

## KEYNOTE ABSTRACTS

### KEY008: Probabilistic Models Of Sensorimotor Control And Decision Making

**Keynote Speaker:** Professor Daniel Wolpert, University of Cambridge, UK

#### Overview

The effortless ease with which humans move our arms, our eyes, even our lips when we speak masks the true complexity of the control processes involved. This is evident when we try to build machines to perform human control tasks. While computers can now beat grandmasters at chess, no computer can yet control a robot to manipulate a chess piece with the dexterity of a six-year-old child. I will review our work on how the humans learn to make skilled movements covering probabilistic models of learning, including Bayesian and structural learning. I will also review our recent work showing the intimate interactions between decision making and sensorimotor control processes. This includes the relation between vacillation and changes of mind in decision making and the bidirectional flow of information between elements of decision formations such as accumulated evidence and motor processes such as reflex gains. Taken together these studies show that probabilistic models play a fundamental role in human sensorimotor control.

### KEY009: The Role Of The Subthalamic Nucleus In Strategic Decision-Making: A Model-Based Approach

**Keynote Speaker:** Professor Birte Forstmann, University of Amsterdam, Netherlands

#### Overview

The basal ganglia are thought to implement a generic action-selection mechanism that releases from inhibition those actions that are desirable and maintains inhibitory control over all others. One key hypothesis that is shared by recent neurocomputational models of decision making is that the subthalamic nucleus (STN), a small nucleus in the basal ganglia (BG), plays a pivotal role in strategic adjustments of response thresholds. In this keynote lecture, I will first discuss the anatomo-functional role of the STN including ultra-high resolution 7Tesla magnetic resonance imaging (MRI) from post-mortem and in-vivo brains. I will provide a critical overview challenging the current academic consensus that the STN consists of three distinct parts, each selectively associated with cognitive, emotional, and motor functioning. I will then present structural and functional 3T and 7T data highlighting the role of the STN in strategic decision-making. The results will be discussed in light of the STN's functional role in both healthy and clinical populations.

## ACNS YOUNG INVESTIGATOR LECTURE ABSTRACT

### Mapping Context-Dependent Changes In Brain Functional Networks Using Event-Related Graph Analysis

**Speaker:** Associate Professor Alex Fornito, Monash University, Australia

#### Overview

Cognition emerges from complex and dynamic patterns of coordinated activity in spatially distributed neuronal ensembles. These patterns can be studied by analyzing statistical dependencies—functional connectivity—between neurophysiological signals recorded in distinct brain regions. Most studies of functional connectivity published to date have focused on spontaneous brain dynamics, recorded in the absence of an explicit task. Although this work has generated important insights into brain functional organization, its applications for understanding cognition are limited because neural activity evoked by active task performance is not considered. In this talk, I will describe recently developed methods that allow quantification of task-related modulations of functional connectivity that are scalable to the analysis of whole-brain networks. I will demonstrate how these techniques can be leveraged to map dynamic reconfigurations of large-scale neural systems in response to changing task conditions, and to understand how these network changes relate to individual differences in cognitive performance.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S19: ECoG Signatures Of Human Cognition

**Chair & Speaker:** Josef Parvizi, Stanford University, USA  
 Jean-Philippe Lachaux, INSERM Lyon, France  
 Robert T. Knight, University of California Berkeley, USA

#### Overview

Electrocorticography (ECoG) is a method for in-vivo sampling of electrical currents from precisely localizable neuronal populations with a high sampling rate and excellent signal to noise ratio. Simultaneous recordings from a large number of brain sites make it possible to study the local activity of neuronal populations along with their dynamic interactions with other brain regions in real time. The speakers of the symposium will highlight some of the latest breakthroughs in ECoG research that have given rise to new waves of discoveries in the field of cognitive neuroscience. They will argue that the anatomical precision and temporal resolution of ECoG, and the simultaneous access it provides to distributed brain networks, make it a suitable method for decoding the electrophysiological signature of human cognition in experimental as well as natural conditions.

#### S19 001: Combined ECoG, fMRI, And Electrical Brain Stimulation: A New Era For Localization Of Functions

Josef Parvizi, Stanford University, USA

In this talk, I will present ECoG data recorded from populations of neurons in the human brain during controlled experimental condition as well as natural conditions in which subjects freely interact with their environment. I will highlight the convergence of evidence across experimental and natural conditions and will compare the ECoG data with fMRI and electrical brain stimulation data obtained from the same individuals. Evidence from this multimodal approach has given us reasons to appreciate specialization of functions in the human brain.

#### Biography

Professor Parvizi is the director of Stanford Human Intracranial Cognitive Electrophysiology Program (SHICEP) and the PI the Laboratory of Behavioral and Cognitive Neurology (LBCN) at Stanford University School of Medicine. His expertise is in multimodal research using electrocorticography, electrical brain stimulation, and functional imaging methods.

#### S19 002: ECoG Signature Of Large-Scale Functional Connectivity In The Brain

Jean-Philippe Lachaux, INSERM Lyon, France

In this talk, I will present old and new evidence regarding amplitude coupling of high frequency activity recorded across different cortical regions in patients implanted with ECoG electrodes. I will discuss the issue of amplitude-amplitude coupling in light of phase-amplitude and phase-phase correlations.

#### Biography

Professor Lachaux works at INSERM Lyon and direct intracranial research in human participants. He is one of the pioneers of research in intracranial electrophysiology and many of his methods are widely used by other researchers in the field.

### S19 003: The Past, The Present, And The Future Of ECoG

Robert T. Knight, University of California Berkeley, USA

In the last decade, there has been an explosion of interest in direct recordings from the surface of the cerebral cortex in patients implanted with intracranial electrodes. ECoG has revealed an extended frequency space in the human cortex extending up to 250 Hz. This high frequency signature of local neural activity coupled with novel methods to examine the role of low frequency oscillations in local and distributed network tuning has provided novel insights into a range of cognitive phenomena including memory, perception, emotion, language and motor control. Importantly, ECoG has also provided a new means for neuroprosthetic control. I will review current developments in human ECoG research and will highlight some of the new challenges to be tackled in the future.

#### Biography

Professor Knight is one of the pioneers of human ECoG research and has been involved in electrophysiological studies of network activity supporting goal-directed behavior in humans.

### S20: The Interplay Of Attention And Prediction In The Human Brain

Peter Kok, Donders Institute for Brain, Cognition and Behaviour, Netherlands

Srivas Chennu, University of Cambridge, UK

**Chair & Speaker:** Marta I. Garrido, The University of Queensland, Australia

Angela J. Langdon, Princeton University, USA

#### Overview

Theoretical models and recent data suggest that the human brain is best viewed as a predictive machine. According to this view, brains learn by minimising the amount of prediction error, or surprise, caused by unexpected events. Neuroimaging and computational work have implicated several brain areas in feedforward propagation of predictions from higher- to lower-order regions and subsequent feedback of prediction errors from lower- to higher-order brain areas. Predictive coding models hypothesise that prediction errors are weighted by their precision, which ties into the notion of attention tuning. In this symposium, we will present a series of studies that support these ideas. Kok will show that attention can reverse the reduction of prediction errors that is observed in fMRI data when sensory inputs are predicted. Chennu will present results from intracranial and ERP recordings that demonstrate how attention can differentially modulate responses typically associated with probabilistic inference such as mismatch negativity (MMN), P300, and contingent negative variation (CNV). Garrido will show model-based connectivity evidence for a rightward attentional bias to unexpected events. Finally, Langdon will discuss the mechanisms by which attention modulates reward-based learning in a neural circuit model.

### S20 001: On The Role Of Expectation In Visual Perception: A Top-Down View Of Early Visual Cortex

Peter Kok, Donders Institute for Brain, Cognition and Behaviour, Netherlands

Perception is not solely determined by the light that hits our eyes. Instead, what we perceive is strongly influenced by our prior knowledge of the world. I will discuss several ways in which prior expectations influence sensory processing. Using fMRI in conjunction with multivariate techniques, I will show that valid prior expectations concurrently enhance stimulus representations and reduce stimulus-evoked activity in V1. This suppression of neural activity by expectation seems at odds with the enhancing effect reported in Posner paradigms, where expectation is used to manipulate attention. However, this seeming contradiction can be resolved by recent predictive coding models wherein attention and expectation interact. Here, I will provide empirical evidence that supports such a view. Predictions do not only pertain to what is likely to happen in the near future, but may also occur across different layers of the visual cortex hierarchy. For example, in the famous Kanizsa triangle, higher-order visual areas may detect an (illusory) shape and send predictive feedback to those neurons in lower order visual areas that are expected to detect the lower level features that make up the shape. According to predictive coding theories, the effects of such feedback should depend on whether or not it is met by congruent bottom-up input. In line with this, using fMRI in conjunction with a novel retinotopic reconstruction method, we find evidence for enhanced activity of neurons whose receptive fields lie on the illusory shape, while the response to the local elements inducing the shape is suppressed.

#### Biography

Peter Kok is a post-doctoral researcher in the Prediction and Attention lab of Dr. Floris de Lange. The lab is part of the Donders Institute for Brain, Cognition, and Behaviour, at the Radboud University Nijmegen, The Netherlands. Peter Kok's primary research interest lies in the effects of expectation on visual perception. According to theories of perceptual inference, expectation can affect how well we see something, and even what we see. Using sophisticated fMRI analyses (retinotopic mapping, multivoxel pattern analysis, DCM) Peter Kok studies how expectation modulates neural processing in sensory cortex.

### S20 002: Expectation And Attention In Hierarchical Auditory Prediction

Srivas Chennu, University of Cambridge, UK

Recent neuroscientific advances have generated new theoretical understanding about the intuitive notion that the human brain is an adaptive prediction engine. There is a growing consensus that this engine is realised by a hierarchy of successively complex neural processes that feedforward prediction errors and feedback predictions to maintain a constantly updated model of the world. We investigate the empirical support for this broad conceptualisation, focusing on expectation and attention in hierarchical prediction. Drawing upon data from high-density E/MEG and intracranial recordings, our findings support an integrative interpretation of commonly observed electrophysiological signatures of neurodynamics, including the Mismatch Negativity (MMN), P300 and Contingent Negative Variation (CNV), as manifestations along successive levels of predictive complexity. Early first-level processing, indexed by the MMN, is sensitive to stimulus predictability: here, attentional precision enhances early responses, but expectation diminishes it. In contrast, later second-level processing, indexed by the P300, is contingent on attentional engagement, and in fact sharpened by top-down expectation. At the highest level, the CNV, a frontally centered negative EEG drift, is a fine-grained marker of expectation itself. Source reconstruction and formal modelling of the MMN and P300, backed by intracranial data, implicates temporofrontal regions differentially active at early and late levels. The CNV's cortical generators suggest that it facilitates the consolidation of context-salient stimuli into consciousness. These results provide convergent empirical support to promising recent accounts of predictive coding, and tie into the notion of attention as the cognitive manifestation of the precision of prediction.

#### Biography

Srivas Chennu is a post-doctoral scientist at the University of Cambridge. He received a PhD in Computer Science from the University of Kent, with a specialisation in computational and cognitive neuroscience. His current research focuses on the use of E/MEG for improving our understanding of altered states of consciousness, including the vegetative and minimally conscious states, sleep and sedation. This research, funded by the James S. McDonnell foundation and the Medical Research Council, aims to advance the scientific study of consciousness, inform diagnosis and prognosis for patients, and further the development of Brain-Computer Interfaces that might benefit some of them.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S20: The Interplay Of Attention And Prediction In The Human Brain cont'd

#### S20 003: Effective Connectivity Reveals Right-Hemisphere Dominance In Audiospatial Perception: Implications For Models Of Spatial Neglect

Marta I. Garrido, The University of Queensland, Australia

Detecting the location of salient sounds in the environment rests on the brain's ability to use differences in sound properties arriving at both ears. Functional neuroimaging studies in humans indicate that the left and right auditory spaces are coded asymmetrically - with a rightward attentional bias that reflects spatial attention in vision. Neuropsychological observations in patients with spatial neglect have led to the formulation of two competing models: the orientation bias and right-hemisphere dominance models. The orientation bias model posits a symmetrical mapping between one side of the sensory space and the contralateral hemisphere, with mutual inhibition of the ipsilateral hemisphere. The right-hemisphere dominance model introduces a functional asymmetry in the representation of space. According to this model, the left hemisphere represents the right side of space, whereas the right hemisphere represents both sides of the sensorium. We used dynamic causal modelling of effective brain connectivity and Bayesian model comparison to adjudicate between these alternative architectures - based on human electroencephalographic data acquired during an auditory location oddball paradigm. Our results support a hemispheric asymmetry in a fronto-parietal network that conforms to the right-hemisphere dominance model. This finding supports the disconnection hypothesis of unilateral neglect and has implications for theories of its aetiology.

#### Biography

Dr Marta Garrido is a research fellow at the Queensland Brain Institute. Her current work involves magneto- and electroencephalographic methods to understand how humans make predictions about an uncertain environment. Before moving to the University of Queensland, Dr Garrido did her postdoctoral work at the Wellcome Trust Centre for Neuroimaging in London, and at the University of California Los Angeles. Dr. Garrido trained in Physics Engineering at the Technical University of Lisbon, and holds a PhD in Neuroscience from University College London, where she used computational models to study connectivity in the human brain.

#### S20 004: Attention For Learning: The Striatal Cholinergic System In Reward-Based Learning

Angela J. Langdon, Princeton University, USA

Humans routinely operate in complex, multi-stimulus environments in which it would behoove them to selectively attend to and learn about only those stimuli that are consistently predictive of rewards. It is by now well established that the dopaminergic inputs to the striatum signal errors in the prediction of reward, and as such are critical for learning mappings between stimuli and rewards. However, how does the striatum know which of the stimuli to be learning about in the first place? That is, how would the striatum focus its 'attention' on those stimuli that are relevant to the task at hand? Based on data ranging from physiology to behavior, we suggest that the striatal cholinergic system—a locally controlled system that is distinct from cholinergic pathways that innervate the cortex—mediates the striatal focus of attention during reward-based learning. We introduce a neural circuit model of the interaction of cholinergic and dopaminergic signals in the striatum, in order to study the cholinergic system as an attentional filter that modulates learning based on dopaminergic prediction errors. This work expands our understanding of the neural implementation of reward-based learning in the brain and provides a window on the interaction between attention and goal-directed behaviour in complex real-world scenarios.

#### Biography

Dr Angela Langdon is a postdoctoral research associate at the Princeton Neuroscience Institute and Department of Psychology at Princeton University. Her current research is focused on modelling the cholinergic system in the striatum in order to understand its functional role in modulating neural activity and behaviour during reward-based learning. She was awarded her Ph.D. from the University of New South Wales, in which she combined experimental and theoretical approaches to study neuronal population dynamics in the somatosensory system during tactile processing.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S21: Cognitive Modeling And Cognitive Neuroscience: A Symbiotic Relationship

**Birte Forstmann**, University of Amsterdam, Netherlands  
**Alexander Provost**, University of Newcastle, Australia  
**Matthias Mittner**, University of Amsterdam, Netherlands  
**Chair & Speaker: Renate Thienel**, University of Newcastle, Australia

#### Overview

Cognitive modeling and cognitive neuroscience have traditionally been regarded as separate fields of study. Cognitive modelers infer underlying cognitive processes based on observable behavioral outcomes, while cognitive neuroscientists examine cognitive processes using neuroimaging measures. The emerging field of model-based neuroscience uses formal cognitive modeling to isolate specific cognitive processes and relate these to brain measurements to develop more fine-grained models of cognition. This approach allows for a reciprocal relationship between the fields of cognitive modeling and cognitive neuroscience that can both enhance our ability to make precise interpretations of patterns of brain activity, and also inform and constrain formal cognitive models based on brain measurements. This symposium highlights examples of the ways in which cognitive modeling and cognitive neuroscience can interact to address a broad range of questions. Birte Forstmann uses cognitive modeling to determine the necessity of basal ganglia structures in regulation of the speed-accuracy tradeoff. Alexander Provost describes a study in which neuroimaging and behavioral data are simultaneously modeled to examine spatial skill acquisition. Matthias Mittner presents a novel way of determining the specific cognitive processes that differentiate task-related from task-unrelated thoughts. Renate Thienel explores the association between networks supporting adjustments in response caution and adaptive functioning outcomes.

#### S21 001: Focal Striatum Lesions Impair Decision Threshold Adjustment In Humans

**Birte Forstmann**, University of Amsterdam, Netherlands

Birte U. Forstmann, Richard B. Ivry, Scott D. Brown, Roshan Cools & Jasper Winkel

Flexible adjustment of the Speed-Accuracy Tradeoff in decision making is known to activate the dorsal striatum and pre-supplementary motor cortex. However, the causal contribution of these regions to decision making behavior is currently unknown. In this experiment, we compare behavior on a Speed-Accuracy Tradeoff (SAT) task between a group of patients with a focal ischemic lesion in the dorsal striatum, and healthy matched controls. Using the Linear Ballistic Accumulator model, we analyze differences in the decision threshold parameter, which regulates fast versus accurate decision making. We show that a striatal lesion reduces the adjustment of the decision threshold between fast and accurate trials. Therefore, we conclude that the striatum is necessary to flexibly adjust the decision threshold to meet speed or accuracy demands.

#### Biography

*Professor Birte Forstmann is Professor of Cognitive Neurosciences at the Cognitive Science Centre, University of Amsterdam, and tenured research fellow of the European Research Council. She completed her PhD in 2006 at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany. Professor Forstmann's general research goal is to understand the brain mechanisms that allow people to adapt quickly to changes in their environment.*

*Her work is motivated by a single strong conviction that behavioral data and brain measurements need to make contact with psychological theory via concrete mathematical models of latent cognitive processes, and combines mathematical modeling with functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI), ultra-high resolution 7T MRI, and electroencephalography (EEG).*

#### S21 002: Simultaneously Modeling The Cognitive And Neural Mechanisms Involving Different Types Of Expertise In Mental Rotation

**Alexander Provost**, University of Newcastle, Australia

Alexander Provost, Brandon Turner, Marieke van Vugt, Blake Johnson and Andrew Heathcote

In a recent study (Provost, Johnson, Karayanidis, Brown & Heathcote, 2013) we found marked improvements in mental rotation (MR) performance with practice in both a small and a large stimulus set. Converging evidence from behavior – mean response time (RT) – and event-related potentials (ERPs), supported different routes to expertise: direct retrieval of solutions from memory with the small set and algorithmic improvement (enhanced rotation speed) in the large set. Here we develop cognitive models for both small set performance, using a standard LBA (Brown & Heathcote, 2008), and for large set performance, by convolving an LBA with a stochastic rotation algorithm model. Using newly developed simultaneous modeling techniques (Turner et al., 2013) we combined choice accuracy and RT distribution data with spectral analyses of EEG and MEG epochs, combined with ERPs and event-related fields (ERFs), to fit these models. We discuss the implications of our results for understanding the cognitive and neural mechanism underpinning different types of expertise in spatial skill.

#### Biography

*Alex Provost is an PHD student, under the supervision of Prof. Andrew Heathcote, Assoc Prof. Frini Karayanidis and Assoc Prof. Blake Johnson. He is first author of a recent publication in Cognitive Neuroscience investigating expertise in Mental Rotation. Alex has been published in Psychophysiology, International Journal of Psychophysiology, Neuropsychologia, Journal of Neurophysiology and Cognitive, Affective and Behavioral Neuroscience. His interests are spatial cognition, learning and signal processing.*

#### S21 003: Analyzing The Multimodal Signature Of Task-Unrelated Thoughts

**Matthias Mittner**, University of Amsterdam, Netherlands

Matthias Mittner, Wouter Boekel, Adrienne M. Tucker, Andrew Heathcote and Birte U. Forstmann

Frequently, humans engage in task-unrelated processing, even under conditions of sustained attention (Smallwood, 2013). Estimates for the frequency of mind-wandering range from 40 to 50% of our waking time (Killingsworth & Gilbert, 2010). Obviously, such a high proportion of episodes of off-task cognition (task-unrelated thoughts, TUTs) poses a significant threat to the interpretation of many studies investigating cognitive functions. We acquire neuroimaging, pupil-diameter, and behavioural data in a Stop-Signal task (e.g., Forstmann et al., 2012) in which we randomly intersperse “thought-probes” (introspective questions about the content of the subject’s current thoughts). In a machine-learning setup, we train a support-vector machine (SVM) on single-trial features derived from neuroimaging data and recordings of the pupil-diameter to predict subjects response to the thought-probes.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S21: Cognitive Modeling And Cognitive Neuroscience: A Symbiotic Relationship cont'd

A cross-validation procedure achieves a cross-subject classification performance of 75% using only brain-data and pupil-diameter as inputs. Based on predictions derived from this classifier regarding the state of mind during the remaining trials, we are able to apply the Stop-Signal Linear Ballistic Accumulator (SS-LBA; Forstmann et al., submitted) to the reaction time (RT) and accuracy data. Since this model can dissociate the RT distribution into underlying cognitive processes, we can derive conclusions about how processing differs in on-task vs. TUT-dominated trials.

#### Biography

*Matthias Mittner (born Ihrke) is currently a Post-Doc at the Cognitive Science Centre Amsterdam in the group of Birte Forstmann. He received his PhD from the University of Frankfurt, Frankfurt, Germany, in 2011 and worked as a Post-Doc in the Max-Planck-Institute of Experimental Medicine, Goettingen, Germany. His current research interests are at the interface of cognitive modeling and neuroimaging research in bringing together data from different modalities in a modeling framework to investigate cognitive phenomena.*

### S21 004: Age-Related Changes In White Matter Pathways Underlying Response Threshold Adjustment

**Renate Thienel, University of Newcastle, Australia**

Flexibly adapting to changes in our everyday environment relies on the ability to balance fast and accurate decision-making. Evidence accumulation models of decision-making suggest that this trade-off is accomplished through the adjustment of response caution. Cortico-basal ganglia networks have been shown to underlie the ability to strategically adjust response caution on a trial-by-trial basis in both two-choice decision making tasks and in cued-trials task switching (Forstmann et al., 2008; Mansfield et al., 2011). These networks are also associated with intrinsic tendencies to take an overall more risky or more cautious approach to responding (Mansfield et al., in revision). We extend on this research, examining whether changes in these networks with age can explain the development of more adaptive decision-making strategies from adolescence to adulthood. We used diffusion-weighted imaging (DWI) to examine structural development in neural networks associated with response threshold adjustment in cued-trials task switching. Further, we examined whether the relationship between white matter integrity and threshold adjustment could be linked with the development of individuals ability to make adaptive behavioral, social and emotional adjustments to the challenges of everyday life. This represents the first attempt to relate structural integrity in networks supporting a specific cognitive process with adaptive functioning outcomes.

#### Biography

*Dr Renate Thienel is an early to mid - career researcher and is a postdoctoral research fellow at the University of Newcastle. Her research focuses on studying event related potentials, functional magnetic resonance imaging, magnetic resonance spectroscopy, and diffusion tensor imaging. Renate is involved in neuroimaging research projects into cognitive control and brain maturation, schizophrenia, the prediction of transition to psychosis, and the shared biological basis of schizophrenia, and a genetically high risk population (22q11DS). Her strong translational approach also includes the creation of a normative database of electroencephalographically recorded sensory auditory memory function in children and adolescents with great potential as a tool for the detection of "at-risk mental state".*

### S22: Cognition And Connectomics

**Co-Chair: Alex Fornito, Monash University, Australia**

**Co-Chair: Michael Breakspear, QIMR Berghofer, Australia**

**Luca Cocchi, Queensland Brain Institute, Australia**

**Andrew Zalesky, University of Melbourne, Melbourne, Australia.**

**Olaf Sporns, Indiana University, USA**

**Michael W Cole, Rutgers University, USA**

#### Overview

Attempts to comprehensively map the constituent neural elements and interconnections of the brain—the so-called connectome—have spurred rapid advances in neuroimaging, with a plethora of methods now available for characterizing the macro-scale connectivity architecture of the entire cerebrum in unprecedented detail. These developments have caused a paradigm shift in cognitive neuroscience, with a major emphasis now being placed on understanding how cognition emerges from the functional integration of spatially distributed, functionally specialized neural systems. Traditionally, the bulk of imaging research into brain connectivity has focused on measurement of structural connectivity or functional interactions during task-free, so-called “resting-states”, although recent studies have begun to apply the tools of network science to map stimulus-evoked changes in brain functional network organization in order to understand the network determinants of cognitive processes. This symposium will provide an up-to-date introduction and overview of this field by examining basic concepts and techniques, their application to cognitive neuroscience experiments, and fundamental questions such as how brain function is constrained by network structure.

### S22 001: Transitory Networks Supporting Cognitive Control

**Luca Cocchi, Queensland Brain Institute, Australia**

The human brain is characterized by a remarkable ability to adapt its information processing based on current goals. This ability, which is encompassed by the psychological construct of cognitive control, involves activity throughout large-scale, specialized brain systems that support segregated functions at rest and during active task performance. Based on recent empirical findings, I will present a new account in which domain-general cognitive control functions rely on transitory changes in the patterns of integration and segregation between brain networks. Specifically, I will discuss how results from studies adopting cutting-edge analysis techniques allowing the characterization of task-based network interactions challenge current models of control functions that assume segregated or antagonistic activity of specialized brain networks. Finally, I will argue that the study of transitory task-based interplays between brain networks may be critical to understand the remarkable flexibility of normal control functions in health and its alterations in pathological conditions.

#### Biography

*Dr Cocchi was awarded a PhD in neuroscience at the University of Lausanne and Geneva (Switzerland) in 2007 and is currently a postdoctoral fellow at the Queensland Brain Institute (The University of Queensland, Australia). Dr Cocchi's current studies use new tools from systems neuroscience to characterize large-scale brain network interactions supporting cognition in health and disease.*

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S22 002: Connectomic Methods For Functional Imaging

**Andrew Zalesky**, University of Melbourne, Melbourne, Australia.

Connectomics is a technically challenging field, rapidly advancing and often perceived as inaccessible for these reasons. In this talk, I will present recent advances in mapping the human connectome using functional MR imaging techniques, with an emphasis on demonstrating how these advances can be used to understand the neural basis of human cognition. I will debunk some fallacies about the connectome, flag limitations and discuss future challenges in the field. Foremost, I will briefly introduce the key methods for mapping functional properties of the human connectome using functional MR data. I will specifically focus on approaches for identifying changes in brain connectivity that can be attributed to changing psychological contexts. I will then discuss methods for dealing with the associated multiple comparisons problem. Finally, I will present several applications where these techniques have been used to understand the dynamic nature of brain connectivity in human cognition.

#### Biography

*Andrew Zalesky is an honorary research fellow at the Melbourne Neuropsychiatry Centre (MNC) at the University of Melbourne, Australia. He currently holds the NHMRC Career Development Award. Previously he served as the inaugural Melbourne Neuroscience Institute Fellow (2012) and an ARC International Fellow. Dr Zalesky has developed internationally recognized methods for analyzing brain imaging data. These imaging methods have been applied to yield some of the first evidence of disrupted brain connectivity in schizophrenia and other psychiatric populations. His recent work identifying disrupted brain circuits in cannabis users received extensive media interest. He has published more than 60 peer-reviewed articles.*

### S22 003: How Brain Structure Constrains Brain Function

**Olaf Sporns**, Indiana University, USA

Numerous studies have shown that dynamic fluctuations of neural signals in the resting brain generate patterns of functional connectivity that exhibit characteristic topography and spatial patterns. When recorded over long time periods, for example with resting-state fMRI, these patterns of functional connectivity provide important information about the functional organization of intrinsic or resting-state networks. Resting-state networks are thought to be important components of the brain's functional architecture, and they have been shown to be differentially engaged in different tasks and modes of cognitive function and to exhibit significant variations across healthy individuals and across disease states. Hence, the generative mechanisms that shape functional connectivity patterns, including the topography of resting-state networks, are of great interest. In my talk I will survey empirical data that suggests an important role for structural brain networks (the connectome) in shaping and constraining endogenous and task-evoked neural dynamics. I will also provide examples of modeling approaches that further illuminate structure-function relations in the brain. These approaches include computational models of large-scale dynamic brain activity as well as analytic approaches for predicting functional connectivity based on measures of network communication.

#### Biography

*Professor Olaf Sporns is Provost Professor and Director of the Computational and Cognitive Neuroscience Group in the Department of Psychological and Brain Sciences, Indiana University, USA. He has been awarded Junior Faculty and Distinguished Faculty Awards from Indiana University's College of Arts and Sciences, and was recently awarded a John Simon Guggenheim Memorial Fellowship. Professor Sporns' research area is theoretical and computational neuroscience, with an emphasis on complex systems, brain connectivity, and neurorobotics. Over his career, Professor Sporns has authored 150 peer-reviewed publications as well as the recent books *Networks of the Brain* and *Discovering the Human Connectome*, both published by MIT Press.*

### S22 004: Multi-Task Functional Connectivity And Flexible Hubs

**Michael W Cole**, Rutgers University, USA

Brain networks are shaped by evolution and experience for the ultimate purpose of implementing cognitive functions. Resting-state functional connectivity (FC) has become a popular approach for characterizing brain networks, yet cognitive mechanisms cannot be directly inferred from information provided by resting-state FC. A recently developed approach – multi-task FC – provides a bridge between brain network dynamics and cognitive functions by identifying dynamic network properties that generalize across many task contexts. Multi-task FC involves graph theoretical characterization of changes in functional connectivity across dozens (e.g., 64) of task states. This new approach was used to test for the existence of 'flexible hubs' – brain regions with extensive brain-wide functional connectivity that updates depending on the task context. Flexible hubs were identified in the fronto-parietal control network, suggesting that flexible hubs facilitate flexible control of cognition via updating of brain-wide functional connectivity patterns. Further, the identified flexible hubs were highly active and updated their functional connectivity patterns during novel tasks, suggesting a mechanism for rapid instructed task learning in humans. These results provide insight into the role of highly dynamic network properties in facilitating highly dynamic cognition, with the potential for further insights to be gained by applying multi-task FC to other dynamic network properties and their relationship with other cognitive functions.

#### Biography

*Michael's research focuses on discovering the cognitive and neural mechanisms that make human behavior flexible and intelligent. This is accomplished primarily by characterizing functional brain connectivity using functional MRI and magnetoencephalography. Michael received his Ph.D. in neuroscience from the University of Pittsburgh, and received post-doctoral training at Washington University in St. Louis. He began as an assistant professor at Rutgers-Newark University in January.*

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S23: Formal Theories Of Dorsal Anterior Cingulate Cortex Function

**William H. Alexander**, Gent University, Belgium

**Mehdi Khamassi**, CNRS Paris, France

**Amitai Shenhav**, Princeton University, USA

**Chair & Speaker: Clay Holroyd**, University of Victoria, Canada

#### Overview

Dorsal anterior cingulate cortex (dACC) is one of the most studied neural systems in cognitive neuroscience yet an understanding of its specific function remains elusive. Evidence from multiple experimental methodologies militates against the development of a unifying theory, implicating dACC in roles as various as conflict monitoring, motivation of effortful behaviors, task maintenance, error prediction, and more. In this symposium we will discuss recent computational modeling efforts to elucidate dACC function. Presentations will reflect a range of approaches including neurobiologically-inspired models that account for detailed neurophysiological data, and more abstract or normative models that focus on explaining functional neuroimaging data and on behavioral impairments following brain damage. The theories propose a variety of different functions for dACC – meta-learning (Khamassi), predicting the outcomes of actions and signaling discrepancies between observed and predicted events (Alexander), evaluation and specification of appropriate control (Shenhav), and hierarchical control over effortful behavior (Holroyd) – but share in common a central role for dACC in the adaptive regulation of behavior. Together these efforts hold out the promise of reconciling the divergent views of dACC function within a unifying theoretical framework.

#### S23 001: E Cingulus Pluram: Multiple Computational Roles Of Anterior Cingulate Activity

**William H. Alexander**, Gent University, Belgium

Recent computational models of anterior cingulate cortex (ACC) have characterized the region as being involved in predicting the likely consequences of actions, and signaling surprising deviations from predicted outcomes. While these models are able to comprehensively account for activity observed within ACC from EEG, fMRI, and single-unit neurophysiology studies, it remains an open question what function the signal ultimately serves in regions of the brain receiving projections from ACC. Suggested roles for the ACC signal include behavioral inhibition and adjustment, attention shifting, selecting and maintaining options, modulation of associative learning rates, and several others. In this talk I describe current modeling work, building on the predicted response-outcome (PRO) model (Alexander & Brown, 2011), that investigates the role of the ACC signal from the perspective of hierarchical model-based reinforcement learning. First, in a generalization of the PRO model, we find that ACC activity reflects predictions of future states, as opposed to outcomes specifically, and signals surprising state transitions, suggesting that ACC activity may act as a model-based learning signal. In a second extension of the PRO model, we propose how ACC may interact with hierarchically-organized regions in lateral prefrontal cortex to train distributed representations of task-related error, and to select items to be maintained in working memory.

#### Biography

*Will Alexander is a research fellow at Universiteit Gent. His work investigates the neural bases of cognitive control and decision-making using a combination of computational modeling and fMRI. He received his degree in cognitive psychology and cognitive science at Indiana University, Bloomington, and completed a postdoctoral fellowship in the lab of Joshua Brown. His work is currently funded by the FWO-Flanders through a 5-year Odysseus II award.*

#### S23 002: Dorsal Anterior Cingulate Cortex And The Adaptive Regulation Of Reinforcement Learning Parameters: Neurophysiology, Model And Robotic Implementation

**Mehdi Khamassi**, CNRS Paris, France

To explain the high level of flexibility of decision making in primates, theoretical models usually invoke reinforcement-based mechanisms, performance monitoring functions, and core neural features within frontal cortical regions. However, the underlying biological mechanisms remain to be specified. In recent models, the regulation of exploration is based on meta-learning principles where exploratory actions are driven by varying a meta-parameter, the inverse temperature, regulating the contrast between competing action probabilities. Here we investigate how complementary processes between dorsal anterior cingulate cortex (dACC) and lateral prefrontal cortex (LPFC) implement decision regulation during exploratory and exploitative behaviors. Model-based analyses of unit activity recorded in these two areas in monkeys first revealed that adaptation of the decision function is reflected in a covariation between LPFC neural activity and the exploration level measured from the animal's behavior. Second, together with action values, ACC more prominently encoded a reflection of outcome history useful for regulating exploratory and exploitative decisions. Overall the data support a role of ACC in integrating reinforcement-based information to regulate decision functions in LPFC. We then deployed the model in a robot to test its ability to reproduce monkey behavioral performance in the real-world. A last experiment extends this to a human-robot interaction scenario where unexpected uncertainties are introduced by the human through cued task changes or by cheating. The robot could autonomously learn to reset exploration in response to such uncertain cues and events. The combined results provide concrete evidence specifying how prefrontal cortical subregions may cooperate to regulate decision making.

#### Biography

*After graduating from a French engineering school in 2003, Dr. Khamassi obtained a PhD in Cognitive Neuroscience from Université Pierre and Marie Curie in 2007. He spent a short period at Kenji Doya's lab at Okinawa Institute of Science and Technology, Japan. Then he pursued a postdoctoral work at INSERM in Lyon, where his work was at the interface between Emmanuel Procyk's neurophysiology team and Peter F. Dominey's modelling and robotics team. He is currently a tenured research scientist at the Centre National de la Recherche Scientifique in Paris, working on computational neuroscience models of behavioral adaptation.*

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S23 003: Anterior Cingulate Cortex And The Expected Value Of Control

Amitai Shenhav, Princeton University, USA

The dorsal anterior cingulate cortex (dACC) has been a near-ubiquitous presence in the neuroscience of cognitive control, and yet the functions it subserves are still under debate. Particularly common in this literature has been the finding that dACC tracks the strength of cognitive control required of a task based on current task demands (e.g., conflict), and influences how control is deployed. More recent work has extended these earlier findings to show that dACC also tracks the experienced cost associated with exerting cognitive effort, suggesting an additional role for this region in estimating not only how much control is necessary, but how much is worth exerting (given available incentives). It therefore remains an open question to what degree the dACC is responsible for the evaluation of both control strength and control costs, and the regulation of control itself, and how these functions relate to what is known about the dACC's role in tracking reward, punishment, and violations of expectation in the domain of motor actions. Building on previous models of cognitive control and action valuation, we offer a normative model of cognitive control that considers how both the type and strength of control is determined based on available payoffs and costs (including the cost of exerting control), similarly to how these calculations might be made when choosing motor actions. Within this framework, we suggest that a central function of the dACC is to determine and specify the optimal type and strength of cognitive control to engage at any given time.

#### Biography

Amitai Shenhav received his B.A. from UC Berkeley and his Ph.D. from Harvard University, and is currently a postdoctoral fellow at Princeton University, working primarily in the labs of Matt Botvinick and Jonathan Cohen. He studies the influence of automatic processes – including affective reactions and choice heuristics – on value-based decision-making. He explores the computational mechanisms and neural substrates underlying such decision-making in contexts ranging from relatively simple (e.g., object/product preference) to more complex (e.g., moral judgments). He currently focuses on how response automaticity considerations are integrated into decisions regarding the type and amount of cognitive control to engage.

### S23 004: Hierarchical Control Over Effortful Behavior By Dorsal Anterior Cingulate Cortex

Clay Holroyd, University of Victoria, Canada

Dorsal anterior cingulate cortex (dACC) and adjacent areas in medial frontal cortex are highly studied but poorly understood. Although current theories emphasize a critical role for dACC in cognitive control and decision making, none adequately explain the most salient consequence of dACC damage: decreased action production despite normal motor ability. Here we propose that dACC is a component of a multi-level hierarchy of brain areas involved in action selection. According to the theory, dACC integrates rewards across trials to learn the value of tasks, selects tasks for execution based on their learned values, and then allocates the level of control necessary for successful task performance by applying top-down control over a striatal mechanism for action selection. Because the deployment of control is assumed to deplete a conserved resource, dACC relaxes regulatory control over the striatum when events unfold smoothly and boosts control when they do not. Computational simulations of rodent behavior in several key maze tasks implicate caudal and rostral areas of midline prefrontal cortex in regulating physical effort and cognitive switch costs, respectively. This proposal accounts for the behavioral sequelae of dACC damage (impoverished action selection in the presence of normal motor ability), unifies many of the cognitive functions attributed to dACC (reward processing, decision making, and cognitive control), and provides a solution to an outstanding question in cognitive control research (how the control system determines and motivates what tasks to perform).

#### Biography

Clay Holroyd is a Professor of Psychology and a Canada Research Chair in Cognitive Neuroscience at the University of Victoria, Canada. He received a B.A. in physics and creative writing from the University of California, Santa Cruz (1991) and a PhD in neuroscience from the University of Illinois at Urbana-Champaign (2001). He subsequently worked for more than 3 years as a post-doctoral fellow in the laboratory of Jonathan Cohen at Princeton University. His research interests center on the role of anterior cingulate cortex in cognitive control, reward processing and decision making.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### S24: Prediction In Perception

**Co-Chair & Speaker: Robert P. O'Shea**, Southern Cross University, Australia

**Bradley N. Jack**, Southern Cross University, Australia

**Co-Chair & Speaker: Juanita Todd**, University of Newcastle, Australia

**Peter Keller**, University of Western Sydney, Australia

#### Overview

Do we make predictions from current sensory information about future sensory input? If so, what form do these predictions take? What are the brain mechanisms involved? Evidence that we do make predictions comes from wrong predictions: performance is reduced. There is a pattern of brain activity that is automatically recruited by prediction errors. What is not agreed is the form the predictions take—whether they simply involve down-regulation of the mechanisms, including memory mechanisms, encoding the current sensory input or whether there is an active process of constructing predicted inputs. The speakers will address these issues in audition and in vision. In both modalities regularities embedded in stimulus sequences are exploited to set up predictions about the what and the when of the forthcoming stimulus.

#### S24 001: We Make Predictions About Eye Of Origin Of Visual Input: Visual Mismatch Negativity From Binocular Rivalry

**Robert P. O'Shea**, Southern Cross University, Australia

The visual mismatch negativity (vMMN) is a negative deflection in an event-related potential (ERP) between 200 and 400 ms after onset of an unpredictable stimulus in a sequence of predictable stimuli. Binocular rivalry occurs when one image is presented to one eye and a different image is presented to the other. Although the images in the two eyes are unchanging, perception alternates unpredictably between the two images for as long as one cares to look. Binocular rivalry, therefore, provides a useful test of whether the vMMN is produced by low levels of the visual system at which the images are processed, or by higher levels at which perception is mediated. I will review research showing that a vMMN occurs when rival images are swapped between the eyes. This is interesting and important because we cannot tell which eye is viewing which image, showing that we make predictions about visual input of which we are not aware.

#### Biography

*Robert O'Shea obtained his PhD in Psychology from University of Queensland. He had postdoctoral positions at Queen's University at Kingston, Northwestern University, and Dalhousie University before taking a Lectureship at University of Otago. In 2009 he moved to Southern Cross University for the Professorship of Psychology. O'Shea's research has mainly been in the psychophysics of various forms of visual perception, particularly binocular vision, although recently he has turned towards EEG studies of visual consciousness and prediction. He has published 52 papers, 11 book chapters, and 14 editions of various books.*

#### S24 002: Prediction Of Vision From Invisible Stimuli

**Bradley N. Jack**, Southern Cross University, Australia

The human brain establishes predictive models encoding regularities in sensory input. For example, if we are stopped in a car at a traffic light and the indicator light of the car in front of us is blinking regularly, we form the prediction that it will continue to exist and to blink in the same way. Accordingly, we are not distracted by each blink of the indicator light, and we are able to attend to something else, such as a pedestrian crossing the road. However, when a prediction is violated (e.g., the indicator skips a blink), the predictive model has to be updated. An essential component of predictive models for visual information processing is that predictions are made even when objects are not consciously experienced (proto-objects). I review studies showing that the mismatch negativity (MMN; a well-established brain signature of prediction and prediction-error) can be elicited by prediction-violating stimuli that are invisible from binocular rivalry suppression. The MMN is essentially identical to that when the identical stimulus is visible during episodes of binocular rivalry dominance. This suggests that predictive models for visual information processing are established, tested, and updated similarly for objects (visible) and for proto-objects (invisible).

#### Biography

*Bradley Jack obtained his Bachelor of Psychology (First Class Honours) from Southern Cross University in 2010 and is in the final year of his PhD there. In 2012, he won a German Academic Exchange Service (DAAD) scholarship to travel to the University of Leipzig for three months to conduct an experiment. His research uses event related potentials to investigate conscious and not-conscious processing of visual information. In particular, he is interested in how the brain makes predictions about visual perception. His work is funded by an Australian Postgraduate Award.*

#### S24 003: When Auditory Mismatch Negativity Deviates From Simple Probabilistic Inference

**Juanita Todd**, University of Newcastle, Australia

When an acoustic sequence contains regularity, as few as 2-3 repetitions are sufficient for the auditory system to extrapolate that patterning within this sequence is likely to continue. If a subsequent sound fails to conform, a prediction-error signal known as mismatch negativity (MMN) is evident in auditory evoked potentials time-locked to the point at which the pattern-deviation occurred. An established assumption in research employing auditory MMN is that the underlying prediction process is reliant upon sensory memory. The strength of a perceptual inference (termed "predictive confidence") is weighted according to the precision in underlying estimates, and this confidence is proportional to amplitude of the MMN generated to a deviating event. This presentation will feature data from a series of studies suggesting that this weighting process may be: (a) subject to bias; and (b) sensitive to accumulation of evidence over periods that extend well beyond sensory memory limitations. The relevance of such observations will be discussed in relation to the potential impact in shaping the theory of how perceptual inferences are formed, modified and updated over time.

# SYMPOSIA OVERVIEW

## & SPEAKER ABSTRACTS

### Biography

*Juanita Todd completed a Masters (Clinical)/PhD at the University of Western Australia and is currently employed as a Senior Lecturer in Psychology, University of Newcastle. Dr Todd's research features the use of clinical, psychophysical and neuroimaging techniques to study differences in brain function in persons with schizophrenia. Her particular focus is using auditory sequences to study perceptual inference.*

*Her most recent contributions to the field include new protocols (developed for use in schizophrenia) that challenge existing theories of the mechanisms that underlie perceptual inference.*

### **S24 004: Neural Entrainment During Musical Rhythm Perception Is Correlated With Individual Differences In Temporal Prediction During Sensorimotor Synchronization**

**Peter Keller, University of Western Sydney, Australia**

The perception of temporal regularities in auditory rhythms is central to many human activities. In ensemble performance of music and dance, for example, the synchronization of movements and sounds is facilitated by the perception of a periodic beat. Electroencephalographic (EEG) studies measuring steady-state evoked potentials (SSEPs; i.e., peaks at specific frequencies in the EEG power spectrum) provide evidence for neural entrainment to the beat even in rhythms where sounds do not occur on each beat. This suggests that beat-related SSEPs partially reflect endogenous processes that may play a role in predicting the timing of upcoming sounds. The current study tested this hypothesis by examining relations between SSEPs in an auditory beat perception task and individual differences in temporal prediction in a sensorimotor synchronization task. SSEPs were measured in 15 individuals with various levels of musical training as they listened to two auditory rhythm patterns, one syncopated (tone onsets were not present on all beats) and the other unsyncopated (tones were present on all beats).

Participants were afterwards asked to tap the beat of the patterns. In a later session, the same individuals completed a finger-tapping task assessing the degree to which they predicted timing variations while synchronizing with tempo-changing auditory sequences. Results indicate that SSEP amplitude at the beat frequency was positively correlated with accuracy at tapping in time with the beat. Furthermore, while beat-related SSEPs were generally weaker for the syncopated than the unsyncopated pattern, the size of this difference was negatively correlated with temporal prediction abilities. These findings suggest that SSEP measures of neural entrainment to the beat reflect a mixture of exogenously and endogenously driven oscillatory processes, and that the endogenous component, in particular, supports temporal predictions that allow individuals to synchronize movements with the beat.

### Biography

*Peter Keller received degrees in Music and Psychology from the University of New South Wales in Australia. His research is aimed at understanding the behavioural and brain bases of human interaction in musical contexts. Peter has held research positions at Haskins Laboratories (New Haven, USA), the Max Planck Institute for Psychological Research (Munich, Germany), and the Max Planck Institute for Human Cognitive and Brain Sciences (Leipzig, Germany), where he led the Music Cognition and Action group from 2007 until 2012. He is currently an Associate Professor of Cognitive Science in the MARCS Institute at the University of Western Sydney.*

# ORAL PRESENTATION

## ABSTRACTS

### OP5: Motor, Social & Emotional Processes

**Aina Puce**, Indiana University, USA

**Tam Ho**, Max Planck Institute for Human Cognitive and Brain Sciences, Germany

**Simmy Poonian**, The University of Queensland, Australia

**Giacomo Novembre**, The Marcs Institute, University of Western Sydney, Australia

#### OP5 001: Neural Activity To Viewed Dynamic Gaze Is Affected By Social Decision

*Presented by: Aina Puce, Indiana University, USA*

Puce et al. (2000) reported larger N170s to gaze aversion in a passive viewing task, while Conty et al. (2007) described larger N170s to gaze change toward the subject in a social judgment task. We aimed to reconcile these studies by recording ERPs in two tasks in the same subjects. In a Social Task, subjects judged if a gaze transition moved Away or Toward them. In a Non- social Task, a gaze transition was judged as moving to the Left or Right. Continuous 256 channel EEG was recorded from 22 healthy adults viewing dynamic gaze stimuli in 6 conditions: (1) Direct to Extreme gaze [Dir-Ext] (2) Extreme to Direct gaze [Ext-Dir] (3) Intermediate to Extreme [Int-Ext] (4) Intermediate to Direct gaze [Int-Dir] (5) Direct gaze to Intermediate [Dir-Int] (6) Extreme to Intermediate [Ext-Int] Conditions (1) and (2) were from Puce et al. (2000), whereas (3) and (4) were a subset from Conty et al. (2007). Conditions (5) and (6) were not used previously. N170 peak latencies and amplitudes were calculated from two occipitotemporal 9-electrode clusters. Repeated measures ANOVAs were run for behavior and N170 latency and amplitude. Behavior: Subjects were faster in the non-social task, and more accurate for gaze aversions (non-social task). In the social task, faster RTs occurred for gaze transitions made toward subjects. ERP findings: In the non-social task, N170s were significantly larger for gaze aversions relative to gaze changes toward subjects. In the social task, this difference disappeared in the right hemisphere. The current study reconciled differences of two earlier studies. The brain's response to a gaze change depends on the decision being made. When not in a 'social' mode, the brain selectively responds (with a larger N170) to another's averted gaze. Operating in 'social' mode leads to larger N170s to gaze transitions toward the subject, suggesting that social context increases salience of direct gaze consistent with our behavioral data.

#### OP5 002: Re-Assessing The Pre-Attentive Nature Of Integrating Emotional Faces And Voices: An Event-Related Potential (ERP) Study

**Tam Ho**, Max Planck Institute for Human Cognitive and Brain Sciences, Germany

Research on emotional face-voice integration has been predominated by the hypothesis that facial and vocal emotional information interacts pre-attentively. We investigated this hypothesis using event-related potentials (ERP). Twenty-nine participants (15 female, 20–35 years old) were presented with congruent and incongruent combinations of angry and neutral facial and vocal expressions in an oddball paradigm. In 2 out of 4 blocks (1 block: angry voice;; 1 block: neutral voice), participants encountered congruent and incongruent combinations as standards (~80%) and deviants (~10%), respectively. Standards and deviants were then switched in the two remaining blocks. Participants were tested in 2 consecutive sessions. In Session 1, they watched the videos passively.

In Session 2, they were instructed to detect and respond when lip movement and voice onset were out of sync (that occurred in ~10% trials). Auditory evoked potentials elicited by deviants were inspected for a mismatch negativity (MMN) – an ERP component associated with pre-attentive deviance detection. Our results indicate that no MMN was elicited in either passive or active condition. Instead, we found effects of emotional face-voice incongruity in the auditory N1 and P2. This suggests that facial and vocal emotional information interacted early. The interaction was most robust in the passive condition when deviant stimuli captured involuntary attention. However, it weakened in the active condition, possibly due to task demand. Therefore, our finding refutes the above hypothesis. It shows that even early interactions of facial and vocal emotional information requires some degree of attention.

### **OP5 003: Neural Correlates Of The Attribution Of Agency For Self-Made And Others' Actions: The Role Of The Medial Portion Of The Anterior PFC In Attributing Expected Consequences To The Self**

**Simmy Poonian**, The University of Queensland, Australia

An important distinction to make is between the sense of agency we infer over own actions and consequences and those that are caused by other agents'. It is thought that the way in which we attribute causality over actions and effects involves a comparison between the expected and actual consequences of a goal-directed action. If this comparison matches, then consequences are attributed as being self-caused rather than caused by another agent. In particular, the neural correlates involved in the comparator model where actions are attributed to the self over another agent, are still to be fully understood in relation to automatic action-effect processing. In this experiment we examined the neural correlates of the comparator model during a task measuring sense of agency in our own and others' actions. By manipulating the expectation that a specific sensory consequence would occur after an action we compared the BOLD signal between trials where consequences were expected and presented and when they were not expected. It was found that the medial portion of the anterior PFC was more activated when consequences matched the expectation in self-made actions over the actions of others'. We conclude that this area is involved in the attribution that expected consequences are self-made rather than caused by another agent.

### **OP5 004: Functional Segregation Of Self And Other In Joint Action. A Dual-EEG Study With Piano Duos**

**Giacomo Novembre**, The Marcs Institute, University of Western Sydney, Australia

Real-time joint action requires the brain not only to integrate representations of one's own and other's movements, but also to maintain a level of autonomy between the two (segregation). This capacity for simultaneous integration and segregation was explored in a dual-EEG study in which pairs of pianists played complementary musical phrases under conditions where co-performers were familiar or unfamiliar with each other's part. We observed a suppression of alpha power (8-12 Hz) over centro-posterior scalp regions that varied as a function of interpersonal synchrony at the millisecond timescale. This suppression was: 1) stronger when interpersonal keystroke synchrony was high, 2) particularly when pianists were familiar with each others' parts, and 3) negatively correlated with indices of mutual adaptation and perspective taking (empathy). Thus, alpha suppression might constitute a neuromarker for the functional segregation (rather than integration) of self and other, determining the success of joint performance, cognitive autonomy and leadership.

### **OP6: Attention**

**Hannah Filmer**, The University of Queensland, Australia  
**Elexa St. John-Saaltink**, Radboud University Nijmegen, Netherlands  
**Nicholas Myers**, University of Oxford, UK  
**Oscar Jacoby**, The University of Queensland, Australia

### **OP6 001: tDCS Of Prefrontal Cortex Improves Multitasking**

**Hannah Filmer**, The University of Queensland, Australia

Making two decisions simultaneously typically leads to substantial performance impairments. Such impairments are thought to reflect a bottleneck in the mapping of sensory information to motor responses (Pashler, 1984, 1994;; Welford, 1952). Brain imaging studies have implicated the left posterior lateral prefrontal cortex (pLPFC) in response selection processes using single-task, dual-task and training paradigms (Dux et al., 2006, 2009;; Ivanoff et al., 2009). More recently, a study using transcranial direct current stimulation (tDCS) showed that the left posterior lateral prefrontal cortex (pLPFC) is causally involved in single-task response selection (Filmer et al., 2013). As yet, however, there is no causal evidence to implicate the left pLPFC in dual-task performance. Here, we used tDCS to test whether the left pLPFC is causally involved in completing two temporally overlapping tasks. Participants completed three sessions, and received nine minutes of anodal, cathodal, or sham stimulation in each. The behavioural paradigm consisted of two tasks, one auditory and one visual. Participants completed a mixture of single- and dual-task trials, where a sound, or an image, or both were presented. Participants responded to the relevant stimuli as quickly and accurately as possible in each of three sessions: before stimulation, immediately after stimulation, and 20 minutes later. For the single-task trials, both anodal and cathodal stimulation disrupted RTs, in line with the findings of Filmer et al. (2013). For the dual-task trials, however, only cathodal stimulation reduced reaction times immediately following stimulation. This reduction was not found for anodal or sham stimulation. Overall, the results confirm that the left pLPFC is causally involved in the central bottleneck that limits multitasking performance. The findings also suggest that response selection may vary for single- and dual-task responses, indicating a potential dissociation within the left pLPFC.

# ORAL PRESENTATION

## ABSTRACTS

### OP6: Attention cont'd

#### OP6 002: Task Demands Modulate The Effects Of Perceptual Expectations In Early Visual Cortex

**Alexa St. John-Saaltink**, Radboud University Nijmegen, Netherlands

Predicted stimuli often lead to a reduced neural response (Summerfield et al., 2008;; Todorovic et al., 2011;; Kok et al., 2012); however, it is unclear whether this suppressive effect of expectation is automatic (Den Ouden et al., 2009;; Alink et al., 2010), or rather requires attention (Larsson & Smith, 2012). To investigate this, we orthogonally manipulated spatial attention and perceptual expectation. To investigate whether the effects of expectation depend on perceptual and working memory (WM) resources, we included two different types of distracting tasks. We acquired fMRI data in 23 healthy human subjects. On each trial, a grating annulus surrounding a noisy, coloured letter at fixation was presented following a tone. Tones predicted the orientation of the upcoming grating with either 100% or 50% validity. Attention was manipulated per scanner run: participants responded to the spatial-frequency of the gratings (grating task) or performed one of two fixation tasks: a 1-back task on letter (perceptual task) or 2-back task on colour (WM task). The grating-evoked response in early visual cortex was strongest during the grating task, weakest during the perceptual task, and intermediate during the WM task ( $F(2,22) = 35.4, p < .001$ ). Task set determined whether predictions led to a suppression or enhancement of grating activity ( $F(1,22) = 5.03, p = .035$ ). During the perceptual task, activity was reduced when perceptual expectations about the grating were strong (100% blocks) versus weak (50% blocks). However, during the grating task, activity was increased with strong expectations. There was no effect of expectation during the WM task. Our results suggest that task demands modulate the effect of perceptual expectations on the response. The neural response to predicted stimuli is facilitated when stimuli are task relevant;; suppressed when they compete with task resources (perceptual task); and unaffected when they do not (WM task).

#### OP6 003: Temporal Expectation Improves Real-Time Decoding of Visual Feature Representations as Measured By Magnetoencephalography

**Nicholas Myers**, University of Oxford, UK

Temporal expectation is increasingly understood to improve the perceptual analysis of visual stimuli. Rhythms are arguably the most common source of temporal predictions of events. Recent evidence has shown that entrainment of sensory areas to rhythmic stimulus presentation improves perceptual gain of attended stimuli. However, it is unknown how this modulation occurs. One possibility is that temporal expectation improves perception by sharpening the neural representation of visual stimuli. Here, we tested this idea using magnetoencephalography (MEG) in combination with electroencephalography (EEG) and multivariate pattern analysis to see whether decoding accuracy improves when stimuli are presented rhythmically. We measured brain activity via combined MEG-EEG in 10 observers as they performed a visual target detection task. In regular rhythmic blocks, observers saw streams of oriented gratings appearing rhythmically at 1.54 Hz, and responded with a button press every time they saw the target orientation.

In irregular rhythmic blocks, stimuli were also presented at an average rate of 1.54 Hz, but individual stimulus onsets were temporally jittered around this average, reducing their temporal predictability. Target orientations could change from block to block. The orientation of each presented grating was decoded from the MEG and EEG data using a multivariate pattern analysis approach that capitalizes on the parametric nature of the orientation feature space via a forward encoding model. Orientations could be decoded robustly in a range between approximately 100 and 400 ms after stimulus onset ( $p < 10^{-5}$  in regular and irregular blocks). We found that stimulus decoding was significantly higher in regular blocks, compared to irregular blocks, beginning around 200 ms (175-225 ms,  $p = 0.035$ ), and lasting between approximately 200 and 400 ms ( $p = 0.019$ ). We conclude that rhythmic temporal expectation sharpens the neural representation of task-relevant visual features.

#### OP6 004: Interactive Effects of Task Set and Working Memory on Attentional Capture

**Oscar Jacoby**, The University of Queensland, Australia

When we search for objects with particular features, activity in brain networks is biased to preferentially process any objects possessing those features. Maintaining such biases, or attentional sets, may involve similar neural resources to those involved in working memory (WM). If so, taxing WM should reduce top-down influences on attentional capture. We used electroencephalography (EEG) to record brain activity while observers monitored dynamic stimulus streams at the midline for targets defined by a particular feature value (e.g., red), and ignored lateralized distractors. First, we replicated previous evidence for top-down modulation of attentional capture by demonstrating an enhanced N2pc component and slowed target responses when distractors possessed the target feature. We then investigated whether taxing WM reduces the effect of task set on attentional capture. A concurrent n-back task, which requires information to be maintained and manipulated in memory, eliminated the influence of task set by reducing the N2pc associated with task-relevant distractors. By contrast, a concurrent digit rehearsal task, which only requires information maintenance, did not change the effect on task set on the N2pc. Neither WM load manipulation affected the extent to which distractors slowed target responses. These results indicate that some – but not all – WM load manipulations compromise set-related biases associated with visual search for specific object features. The findings support the notion that WM and selective attention compete for common neural resources.