MINI SYMPOSIUM

2nd Mini Symposium on Cognition, Decision-making and Social function: Oxford-special

January 23 (Friday), 2015
13:30 – 17:10
1F Seminar Room, BSI Central Building

13:30-13:35 Opening

13:35-14:25
Bridging microscopic and macroscopic choice dynamics in prefrontal cortex
Dr. Laurence Hunt, Wellcome Trust Centre for Neuroimaging and Sobell Department of Motor Neuroscience, University College London

14:25-15:15
Neuronal networks for social cognition in primates
Dr. Jerome Sallet, Department of Experimental Psychology, University of Oxford

15:15-15:30 Break

15:30-16:20
Non-invasive measurement of population dynamics during computation of choice
Dr. Miriam Klein-Flügge, University College London / University of Oxford

16:20-17:10
Mesolimbic dopamine: reward prediction in action?
Dr. Mark Walton, Department of Experimental Psychology, University of Oxford

Host:
Hiro. Nakahara Lab for Integrated Theoretical Neuroscience

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Bridging microscopic and macroscopic choice dynamics in prefrontal cortex

Dr. Laurence Hunt

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The significance of prefrontal cortex for reward-guided choice is well known from both human imaging and animal neurophysiology studies. However, dialogue between human and animal research remains limited by difficulties in relating observations made across different techniques. A unified modelling framework may help reconcile these data. We have previously used attractor network models to demonstrate that varying decision values can elicit changes in local field potentials (LFP) dynamics, causing value correlates observable with human magnetoencephalography (Hunt et al., Nature Neuroscience 2012). Extended, hierarchical forms of such models can also predict human functional MRI signal in different frames of reference during a multi-attribute decision process (Hunt et al., Nature Neuroscience 2014). In light of this framework, we have recently sought to relate simultaneously recorded LFP and single-unit data from prefrontal cortex of macaque monkeys performing a cost-benefit decision task. By performing principal component analysis of unfiltered LFPs timelocked to choice, components emerged that resembled the main choice-related LFP signature (PC1) and its temporal derivative (PC2). PC1 thus indexes LFP event-related *amplitude*, but crucially PC2 indexes its *latency*, reflecting the speed at which choice dynamics occurred on each individual trial. We found PC1 scores were correlated with overall value sum: the *inputs* of a decision process. PC2 scores, however, were correlated with chosen (but not unchosen) value: the *outputs* of a decision process. To relate LFP dynamics to single unit activity, we regressed single-trial PC1 and PC2 scores onto simultaneously recorded single-unit firing rates. PC2, indexing the *internal latency of each individual choice*, predicted single-unit activity in nearly half of all recorded units – in particular those cells that showed a value-to-choice transformation. Similar results could be found by principal component decomposition of the attractor network model. These results provide a novel bridge between LFP single-trial dynamics and simultaneously recorded single-unit activity. Perhaps more significantly, it allows us to relate value correlates in human neuroimaging studies to their cellular origins.

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Neuronal networks for social cognition in primates

Dr. Jerome Sallet

Department of Experimental Psychology, University of Oxford

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To social species such as primates, the ability to use social information is essential to gain access to valued resources such as food or a sexual partner. We can compete or cooperate with others but at the core of our daily social interactions is our ability to learn information from and about others to guide our decisions. Facial expressions, for example, are used to infer others' feelings that in turn helps us to predict their behaviours. The problem becomes even more complex if others convey deceiving information. How do we learn the value of information provided by other social agents? How do we then use our social knowledge to guide our decisions? Impairment in socio-cognitive abilities is a key feature of many neurological and psychiatric disorders that impact not only on the patients and their families but also impose a huge financial cost on society. Understanding the neural basis of normal neurocognitive functioning is a prerequisite for any treatment for disorders that affect socio-cognitive abilities.

Using neuroimaging tools I will present results showing experienced-induced structural and functional plasticity in the macaque brain that follow a manipulation of the animals social environment. Importantly changes in gray matter volume or in the degree of functional coupling between brain regions were only observed in a limited set of brain regions that we identified as a precursor of the human social brain, i.e. a set of brain regions known for processing social information. I will present comparative resting state fMRI studies in macaques and humans that showed that areas of the social brain, which are thought to be unique to the human brain, such as the medial prefrontal cortex (MPFC) or the temporo-parietal junction (TPJ) have counterparts which, although not identical, have similar connectivity profiles in macaques. Finally I will show that structural and functional variations in subcortical and cortical regions have important implications for the animal social life. Social status is an important feature of group life in many primates. Position in the dominance hierarchy influences access to food and mates, and is correlated with both general and mental health. I will present results showing that two neural circuits that appear to have a relatively simple and direct relationship with social status—one circuit that includes notably the raphe nucleus and the amygdala in which gray matter volume tended to be greater in socially dominant individuals and a striatal circuit in which gray matter volume was greater in those with a more subordinate social position. Social status in male macaques depends not only on successful engagement in agonistic behavior but also on success in forming social bonds that promote coalitions. I will show that gray matter relates to both social status and social network size in a neural circuit that includes notably prefrontal and temporal cortex. This circuit may mediate the way in which dominance is dependent on social bond formation, which is in turn dependent on social cognition.

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Non-invasive measurement of population dynamics during computation of choice

Dr. Miriam Klein-Flügge

University College London / University of Oxford

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One key advance in the way neuroscientists study neuronal computations was caused by a recent shift from studying individual neuronal responses towards studying neuronal population dynamics. Changes in firing rates of a neural population can be thought of as a trajectory through a high-dimensional state space, and movement along trajectories in this 'state' space can reveal the neural computations this population of neurons is performing. We developed a novel approach for similarly examining ongoing computations of neural populations using non-invasive neuroimaging in humans. Decisions were made about the colour or motion of a random-dot stimulus (compare Mante et al., Nature, 2013). We used magnetoencephalography (MEG) to record the magnetic fields produced by the summed neural activity of large populations of neurons with a high temporal precision. We selectively manipulated the neural populations of interest using repetition suppression. Each random dot stimulus ('test stimulus') was preceded by another random dot stimulus ('adaptation stimulus'), which determined the population of neurons that would be 'primed' and thus the feature of the choice – colour, motion, or response – that was selectively suppressed in the neuronal population. By comparing situations where adaptation and test stimuli were the same versus different in either their inputs or their responses, we could then examine rapid transitions in neuronal representations during the decision computation. This revealed that responses in premotor cortex first suppressed to the relevant input and only later to the response. Plotting this input suppression directly against the response suppression revealed a 'suppression' trajectory that first deflected in the direction ('axis') of decision input and later response. This trajectory closely resembled the state-space population trajectories obtained from direct recordings in the prefrontal cortex of monkeys performing the same task (Mante et al.). Thus, our combined repetition suppression and MEG approach allows a time-resolved study of the computations of populations of neurons using non-invasive measurements obtained in humans.

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Mesolimbic dopamine: reward prediction in action?

Dr. Mark Walton

Department of Experimental Psychology, University of Oxford

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It is widely held that the activity of many dopamine neurons encodes a quantitative reward prediction error, which can act as a teaching signal to represent and update predictions of future rewards. A largely separate literature has also implicated striatal dopamine transmission as critical for driving behavioural responses and action initiation. However, to date, the precise relationship between dopamine release, reward prediction, movement and economic choice remains ambiguous. I will discuss a series of ongoing electrochemistry studies in rats where we monitor sub-second dopamine release dynamics directly in the striatum as they make or withhold responses to attempt to understand the relationship between rapid changes in dopamine, net value and movement.

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