M (2009) PNAS, 106(5):1666-71.
6 Bauer M, Akam T, Joseph S, Freeman E, Driver J (2012) J Vis. 12(4).

Dr Jan Derrfuss

My research focusses on cognitive control, working memory, attention, and error processing. Paradigms that I have been using include task switching, attentional blink, attentional capture, the Stroop task, the flanker task, and the n-back task. In my research, I use fMRI, transcranial direct current stimulation, and behavioural methods.

I am particularly interested in the functional and structural organisation of the prefrontal cortex. Within the prefrontal cortex, the focus of my research is the inferior frontal junction area (IFJ). This area lies at the junction of the inferior frontal sulcus and the inferior precentral sulcus and has been implicated in all of the paradigms mentioned above. I investigate what the IFJ contributes to these paradigms and how it interacts with other brain regions.

Please contact me to discuss possible projects if you are interested in the cognitive functions and/or brain regions outlined above.

Professor Stephen Jackson

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.

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 Roger Newport

Body illusions; ownership; sensory integration; motor control; agency

I supervise projects that investigate the way in which we control and recognise our own body and actions. In particular, I am interested in how our brain represents our body image (a conscious internal representation of the appearance of our body and our attitudes towards it) and our body schema (an unconscious representation of the body that the brain uses for action and to solve problems such as moving through space and reaching for objects). Investigating how the brain processes the body can help us to understand important issues such as unexplained pain, body image distortion, developmental deficits and brain damage.

My research is mainly conducted using a virtual reality device called MIRAGE (http://miragelab.co.uk) that displays real-time video of your own hand so that it appears in the same physical location as your real hand. The live video of your hand can be

manipulated so that the size and shape of your hand or any object in the environment can be changed instantaneously, as can the speed and timing of your movements. Using this technique we can give the impression of having multiple, stretched, shrunk, misbehaving or even missing limbs. The application of these methods allows the investigation of a variety of key issues related to the body, pain, motor control, movement agency and sensorimotor adaptation in normal, damaged and developing brains, especially those with sensory disorders. The lab also makes use of a robotic arm, skin conductance, skin temperature, grip force, movement kinematics, neuropsychology and transcranial magnetic stimulation. Prospective students are strongly encouraged to read recent publications by this group before applying.

Dr Martin Schürmann

A single brain area can represent multiple aspects of the environment or of the individual's body. For example, stimuli of two sensory modalities can converge on one brain area, as in the case of auditory and vibrotactile stimuli that share a representation in auditory belt areas. Similarly, in certain motor areas the representation of the individual's own actions overlaps with areas activated during the observation of other individuals' movements. To study shared representations in the brain, the following projects will be pursued using functional magnetic resonance imaging (fMRI, for optimal spatial resolution) and whole-head magnetoencephalography (MEG, for millisecond temporal precision).

Crossmodal activation of auditory brain areas by tactile stimuli has been observed with functional magnetic resonance imaging (fMRI) in healthy subjects (Schürmann M, Caetano G, Hlushchuk Y, Jousmäki V, Hari R, NeuroImage 2006; 30: 1325-1331). Such co-activation could be related to facilitated hearing when sounds co-occur with vibrotactile stimuli delivered to the subject's palm. Future studies need to explore to what extent auditory brain areas contribute to the analysis of sound-like temporal patterns in vibrotactile stimuli.

Shared representations in the brain have also been suggested as a correlate of social perception: the observer's motor areas are activated during the perception of other persons' movements or postures. For example, we searched for brain correlates of the exceptional perceptual salience of abnormal postures. In an fMRI study, subjects viewed computer-generated pictures of distorted hand postures. Cortical activation sensitive to distorted (vs. natural) finger postures was found in the primary motor cortex, postcentral somatosensory areas, and amygdala. This activation pattern suggests that the instantaneous "gut feelings" during the observation of bodily distortions in others are related to embodied percepts that also involve affect-related brain areas (Schürmann M, Hlushchuk Y, Hari R, Human Brain Mapping, 2011; 32: 612-623). Future studies will explore brain activation patterns during

the observation of normal and abnormal hand postures, including postures related to tool use.
Social perception is also relevant to decision making. We studied brain activation patterns in an economic game with multiple players where competition imposes constraints on subjects' decisions.

The setup was developed from a game where subjects typically accept equal-share offers but reject unduly small offers. Using fMRI, we studied adjustment to competition in this game: subjects competed against another person for the share of the stake. For medium-sized, but not for minimum offers, competition increased the likelihood of acceptance and was associated with increased brain activation bilaterally in the temporo-parietal junction, a region associated with mentalizing. The results suggest a network of brain areas supporting decision making under competition, with incentive-dependent mentalizing engaged when the competitor's behavior is difficult to predict and when the stake is attractive enough to justify the effort (Halko ML, Hlushchuk Y, Hari R, Schürmann M, NeuroImage 2009; 46: 542-548).

Facilities for the required methods, fMRI and MEG, are available in the Sir Peter Mansfield Magnetic Resonance Centre on the campus of the University of Nottingham.

Dr Debbie Serrien

The functional specialisation and integration of hemispheric activity during cognitive skills

The prevalent view is that specialised functions of the cortical hemispheres are essential for behavioural performance. That is, both hemispheres have different functional capacities that provide distinct contributions to skilled behaviour. However, little is known about how the hemispheres cooperate to achieve an optimal outcome. This PhD project will study the neural correlates of skilled behaviour in order to identify domain-general and domain-specific characteristics that guide performance outcomes across the lifespan.

The neural dynamics of motor dexterity

In right-handers skillfulness associates with left hemisphere dominance; a prioritisation that has been attributed to anatomical and functional asymmetries of cortical brain regions. Whereas right-handers have been extensively studied in the literature, limited data are available from other handedness groups. This PhD project will evaluate and contrast the neural dynamics of motor behaviour in different handedness groups.

Personality, Social Psychology and Health

Dr Pete Bibby

My research has two separate strands: The relationship between emotions and decision making and cross-cultural studies of learning behaviours in students.

What is the relationship between emotion processing, loss aversion and reward sensitivity?

Research has shown that people who are poor at processing emotional information are less loss averse. In other words, they are willing to tolerate greater losses when making risky decisions. However, this may well not be less loss aversion but greater reward sensitivity. The aim of this research is to develop behavioural measures of both loss aversion and reward sensitivity and use them to exam the role of emotions in risky decision making.

Why is alexithymia a precursor to problem gambling?

People who are high in trait alexithymia are more likely to be problem gamblers. At the same time, people high in alexithymia as less loss averse. Perhaps lower loss aversion is one mechanism through which people become problem gamblers. Problem gamblers may well be less sensitive to negative emotional events due to alexithymia. The aim of this research is to further examine the mechanisms that underly the relationship between problem gambling and alexithymia.

What effect do different cultural attitudes to learning have on students' learning behaviour?

It has been argued (e.g. Li, 2003) that the ideal Chinese learner can be described as having 好学心 (hào-xué-xĩn), that is, seeking knowledge and maintaining passion for unceasing learning, persisting through hardship, perseverance, concentration and the spirit of never giving up. At the same time, the ideal Western learner learns by doing, is free thinking, practices critical reflection, is socratic in their approach to knowledge and is individualistic. Given these striking differences what can the West

learn from Chinese learners and what can the Chinese learn from Western learners?

Professor Eamonn Ferguson

Altruism, charitable donations and blood donation

Why do we help others, especially strangers or give to charity? I am interested in exploring the underlying mechanism associated with human altruism. I am interested in integrating theory from psychology, economics and biology to understand altruism towards strangers and kin, and in particular with respect to charitable donations especially blood and organ donation. I am interested in testing competing theories form economics (e.g., inequality aversion, warm glow and strong reciprocity), psychology (emotional response such as empathy, guilt, gratitude, shame, pride etc.) and biology (reciprocity and reputation building) within this domain.

Personality and altruism

I am interested in the role of individual difference with respect to emotional regulation and understanding (e.g., empathy & alexithymia) to understand behaviour in economic games designed to explore human altruism (e.g., ultimatum games, dictator games, public good games). Emotions (anger, spite) are seen as one key proximal determinant of departure from the standard selfish model in these games. Those with an inability to understand emotion (e.g., alexithymics) should therefore, be less susceptible to such effects. There is great behavioural heterogeneity in these types of games and I am interested in the way in which personality may help us to understand some of this heterogeneity.

Altruism and Sexual Selection

Altruism may survive in the population because it is sexually selected trait when people are choosing partners for long-term relationships. I am interested in how and when people choose to make displays of altruism and other characteristics that may be

seen as desirable in the opposite sex. I am particularly interested in the role of displays of punishment of unfair behaviour. For example, if an agent punishes someone who has harmed them or others does this make them attractive to the opposite sex or not.

Health communications

I am interested in the ways in which people respond to public health information designed to improve their health. In particular I am interested in cases where well intentioned strategies results in counter-productive and detrimental effects. We have recently been developing a line of work in the area of counter-normative messaging (messages that are deign to improve health behaviour, by expressing a belief that is counter to the accepted norm: e.g., stress is good for you). The rise of evidence based medicine is resulting in counter-normative messaging being used more and more. We are interested in exploring if such messages result in counter-productive outcome such worse health (symptom reporting, health care utilization) and identifying the mechanism that contribute to this effect.

Dr Claire Lawrence

My work broadly seeks to contribute towards answers to the question: **What makes people behave aggressively and violently?** This leads me to examine social processes, individual differences, cognition and brain structure and function. I would be happy to supervise PhDs in any aspect of these areas but in particular:

Under what circumstances are people triggered to act aggressively?

I am particularly interested in the effects of frustration and provocation together with individual differences in sensitivity to different external triggering factors. Can we take this knowledge in designing strategies to reduce aggression? I use a variety of methods to measure aggressive behaviour in the lab, and I am interested in supervising PhDs developing new methods.

Lawrence, C. (2006). Measuring individual responses to aggression-triggering events: Development of the Situational Triggers of Aggressive Responses (STAR) Scale. *Aggressive Behavior*, 32, 241-252.

Lawrence, C. & Hutchinson, L. (2013). The influence of individual differences in sensitivity to provocations on provoked aggression. *Aggressive Behavior, 39*, 212-221.

Yusainy, C. and Lawrence, C. 2014. Relating mindfulness and self-control to harm to the self and to others. *Personality and Individual Differences, 64*, 78-83.

Who is more likely to behave aggressively?

Despite received wisdom identifying those with low self-esteem being more likely to act aggressively, the wealth of evidence shows that it is those with very high self-esteem who are prone to act aggressively in the light of provocation. I am interested in supervising work which examines the role of personality variables that increase (e.g. psychopathy, narcissism, Machiavellianism) as well as reduce (e.g. empathy, agreeableness) the likelihood and intensity of aggressive behaviour.

Heym, N., Ferguson, E. & Lawrence, C. (2013). The P-Psychopathy continuum: Facets of Psychoticism and their associations with psychopathic tendencies. *Personality and Individual Differences, 54*, 773-778.
Kyler, R. (2016). Entitled vengeance: A meta-analysis relating narcissism to provoked aggression. *Aggressive Behavior, 42*, 362-379.

Are antisocial and aggressive traits evolutionarily functional?

Recent approaches to individual differences suggest that the variation seen in personality traits have evolved via a balancing-selection mechanism. As such, extreme levels of any trait may be adaptive in extreme contexts. This may explain, in part, why some ostensibly negative or antisocial traits remain present in populations, despite being otherwise undesirable. There is also evidence for a (limited) sexual selection advantage for some of these antisocial traits. However, on the face of it, there is little advantage of these traits from a sexual selection perspective. Using a mixture of psychometric and economic games, I am collecting data currently to examine when people are attracted to individuals who have demonstrated negative or antisocial behaviours. I would be interested in developing this work further.

Jonason, P. (2015). Birds of a bad feather flock together: The Dark Triad and mate choice. *Personality and Individual Differences, 78*, 34-38.
Penke, L., Denssen, J.J.A. & Miller, G. (2007). The evolutionary genetics of personality. *European Journal of Personality, 21,* 549-587.
Wallum, H., Westberg, L., Henningsson, S. *et al.,* Genetic variation in the vasopressin receptor 1a gene (AVPR1A) associates with pair bonding behaviour in humans. *PNAS, 105,* 14153-14156.

Dr Chuma Owuamalam (Malaysia Campus)

My current interest is on the influence of social perceptions on attitudes, behaviour and well-being of members of historically disadvantaged/stigmatized groups (such as ethnic minorities, women and mental health patients, and single mothers). I am particularly interested in the processes underlying people's beliefs about the impressions they make on others (i.e., meta-perceptions) and, how these beliefs in turn impact mental health, as well as behaviours that may be adopted to bring about social change. I would be especially interested in supervising projects that aim to explore interventions that could enhance harmony between conflicting groups, especially when such conflicts are rooted in meta-perceptions. Being at the cross-road of Western influence and collectivistic cultural orientations of the East, Malaysia, with its diverse ethnic mix, offers a unique opportunity to examine these ideas and to test the efficacy of some Western-style interventions for promoting intergroup harmony.

Other topics that are closely related to the research programme outline above are also welcome

Dr Alexa Spence

My research focuses on attitudes, broader related perceptions (particularly risk perceptions) and how these translate into behaviour. I am particularly interested in environmental psychology and specifically public perceptions and behavior in relation to energy and climate change. My work continues to explore the abstract nature and overall psychological distance of climate change, and how experiences or imagination may influence these perceptions (e.g. through experiences of events such as flooding). Much of my research also focuses on new smart energy technologies and services and acceptance, engagement and cooperation around these technologies. The future orientated focus of my research means that I spend a lot of time thinking about how to examine attitudes towards things that people are not necessarily familiar with and also feeding that back to industry and policy makers in order to feed into research and strategy involving these things. Below are some current research directions (all suitable for international and home students).

Planning sustainable behavior change

The intention behavior gap is well known across fields in Psychology and similarly whilst most people would like to behave sustainably (e.g. not many people really wants to waste energy), many do not. Implementation intentions in particular are a planning tool that have been highly impactful in Health Psychology and to date have been little used within Environmental Psychology. Initial investigations indicate that this is a very useful tool in enacting behavior change but further research is needed in order to examine the conditions under which these tools may be most usefully employed.

Acceptance, engagement, and cooperation around new energy technologies

With the current rollout of smart meters, I'm exploring how and when people are engaged by associated devices and smart energy technologies and services that build on the increased information provided by smart meters (e.g. smart washing machines, electric cars as grid storage). I'm interested in when and why people will accept new energy technologies and what benefits are perceived from interacting with these. I'm also interested in interactions and cooperation around new energy technologies and systems. There may be unintended consequences of introducing new energy technologies to social situations and environments (e.g. the workplace), that have not been considered.

Policy acceptance

To date, behavior change models do not deal with policy acceptance; it is an area generally ignored within theoretical models. However there are good reasons (coming from surrogate decision making and construal level theory in particular) to consider that policy acceptance and its drivers may differ from individual behavior change. I'm interested in examining how acceptance of policy may be different from individual changes in behavior and what this means for using behavior change data to understand policy acceptance and vice versa.

How location and context may influence digital engagement

I'm interested in how spatial location and activity may influence people's interactions with technologies. Might people perceive information differently, and therefore also respond to this differently, when this is received when they are travelling, or when they are in a spatially distant environment compared to a static office or home environment?

Dr Ellen Townsend

My research currently examines key psychological constructs associated with self-harmful thoughts and behaviours such as attachment style, attitudes (implicit and explicit), hopelessness, defeat and entrapment. Methods I have used to examine these factors include experiments, semi-structured interviews, questionnaires and Audio Computer Assisted Self-Interview.

Dr Laura Blackie

Personality, Social Psychology and Health

Post-Traumatic Growth

We live in a world where environmental adversity is an unfortunate and persistent reality – global health threats, natural disasters, spiralling conflict and forced displacement of people – threaten countries and individuals around the world. My research into post-traumatic growth investigates when and how the experience of adversity may lead to lasting positive personality change. Research into post-traumatic growth has been limited by cross-sectional studies that ask individuals to retrospectively report how they have changed after an adverse event has already occurred. These studies tell us little about how reports of perceived change are correlated with trajectories of actual personality change over time or about the role that personality, social, cognitive and cultural factors play in the process. I would be interested in supervising PhDs that aim to both improve the measurement of post-traumatic growth and examine the factors that make it more or less likely to occur.

Mortality Awareness, Well-Being & Prosocial Behaviour:

There is extensive research demonstrating that subtle reminders of mortality can increase an individual's anxiety and propensity to react defensively. However, research in recent years has started to demonstrate that mortality awareness manipulations can also encourage individuals to engage in less greedy and more charitable behaviour. Thus, although the psychological mechanisms that trigger defensiveness are well researched, there is currently very little research dedicated to understanding the conditions and personality characteristics that enable some individuals to respond more positively to reminders of their own mortality. I would be interested in supervising PhDs in the area of mortality awareness more broadly, but I am particularly interested in projects that seek to understand the factors that promote more life-affirming responses to mortality awareness.

Visual Neuroscience

Professor Tim Ledgeway

How is texture-defined motion detected by the visual system?

Moving objects typically differ from their surroundings in terms of their textural properties (e.g. surface markings), but how these cues are extracted by the visual system to encode movement is still little understood.

[uses: psychophysics/computer models/TMS]

How are the direction and speed of global object motion encoded?

We know a great deal about how the visual system extracts velocity information from individual (localised) edges in the visual world, but rather little about how that information is subsequently combined to reveal the overall movement of complex objects.

[uses: psychophysics/computer models/TMS]

Detection of spatially-extensive image contours and shapes.

How the visual system is able to detect the outlines/boundaries of arbitrary spatial objects in cluttered visual scenes, by linking local measurements of edge orientation is an unresolved issue.

Impairments to dorsal stream processing in the brain

The dorsal pathway in the brain projects from primary visual cortex to the parietal lobes and is often referred to as the "where" pathway, as it is involved in motion processing, spatial cognition and visual motor planning. The ventral pathway projects from visual cortex to the temporal lobes and has been termed the "what" pathway, as it is involved in shape perception, visual memory and recognition of familiar objects/faces. Impairments to dorsal pathway functioning have been suggested as a defining characteristic of many developmental disorders, as well as healthy ageing. However the selectivity of this deficit is equivocal and its underlying nature is currently unknown.

[uses: psychophysics/computer models].

Dr Jonathan Peirce

My work investigates the way in which the visual system detects particular *combinations* of edges when recognising objects.

Are dyslexics incapable of detecting particular edge combinations?

A number of studies have aimed to find a low-level, visual cause of dyslexia. One possibility is that dyslexics may be unable correctly to detect the precise relative locations of particular edge combinations.

[uses: psychophysics with dyslexic and 'normal' populations]

How groups of edges are detected by the visual system?

We know a great deal about how the visual system extracts information about individual edges in the visual scene, but rather little about how that information is used and combined.

[uses: psychophysics/fMRI/computer models].

Dr Neil Roach

My research aims to understand perceptual phenomena in terms of the underlying neural mechanisms. This typically involves a combination of psychophysical experimentation and physiologically motivated computational modeling. I am interested in supervising projects that apply this approach to address questions concerning normal and abnormal sensory processing. Potential research topics include, but are not limited to:

What is the role of prediction in visual processing?

In a constantly changing world, the ability to predict future events can be vital. Financial analysts, for example, exploit patterns in the ebb and flow of market conditions to estimate the outcome of investment decisions. Meteorologists simulate trends in atmospheric conditions to forecast the weather. Although we are typically unaware that it is happening, our brains are also constantly forming predictions. The ability of the brain to predict the consequences of our actions has been studied by scientists for many years. However, the capacity of our senses to form predictions is far less well understood.

Roach et al. (2011), Visual motion induces a forward prediction of spatial pattern, Current Biology, 21, 740-745.

How does the brain code the timing of sensory events?

Roach et al (2011), Asynchrony adaptation reveals neural population code for audio-visual timing, Proceedings of the Royal Society, B, Biological Sciences, 278, 1314-1322.

Being able to perceive the flow of time is essential to just about every aspect of our lives. However at present, we don't have a clear understanding of how our brains manage to keep track of time. One way of getting insight into this process is to study situations in which our perception of time is distorted. Interestingly, this seems to occur rather frequently - for example, in the laboratory the perceived duration and temporal order of auditory and visual stimuli can be distorted via adaptation.

Dr Denis Schluppeck

The aim of my research is to understand how we use our senses of vision and touch to gather information about the world and how sensory information is retained in memory on the timescale of seconds. In the visual domain, I study how humans perceive the colour, form, and motion of visual objects, how they remember different aspects of visual information, and how they make decisions based on those perceptions.

In the somatosensory system, my primary interest is how the sensory sheet of the body surface is topographically mapped onto cortical (and subcortical) areas and how other basic stimulus properties are encoded in the brain, as well as how this mapping can change over time.

I use a combination of functional magnetic resonance imaging (fMRI), psychophysics, and computational modelling. Most recently, I have conducted MRI experiments at ultra high field (7 T) in collaboration with colleagues at the Sir Peter Mansfield MR Centre at the University to explore the use of functional and anatomical imaging at very high spatial resolution.

1. Functional imaging of the human visual system (working towards measurements at columnar and cortical layer level)

2. Mapping the human somatosensory system with high-resolution fMRI.

3. "Mind-reading" – trying to understand the signals that allow multivariate pattern classification to decode perceptual and sensory states from functional imaging data.

[methods: functional MRI at 3 T and 7 T in normal subjects, computational modelling, psychophysics, data analysis]

If you have other possible projects in mind, don't hesitate to contact me to discuss your idea

Dr Ben Webb

Perceptual Learning; neural plasticity; visual adaptation; individual differences; sensory integration; neural computation;

I supervise projects that investigate the way in which visual experiences shape the function of the visual brain and how we combine different sources of visual information to make perceptual decisions. In particular, I am interested in how visual experiences ranging from very short timescales (e.g. visual adaptation) to longer timescales (e.g. perceptual learning) interact to shape visual brain function over entire the lifespan. As part of this work, we are investigating how individuals differ in their state of visual adaptation to the environment and how this contributes to learning. We also harness the

knowledge garnered about basic mechanisms of experience-dependent plasticity to develop treatments for improving the visual quality of life of adult and children suffering with amblyopia ('lazy eye') and age-related macular degeneration. My research in mainly conducted using psychophysics to measure the visual performance of humans whilst we change something about their visual experiences of the environment (e.g. alter their adapted state or visual reality). The lab also makes use of eye movement recordings, fMRI (in collaboration with Dr. Denis Schluppeck, University of Nottingham), extracellular recordings from populations of neurons in visual cortex (in collaboration with Professor Carandini, UCL), and computational modelling.

Professor Alan Johnston

My research focusses on the perception of motion, time and space. The work ranges from detailed models and experiments on motion in early vision to the representation of dynamic change in faces. I am happy to consider supervising projects in the following general areas:

Motion Perception

In this area we seek to understand the computations involved in local velocity encoding, motion prediction and integrative "mid-level" processes, in which local motion estimates are combined to encode the motion of objects and textures, through experiments on the perception of the global motion of patterns of simple moving lines and gratings.

Roach, N.W., McGraw, P.V. & Johnston, A. (2011) Visual motion induces a forward prediction of spatial pattern. *Current Biology*, 21 (9) 740-745

Time Perception

It is possible to adapt visual mechanisms involved in time perception using local motion patterns leading to a reduction in perceived duration of around 20%. This shows we don't have a single central clock but that there are many disparate routes to a perception of duration. We are working to understand the mechanisms of these clocks.

Johnston, A., Arnold, D.H. and Nishida, S. (2006) Spatially localised distortions of event time. *Current Biology,* 16, 472-477.

Space Perception

Although we have good models of the perception local visual information such as brightness, colour, motion and pattern orientation we have little understanding of how we encode the distance between points or geometric figures. Recently we have found a way to adapt spatial separation and paradoxically a reduction in spatial separation between pairs dots is accompanied by an increase in separation for dots in textures. This provides a new tool for the study of spatial vision.

Hisakata, R., Nishida, S. and Johnston, A., 2016. An Adaptable Metric Shapes Perceptual Space. *Current Biology* : CB. 26(14), 1911-5.

Faces and Voices

How do we encode and represent subtle facial expressions? The motion of faces may be the key to how we encode faces in general. In this area we are interested in: recognition from motion cues, dynamic feature interactions, how we encode expressions and how we link facial action and facial speech.

Cook, R., Aichelburg, C., & Johnston, A. (2015). Illusory Feature Slowing: Evidence for Perceptual Models of Global Facial Change. Psychological Science, 1–6. doi:10.1177/0956797614567340