ORAL SESSION: Brain states of awareness & consciousness

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Oral Sessions

Presentations

Connectome Harmonic Signatures of Consciousness in Anaesthesia and Disorders of Consciousness

Harmonic patterns, ubiquitous in various natural phenomena, have recently been shown to reveal the functional networks of the human brain when applied to the structural connectivity of the human brain (Atasoy, Donnelly, & Pearson, 2016). Crucially, these harmonic modes of human brain's structural connectivity – termed connectome harmonics – provide an extension of the well-known Fourier basis to the human connectome. Hence, connectome harmonics allow for representing any pattern of cortical activity derived from functional MRI in terms of a combination of oscillatory modes with different frequencies, i.e. connectome harmonics (Atasoy, Deco, Kringelbach, & Pearson, 2018). Previous work has shown that the connectome-harmonic decomposition can identify consistent signatures of altered states of consciousness induced by the classic psychedelics LSD and psilocybin. Specifically, these states are characterised by reduced energy of low-frequency connectome harmonics, accompanied by increased energy of high-frequency harmonics (Atasoy et al., 2017; Atasoy, Vohryzek, Deco, Carhart-harris, & Kringelbach, 2018). Here, we set out to investigate the connectome harmonic signatures of other altered states of consciousness – namely, loss of consciousness due to anaesthesia, and disorders of consciousness arising from brain injury. In the light of the entropic brain hypothesis of consciousness (Carhart-Harris, 2018; Carhart-Harris et al., 2014), which postulates that loss of consciousness and the psychedelic state occupy opposite ends of a continuum, we hypothesised that the alterations of connectome harmonics in loss of consciousness would exhibit the opposite characteristics of that observed under the effects of psychedelics.

Presenter

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Reconfiguration of network hubs under anesthesia may predict recovery of consciousness

Despite major advances in our understanding of the neural mechanisms of consciousness, clinical assessments still result in the misdiagnosis of disorders of consciousness (DOC) in up to 40% of unresponsive patients. Recent studies have shown that the complexity of cortical response to a direct perturbation of the brain network through transcranial magnetic stimulation provides a reliable index of the brain's capacity for consciousness. Moreover, network neuroscience has shown that a healthy brain adaptively reconfigures its functional network under anesthesia, maintaining a critical state that enables it to regain consciousness post-anesthesia. In healthy individuals, anesthesia induces an anteriorization of alpha network hubs. In this study, we hypothesized that the capacity for this reconfiguration of brain network hubs under anesthesia would be indicative of the brain's ability to support consciousness. In order to test this hypothesis, we applied graph theoretical analysis to high-density electroencephalography (EEG) data recorded in waking, anesthetized, and recovery states in patients with DOC.

Presenter

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Ketamine's influence on global rs-fMRI and individual variation in neuro-behavioral relationships

Ketamine, a nonspecific NMDA receptor antagonist, induces a broad range of "schizophrenia-like" symptoms at sub-anesthetic doses in healthy adults, as well as having clinical utility as a rapid-acting therapeutic for treatment-resistant depression (Krystal et al., 1994; Murrough et al., 2013). Neurally, ketamine has widespread effects on functional connectivity (Anticevic et al., 2012). However, no study to date has extensively characterized the effects of ketamine on brain-wide functional connectivity of neural systems at the network- and parcel-level, or how these neural effects are related to individual variation in changes in symptoms. To address this question, we first examine the group-level brain-wide dense and network-level global brain connectivity (GBC) effects of ketamine. We then explore relationships between individual symptom and neural variation in response to ketamine, using the Neuro-Behavioral Relationships In Dimensional Geometric Embedding (N-BRIDGE) framework (Ji et al., 2019b). Finally, we use N-BRIDGE to test the hypothesis that the effects of ketamine vary similarly to the Brain-Behavior Space (BBs) of the clinical psychosis spectrum.

Presenter

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Non-REM Sleep Network Connectivity Represents an Altered, Not a Reduced State of Consciousness

Resting state network (RSN) functional connectivity (FC) has been evaluated for a number of compromised and non-wakefulness states, including sedation (Boveroux, 2010), the vegetative state (Boly, 2009) and sleep (Larson-Prior, 2011). These studies suggest that reduced states of conscious awareness are associated with a reduction in the magnitude of RSN FC, particularly for "higher-order" RSNs such as the default mode network (DMN, Heine, 2012). Further, higher-order RSNs have been associated with executive cognitive functions such as task shifting (Reineberg, 2015). Thus, RSN FC configurations provide a useful tool for profiling both consciousness and higher-order cognitive activity. However, RSN FC in sleep is the least well understood, due to the paucity of fMRI data acquired during rapid eye movement (REM) and slow wave sleep (SWS). These sleep stages are accompanied by dramatic changes to the electrophysiological milieu of the brain. Nonetheless, it remains to be determined how these systems-level changes are reflected changes to RSN FC, and, by association, alterations of higher-order cognitive activity and consciousness.

Presenter

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Canada

The impact of sleep deprivation on cortical functional integration and cognition.

Sleep deprivation (SD) is associated with impaired cognitive functioning and vigilance. However, the mechanisms of brain activity underlying the cognitive impact of sleep deprivation remain unclear. Functional connectivity of BOLD activity during tasks can provide insight into how the disruption of the integration of functional brain networks may impact cognition.

Presenter

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Predicting depth of sedation from latent structure in whole-brain cortical networks

Changes in brain activity under general anesthesia have been used to probe the neural correlates of unconsciousness and unawareness (e.g. Hutchison, et al. 2014; MacDonald et al., 2015). In recent years, resting-state fMRI in particular has proved fruitful in probing changes in whole-brain network structure under varying depths of anesthesia. Here, we studied resting state functional connectivity (RSFC) in Macaque primates under varying doses of isoflurane, with a view towards characterizing dose related changes in RSFC structure, as well investigating the feasibility of predicting depth of unconsciousness from resting-state brain activity.

Presenter

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