Leverhulme Doctoral Scholarship Programme: Research projects

Applicants should select ONE of the advertised research projects below.

Active learning in visual navigation

Supervisors:

Professor Andrew Philippides (Department of Informatics); second supervisor to be confirmed.

Project description:

Perception is not a passive problem. Animals actively explore their environments to acquire the information they need to guide future behaviour. This can be seen in disparate systems from the beautifully choreographed learning flights of bees (Philippides et al., J. Exp Biol, 2013) to eye movements of humans (Land and Hayhoe, Vis. Res., 2001). As such, the details of how active vision is tuned to task, environment and visual system is an important theoretical question. We are seeking a student to explore these questions both experimentally and theoretically, the details of which will be guided by the student but can range from insects to humans or even autonomous robots. A good applicant will have a technical background and interest in bio-inspired solutions, or a biological background with some technical skills and a desire to improve them, and will join a strong multi-disciplinary research team.

Behavioural and neurophysiological indices of voluntary action in the presence and absence of experience of intention

Supervisors:

Dr Warrick Roseboom (School of Engineering and Informatics) and Professor Anil Seth (School of Engineering and Informatics; Sackler Centre for Consciousness Science).

Project description:

Experiences of the intention to act and accompanying feelings of ownership of one's actions – sense of agency - are fundamental aspects of self-consciousness. How these feelings are constructed from the available sensory and experience-based (prior belief) sources of information remains an unresolved question. Recent work in our group has found that changes in the experience of an intention to act are reflected in differences in the basic properties of temporal perception regarding action (Lush et al. 2017; *Psychological Science*). This project will investigate how changes in experience of volition – conceived as changes in higher-order access to first-order motor intention information - are reflected in behavioural (e.g. intentional binding) and neurophysiological (e.g. readiness potential) measures that have previously been related to volition. The applicant should have a background in psychology or cognitive neuroscience and experience with neuroimaging is desirable.

A "blind mind's eye": Visual knowledge in aphantasia

Supervisor:

Professor Julia Simner (School of Psychology).

Project description:

Most people can construct images in their "mind's eye" of objects in the world. Imagine your house and you can probably evoke its visual features in a type of mental pictorial sketch (e.g., Pearson et al., 2013, *Clinical Psychology Review*). But people with *aphantasia* are unable to form mental images at all, or their images might be fleeting or degraded (Zeman et al., 2016, *Cortex*). Yet these individuals appear otherwise normal and can spend a lifetime unaware they lack anything at all. Imagery draws on mechanisms used in other activities, such as perception and motor control (Kosslyn et al., 2001, Nature reviews) so how might these be affected in the absence of imagery? We will study people with aphantasia to examine differences their relative strengths and weakness across multiple domains. A student working in this area should have a background in psychology or behavioural cognitive neuroscience.

Brain-body interactions underlying metacognitive awareness

Supervisors:

Dr Sarah Garfinkel (BSMS; Sackler Centre for Consciousness Science); second supervisor to be confirmed.

Project description:

Cognitive and perceptual processing are dynamically integrated with signals from the body. Detection of fear stimuli is selectively enhanced by cardiac afferent signals (Garfinkel et al., *2014 J. Neuroscience*; Garfinkel and Critchley 2016 *TiCS*). Subliminal emotional priming enhances systolic blood pressure and interferes with subsequent decision making (Garfinkel *et al.,* 2016 *SCAN*). However little is known about how signals from the body interact with the brain to influence metacognition. Using fMRI with concurrent physiological monitoring (e.g. the heart), this project will investigate how autonomic signals influence implicit and explicit processing. For example, how do bodily signals interact with brain to guide behaviour in the absence of conscious awareness? What autonomic signatures are associated with metacognitive insight? A student in this area will have a background in Psychology, Cognitive Neuroscience or Computer Science / Informatics. Good programming skills are desirable, and an interest in developing them is essential.

Cognitive training in middle aged adults

Supervisors:

Dr. Natasha Sigala (BSMS) and Professor Mara Cercignani (BSMS).

Project description:

The study of experts defines the upper limits of human ability, which is why we are fascinated by peak performers, such as chess grandmasters and Olympic athletes. This project will examine structural and functional brain changes that result from perceptual and memory training. We will use univariate and multivariate analyses approaches of imaging data. By combining these two approaches, we can model brain activity in terms of brain area activations, as well as network architecture and neural context. We have shown that graph-based mapping of effective connectivity, can reveal distinct anatomical locations of ‘‘cortical hubs’’ supporting the processing of well-practiced problems and less-practiced ones in an expert mental calculator (Minati & Sigala, 2013). These results point to the effect of extensive practice on the development of expertise and long term working memory. We will also investigate the structural effects of training in the brain white and grey matter with Voxel Based Morphometry (VBM), Diffusion Imaging and quantitative Magnetisation Transfer (qMT) (Cercignani et al. 2005).

Common determinants of involuntary attention to sensory stimuli and mental representations

Supervisors:

Dr Sophie Forster (School of Psychology) and Professor Jamie Ward (School of Psychology).

Project description:

Over the past several decades, much research has characterised the process by which external sensory input can involuntarily capture attention and reach awareness. Another source of information that often appears to capture attention involuntarily is our own thoughts, yet this latter process has received very little research attention. Recent research suggests that common processes may be involved in directing attention to both internally and externally generated sensory representations (Forster & Lavie, 2009, Cognition; 2013, JEP: LMC). This raises the possibility that the same factors that make an external sensory stimulus 'salient' may also apply to internally-generated mental representations. A student working in this area should have a background in psychology or cognitive neuroscience and experience with programming is desirable.

Ecological strategies of colour vision

Supervisors:

Dr Jenny Boston (School of Psychology) and Professor Anna Franklin (School of Psychology; The Sussex Colour Group).

Project description:

Human colour vision has developed to suit a particular visual niche. For example, the middle- and long-wavelength sensitive photopigments that are critical for distinguishing red and green colour differences evolved in old world primates about 30 million years ago, to allow them to detect ripe fruit on a background of foliage. In the modern human population, there are a variety of common genetic polymorphisms of genes for the middle- and long-wavelength sensitive opsins that confer different colour apparatus (Sharpe et al. 1999, In Gegenfurtner, K. and Sharpe, T. T. (eds), *Color Vision: From Genes to Perception*), leading to anomalous trichromacy, variation in colour vision within the normal range, and putative human tetrachromacy (Jordan et al. 2010, Journal of Vision). What the selective pressure is that has maintained the polymorphisms in the population is an unanswered question. The PhD project would use a variety of techniques including modelling of the colour visual system's response to natural scenes, genetic analysis, and psychophysical experiments, to explore the ecological niches that may give each different phenotype the advantages that maintain it in the population. Another possible direction would be to investigate the genetic variation in *OPN1SW* and its functional significance. Such variation may lead to individual differences in the peak sensitivity of the short-wavelength sensitive cones, with consequences for colour vision that have not yet been explored. Jenny Bosten's lab uses psychophysical techniques to measure visual performance, analyses natural scenes, and investigates individual differences at a genetic level from DNA samples. Anna Franklin (co-supervisor) has expertise in colour, EEG, cross-cultural studies and developmental psychophysics.

Elemental perceptual process in insect vision for navigation

Supervisors:

Dr Paul Graham (School of Life Sciences) and Dr Jeremy Niven (School of Life Sciences). Professor Tom Collett will act as project advisor.

Project description:

Visual navigation, by which animals find places (e.g. home) defined by memories of a visual scene, has basic similarities across a wide range of species from ants to humans. The behaviour depends on both identifying objects within scenes and encoding their relationships to goals and possibly to each other. We can investigate these perceptual and learning processes in navigating ants (Lent et al., 2013, Curr Biol; Buehlmann et al., 2016, Curr Biol) where modern trackball systems allow for fine-grained presentation of visual stimuli to freely behaving animals. Excitingly, this new technique using virtual reality will enable us to approach many new questions. Two examples being whether ants memorise the three-dimensional arrangement of objects or whether attentional mechanisms allow ants to prioritise areas of the visual scene. We would like to recruit a technically inclined student with a background in neuroscience or behaviour to the Sussex Insect Navigation group to investigate these questions.

Encoding of information at the first synapse in the visual pathway

Supervisors:

Professor Leon Lagnado (School of Life Sciences; the Lagnado Lab) and Dr Tom Baden (School of Life Sciences; Baden Lab).

Project description:

Visual processing in the retina depends on the transformation of signals as they are transmitted across synapses (Lagnado & Schmitz, Annu Rev Vis Sci. 2015; Franke et al., Nature. 2017 542, 439-44). The first synapses in the visual pathway are structurally distinct and employ a "vesicle code" that represents information by both the rate and, surprisingly, the amplitude of events releasing neurotransmitter. We will investigate this code at photoreceptor synapses using multiphoton imaging in the retina of transgenic zebrafish. How does the vesicle code transmit information from cones of different colour? How is it adapted to cones sampling different parts of visual space? How does it compare to synapses transmitting the visual signal in the inner retina? The project involves both experiments and computer-based analysis. Students should have a background in neuroscience, engineering, physics or computing.

Entrainment and musical experience: New methods for investigating individual experiences and group dynamics in ensemble music making

Supervisors:

Dr Alice Eldridge (Department of Music) and Dr Chris Kiefer (Department of Music).

Project description:

Current trends in performance studies and music cognition promote the value of phenomenological accounts of musical experience: intersubjective contexts are increasingly approached through studies of concrete (inter)actions of players, rather than solely reduced to processes going on 'in the head' (Schiavio & Hoffding, 2013). Holmes and Holmes (2013) argue that music cognition research in general could benefit from the integration of phenomenological, qualitative and quantitative methods, yet tools to carry out ecologically valid research – in situ, in rehearsal, rather than in lab - are lacking. This project will develop and deploy networked tools for telemetric multisensory in-situ data collection for performance studies, using contemporary sensing/machine learning/data analysis, to investigate the relationship between individual experiences in performance and measurable group dynamics of the ensemble. A student working in this area should have solid programming skills and data analysis experience, an interest in sensors, electronics and musical performance.

An expectation-based account of the content of conscious experience

Supervisors:

Dr. Ron Chrisley (School of Engineering and Informatics); secondary supervisor to be confirmed.

Project description:

Results from the theory of non-conceptual content imply that a precise, scientifically useful characterisation of the content of conscious experience (e.g., a specification of the *way* we perceive the objects and properties around us, rather than of those objects and properties themselves) cannot employ the standard, “that”-clause means of specification used for the content of conceptual thought. One proposal (Chrisley, R., 2009, “Synthetic Phenomenology”, *International Journal of Machine Consciousness*) is that some personal-level experiential content derives from the sub-personal expectational content of the sensory-motor system. Such a proposal may derive support from, and in turn develop, predictive processing models of cognition. But does such support imply that experiential content is fundamentally probabilistic or indeterminate? Can the advantages of expectational content specification be empirically demonstrated, with real data or in simulation? A student working in this area should have a background in the philosophy of cognitive science; experience with constructing computational or robotic cognitive models is desirable

Exploring how undisclosed intentions influence perceptual processing and emotional responses to conscious and unconscious stimuli

Supervisors:

Dr Ryan Scott (School of Psychology) and Professor Thomas Ormerod (School of Psychology).

Project description:

Structured interview-based approaches have proven to be effective in detecting undisclosed intentions in security screening contexts (Ormerod & Dando, 2014). Psychophysiological measures and RT based tasks have shown potential in determining undisclosed knowledge (e.g. Seymour & Kerlin, 2008) but have limited use in isolation and are unsuited to typical security screening contexts due to their overt nature. There is a need for non-invasive methods that can be usefully combined with interview techniques to enhance deception detection. This project will seek to combine unconscious presentation methods and physiological markers of stress, such as heart-rate variability, to examine how perceptual processing and emotional responses to relevant stimuli vary as a function of intentions and awareness. The work will both contribute to theoretical knowledge of unconscious attentional control and multi-sensory interactions while also targeting potential application in real-world contexts. Potential candidates would have a background in cognitive psychology and experience utilising psychophysiological methods.

How sequence recognition emerges from neuronal activity

Supervisors:

Professor Miguel Maravall (School of Life Sciences); secondary supervisor to be confirmed.

Project description:

To make sense of the world around us, we need to recognise stimuli that unfold over time. A patterned stream of sound, such as a piece of music or passage of speech, or a surface scanned by our fingertips, can only be identified by sensing the order and timing of its elements (notes, phonemes, ridges). Humans and other animals have remarkable capacities for discriminating temporally patterned sequences. How the brain perceives and learns sequences remains mysterious. This project will address this gap by training humans and mice to recognise a sequence (Bale et al, eLife, 2017) and recording neuronal activity in relevant brain areas. A student working in this project should have a background in neurobiology, cognitive neuroscience or a quantitative subject (e.g., physics or computation) and be interested in combining experiments with coding (Matlab, Python). The project will emphasise human or mouse work depending on the student’s interests.

Individual Differences in Sensory Sensitivity and its Links to Autism and Synaesthesia

Supervisor:

Professor Jamie Ward (School of Psychology) and Dr Sophie Forster (School of Psychology).

Project description:

Some people report being unusually sensitive to simple sensory stimuli (e.g. lights and sounds). This can occur across multiple senses, suggesting a central original, and is particularly apparent in certain groups such as those with autism or synaesthesia (Ward et al., 2017a, Scientific Reports; 2017b Cortex). However, little is known about the underlying mechanisms. For instance, are people with heightened subjective sensitivity better able to discriminate between sensory stimuli, or better able to notice small details in a complex scene? Does their sensory world appear more intense because they are less able to predict it? Within the brain, what structural and functional differences accompany this trait? A student working in this area should have a background in psychology or cognitive neuroscience and experience with neuroimaging is desirable.

Integration of Taste and Smell in Virtual Reality and its Effect on Embodiment

Supervisors:

Reader Marianna Obrist (School of Engineering and Informatics); secondary supervisor to-be-confirmed.

Project description:

It has been shown in prior works that the use of Virtual Reality (VR) systems can change a person's own body perception through modulating visual, auditory, and haptic parameters. No such research has been conducted involving the chemical senses. Both, the sense of taste and smell have become a target for interaction design and Human-Computer Interaction (HCI) research [Spence et al. 2017: IJHCS] to augment and transform interactive experiences with technology (e.g., TastyFloats – Vi et al. 2017: ISS). In light of increased eating disorders and obesity, novel multisensory interfaces combined with the opportunities around VR provide an exciting platform for systematic investigations into the effect of taste and smell on body perception and embodied experiences. A student working in this area should have a background in psychology or cognitive neuroscience with a high appreciation for computer science, and novel interactive systems; basic programming skills (e.g. Unity) are desirable.

Musical composition and perceptions of light and colour

Supervisors:

Professor Ed Hughes (Department of Music) in collaboration with a cognitive scientiest.

Project description:

Light and colour as metaphors in music are widespread. Much work has been done on this already but there has been little practice-led scholarly work undertaken to link the perspectives and experiences of practising creative musicians to scientific understanding. According to music scholar Michael Spitzer, painting (visual art) 'established a common interest in expressive immediacy based on the perceived analogy between the dynamics of light and sound' (Spitzer, 2004, 148, Metaphor and Musical Thought, University of Chicago Press). Composer Joseph Haydn famously used a fortissimo C major chord to invoke the dazzling effect of God's light in The Creation (1798). The composer Eisler and theorist Adorno (1947, Composing for the films, OUP), in their critique of composition for films, attacked what they saw as the latency between eye and ear as a function or product of cultural industry. The modernist composer Karlheinz Stockhausen was obsessed with the metaphor of light and created a cycle of seven operas 'Licht' (1977-2003) which links days of the week to the seven planets of Antiquity (closing with Sunday = The Sun). For this practice-led PhD research project we would recruit a composer with an artistic track-record in connecting her/his music to phenomena/metaphors of light, possibly using electronic and/or computational methods in conjunction with acoustic instruments to achieve theatrical performances involving light effects and/or visuals. Uniquely the research would then inform the development and live performance of a portfolio of original musical compositions to interrogate this 'attraction' between music and light from the combined perspectives of humanities' aesthetics traditions and science.

Neural basis of training-induced changes in conscious perception

Supervisors:

Professor Anil Seth (School of Engineering and Informatics; Sackler Centre for Consciousness Science) and Dr Warrick Roseboom (School of Engineering and Informatics).

Project description:

Individuals with synaesthesia provide a unique window into consciousness because they experience the world in a very different way – for example experiencing colours when they perceive black letters or numbers (e.g., Gould et al, 2014, *Cerebral Cortex*). Recently, our group has been able to train non-synaesthetic people to have synaesthesia-like experiences (Bor et al., 2014, *Scientific Reports*; Rothen et al., *in review*), demonstrating a previously undiscovered plasticity in adult human conscious perception. However, the neural basis of these changes remains poorly understood. This project will involve large-scale training of novel conscious experiences (like synaesthesia) along with computational modelling and neuroimaging, to shed new light on how changes in the brain give rise to changes in conscious experience. The project will suit a student with a background in cognitive neuroscience and experience with computational modelling, statistics, and/or neuroimaging is desirable.

Olfactory learning and decision making in Drosophilia

Supervisors:

Professor Thomas Nowotny (School of Engineering and Informatics); second supervisor to be confirmed.

Project description:

Olfaction, the sense of smell, is essential for insects in order to locate food, sexual mates or escape predators. Many aspects of the olfactory system of insects have been investigated and understood, both in experiments and corresponding computational models. However, most models only cover the early sensory layers of the olfactory system. There are now large efforts in leading labs, e.g. at the Janelia Research Campus in the States, but also in the fly circuit project in Taiwan, to map the anatomy and physiology of the brain of the fruit fly, *Drosophila melanogaster*, in unprecedented detail. In this PhD project, you would use this new knowledge to build on existing models of olfaction (Nowotny and Huerta, 2005, Nowotny et al., 2013, Chan et al. 2017) to also cover deeper brain structures related to decision making and higher order learning. The project will suit candidates with a strong quantitative background and a keen interest in computational Neuroscience. Some programming skills and mathematical understanding will be essential. Prior knowledge in Neuroscience would be useful.

Temporality and rhythmic perception in performance and their representation in musical consciousness

Supervisors:

Dr Thor Magnusson (Department of Music); second supervisor to be confirmed.

Project description:

Rhythm, pulse and their representation in temporality, whether felt or performed are inherent part of human consciousness. This occurs in movement as part of the performative and becomes particularly manifest when individuals interact. Scholars of Paleolithic culture (Tomlinson, 2017) have proposed that evidence of rhythmic and temporal perception and communication have in part constituted human development, including our temporal and rhythmic awareness. The embodied act of musical performance generates a particular awareness of time and rhythm, one that has profound implications in understanding the evolution of human consciousness. Under this broad description, this project offers opportunities to study music and perception of time and rhythm, and how these are expressed in improvisation, composition, instrument design and the general context of human musicking (Small, 1998). How is shared and synchronised temporality constructed in the performative, musical or otherwise? This project would study the musical brain (Sacks, 2007) working towards understanding observations from performance and practice. We are open for proposals from researchers in the areas of music, psychology, cognitive science and informatics.

Potential applicants may also be interested in these related studentships not funded by the Leverhulme Doctoral Scholarship Programme (note difference in closing dates):

Distributed neural processing of self-generated visual input in a vertebrate brain

Causality and complexity in human neural dynamics during natural vision