Functional Roles of Cross-Frequency-Coupling

Organizer: Virginie VAN WASSENHOVE

Room: # 104

Date and Time: Tuesday, October4 / 17:00-18:30

Functional Roles of Cross-Frequency-Coupling in the Neurosciences of Cognition

Cross-frequency-coupling (CFC) is used generically to indicate the inter-dependencies between low-frequency oscillations and high-frequency neural activity. Different types of oscillatory coupling have been reported and MEG is one of the best techniques to provide non-invasive characterization of CFC. This symposium aims to illustrate the possible implications of CFC in neurosciences, highlighting both state-of-the art techniques and up to date thinking on the role of CFC in perception and cognition.

Speakers:

- **Ole Jensen** (Donders Univ., The Netherlands)
  "Cross-frequency interactions route sensory information to working and long-term memory"

  Several MEG, ECoG, and monkey studies have demonstrated that the phase of alpha oscillations are coupled to gamma band activity. Importantly, we have shown that alpha oscillations in deeper layers relate to gamma activity in more superficial layers (Spaak et al., 2012, Curr Biol). In a set of MEG studies we have invested how the cross-frequency coupling relates the encoding of working and long-term memory. The working memory study showed that high alpha power is associated with weaker gamma power at the trough of the alpha cycle (Bonnefond and Jensen, 2015, PLOS One). This effect was enhanced prior to the suppression of distractors. The long-term memory study revealed that in anticipation of items to be remembered, alpha power decreased while the cross-frequency coupling increased (Park et al., submitted). A measure of directionality between alpha phase and gamma power (Jiang et al., 2015, Neuroimage) predicted the individual ability to encode memory: a relatively stronger control of alpha phase over gamma power was associated with better memory. In sum, these findings demonstrate that gating of visual information to memory is reflected by the cross-frequency interaction between alpha and gamma activity.

- **Markus Siegel** (Univ. of Tuebingen, Germany)
  "Large-scale cross-frequency phase-amplitude coupling in the mammalian brain"

  Phase-amplitude coupling between different neuronal oscillations has been implicated in neuronal coordination and encoding, but direct evidence remains sparse. I will discuss electrophysiological studies investigating this in awake behaving rats and monkeys during different visuomotor behaviors. Cortiostriatal phase-amplitude coupling in awake behaving rats suggests that neuronal coordination through coherent phase-amplitude coupling may be a general mechanism to regulate neuronal interactions between different brain regions. Furthermore, functionally specific phaseamplitude coupling along the visuomotor pathway of awake behaving monkeys suggests that large-scale phase-amplitude may establish a temporal scaffold for corticocortical interactions during spatial working memory.

- **Bernadette Van Wijk** (Univ. College, London, UK)
  "Phase-amplitude coupling: the bad guy in movement disorders?"

  Current theories suggest that phase-amplitude coupling may support cognitive functions in the healthy brain. By contrast, high-levels of phase-amplitude coupling have been found in patients with Parkinson's disease, implying that it could also impede normal functioning. Here I will present our experimental findings showing that the strength of phaseamplitude coupling between beta and high-frequency oscillations correlates with severity of motor impairment. As high-frequency oscillations typically show a movement-related increase in amplitude, this could mean that increased locking with beta band phase may hamper movement initiation. Our data set omprised an extensive number of local field potential recordings from deep brain stimulation electrodes implanted in the subthalamic nucleus. While others have also reported increased phase-amplitude coupling in ECoG recordings above motor cortex in Parkinson's patients, I will discuss the challenges we are facing to replicate this with MEG due to lower signal-to-noise levels and the multiple comparisons problem. This will trigger the debate on the appropriate use and interpretation of cross-frequency coupling measures in studying oscillatory dynamics.

- **Brett Foster** (Stanford Univ., USA.)
  "Slow fluctuations of high frequency activity reveal intrinsic network structure in human cortex"

  Spontaneous neural activity has historically been viewed as ongoing background noise, which is to be removed through experimental design and data analysis. However, over the past decade, growing evidence from human neuroimaging supports the view that spontaneous neural activity contains structured patterns that reflect the putative organization of functional networks. To explore the electrophysiological correlates of these intrinsic dynamics, we utilized intracranial recordings to study the spatio-temporal properties of spontaneous and evoked activity in the human parietal cortex. During conditions of memory retrieval subregions of the medial and lateral parietal cortex displayed increased high-frequency activity, consistent with a wealth of human neuroimaging data. In addition, we studied the spontaneous covariation of highfrequency activity across parietal cortex during resting and sleeping states. We observed that slow fluctuations (<1Hz) of spontaneous (rest & sleep) high-frequency activity recapitulated network patterns observed during memory retrieval. This covariation was also shown to closely match the network organization observed with resting state fMRI in the same subjects. These observations highlight clear electrophysiological correlates of spontaneous network patterns in resting state neuroimaging data, and link into a wide literature associating spontaneous and evoked neural dynamics.