Multimodal Windows on Spontaneous Brain Activity

Organizer: Louis Lemieux

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MEG, EEG and fMRI at Rest: Complementary Windows on Spontaneous Brain Activity
MEG and EEG signals are both generated by primary currents within local cortical neuron populations, whereas fMRI is usually interpreted as a marker of neural function. The studies presented will show that neural and BOLD responses are two distinct measures, which can when brought together provide a more global picture of brain activity. PET and fMRI studies revealed the existence of resting-state networks, that can be relatively easily identified in individuals but remain difficult to interpret in relation to neural function. The relationship with EEG and MEG rhythms recorded during rest should therefore lead to a better understanding of these phenomena. An overview will be presented of some key findings on resting-state activity in healthy and diseased brains with special emphasis on the complementarity of various modalities, brought together through data fusion and computational modelling.

Speakers:

- **Seppo P. Ahlfors** (Massachusetts General Hospital / Harvard Medical School, USA)
"Complementary properties of MEG, EEG, and fMRI"

  Functional MRI is well suited for localization and connectivity analyses of brain activity, including resting state networks of functionally connected areas. MEG and EEG provide powerful means for characterizing cortical activity in terms of dynamic patterns of activity, such as transient and oscillatory time courses, functional and effective connectivity, and cross-frequency coupling. For the interpretation of MEG and EEG data, however, partial cancellation of signals from simultaneous source currents is a challenge, in particular when compared or combined with fMRI data. Cancellation takes place at multiple spatial scales: at the level of synaptic and dendritic currents, local neuron populations, sulcal and gyral folding, and large-scale networks of cortical areas. The last two are perhaps of most interest in resting state analyses. At each level, different types of computational modeling are needed. For data fusion, MEG and EEG can be directly combined for estimating common sources, i.e., the primary currents. In contrast, the fusion of MEG/EEG with fMRI generally requires a model for neural activity from which both the primary current distribution and the hemodynamic effects can be derived. The complementary properties of MEG/EEG and fMRI suggest that combining data has the potential to enhance the characterization of brain processes.

- **Diego Vidaurre** (Univ. of Oxford, UK / Aarhus Univ., Denmark)
"Large-scale resting-state networks: complementary views from different modalities"

  When we are engaged in a task, our brain recruits circuits of regions that are specialised. Strikingly, many of the networks of activity that we find in the brain in task are also observed at rest. The role of these coherent patterns of activation in unconstrained cognition has been speculated to relate to memory consolidation, planning and imagination. fMRI studies reveal the existence of these robust resting-state networks (RSNs) with very slow signatures (<0.1Hz). More recently, these networks have been also observed using MEG, seeming to indicate that resting-state fMRI connectivity is closely related to correlated modulations in the power (or amplitude) of alpha and beta-band oscillations captured with MEG. Computational modelling can offer valuable insights on this relationship.

Both fMRI and MEG offer a different view on this kind of activity, and we need methods to leverage the advantages of each modality to identify RSN at the finest possible spatial and temporal resolution. I will discuss here some of these methods and will offer hints of their interpretation with respect to behaviour.

- **Pauly P.W. Ossenblok** (Kempenhaeghe&Maastricht UMC+; Eindhoven Univ. of Tech., The Netherlands)
  "MEG vs EEG correlated functional MRI in epilepsy research"

  In general it is assumed that the spatiotemporal characteristics of the activity underlying interictal epileptic discharges (IEDs) can be described by a network of brain regions as identified by either EEG, MEG or EEG correlated fMRI (EEG-fMRI) and the interactions of these regions. EEG-fMRI may yield a more realistic estimate of the spatial distribution of these epileptic networks, whereas MEG tends to localize the region within this network which is responsible for the epilepsy of the patient.

  The results of these modalities will be discussed for patients who were candidate for epilepsy surgery and who underwent pre-surgical invasive recordings, i.e. either subdural grid or depth electrode EEG recordings. Network analysis is applied to evaluate whether EEG-fMRI correlation patterns indeed consist of interacting highly correlated brain regions which reflect the onset (‘hub’) and the propagation of the IEDs. For comparison, modelling of the network underlying the invasively recorded IEDs using the same analysis framework reveals the brain regions involved and their interactions. It will be evaluated whether the ‘hub’ of the epileptic network has additional value compared to interictal MEG with regard to the ability to identify the region within the network that is responsible for the epilepsy of a patient.