What can functional connectivity tell us about mechanisms of brain function?

Monday, Jun 18: 8:00 AM - 9:15 AM
1880
Symposium
Monday - Symposia AM

Functional connectivity (FC) analyses have been applied to virtually all functional brain imaging modalities. They are frequently used in fundamental research to study large-scale neuronal communication, as well as in clinical and translational research aimed at characterizing the neural underpinnings of neurological diseases and psychiatric illness. Despite its importance in the field, there remains much debate over how, and to what extent, these findings can be interpreted with respect to the underlying neural mechanisms of brain function. This disagreement may largely be attributable to a lack of rigorous definition for the term, which is important for constraining what inferences can, and cannot, be drawn from a particular FC finding. The goal of this symposium is to outline a conceptual framework for defining FC in a standardized way, applicable regardless of a specific statistical method or imaging modality. Symposium speakers will discuss this topic in the context of their own research, and interaction between speakers, panel members, and community members in the audience will be encouraged. It is our hope that this discussion will help facilitate consensus on two major questions: “What precisely can (and cannot) be inferred from a given FC measure?”; and “How do we go from FC observations to mechanistic interpretations?”. The symposium speakers will address these questions from different methodological backgrounds (fMRI, M/EEG and electrophysiology).

Objective

1. To understand how interpretations from functional connectivity measures should be constrained by methodological limitations and inherent confounds
2. To understand how functional connectivity approaches can be used to help elucidate the neural mechanisms of brain function
3. To understand how the integration of functional connectivity results across multiple modalities can be used to support more direct inferences about the neural mechanisms of brain function

Target Audience

Any researcher who uses, or is interested in using, functional connectivity methods for their investigations should find this symposium informative and useful for future research. This includes cognitive, clinical, and theoretical neuroscientists.

Co Organizer(s)

Michael Cole, Rutgers University
Linda Geerligs, Donders Institute, Radboud University
Daniele Marinazzo, Ghent University

Organizer

Andrew Reid, Donders Center for Cognition

Presentations

Estimation of large-scale network synchronization from MEG /EEG data (index.cfm?do=ev.viewEv&ev=1655)

Functional connectivity (FC) in the form of neuronal synchronization (i.e., oscillatory phase-phase coupling) or amplitude correlations are frequently estimated from EEG and MEG data. Yet, field spread and source mixing

confounds the FC analysis in the MEG and EEG sensor space. Hence, MEG and EEG sensor space connectivity estimates can't be used to reveal true network FC in the human brain. These confounds can be alleviated when using source reconstructed MEG/EEG data. Even then, some signal and source mixing remain as a confound in the FC analyses. Different connectivity metrics and data analysis approaches can be used to alleviate this problem. I will talk about the effects of signal / source mixing on connectivity measures, how they can alleviated and what we have to know when interpreting MEG/EEG connectivity data. I will further discuss our recent results obtained with data-driven all-to-all connectivity analyses (synchronization across all brain regions), which show that large-scale network synchronization is correlated with and predicts performance in visual attention working memory, and sensory perception tasks.

Presenter

Satu Palva, University of Helsinki

Resolving ambiguities in functional connectivity (index.cfm?do=ev.viewEv&ev=1656)

Correlation and covariance are ubiquitous measures for assessing the similarity of signals in science, and how these relations change across different contexts. For functional brain imaging, they underpin analyses of functional connectivity, which are intended to reveal aspects of the structure of neural interactions. These approaches have been central for characterising imaging data, and are important for guiding the design and interpretation of biophysical models of large-scale neural dynamics. However, these measures, and many derived from them, are sensitive to a wide variety of changes in signal properties, which can profoundly limit the insight that these analyses provide. In this talk I will review the ambiguities of functional connectivity measures, and describe methods and strategies that may allow more reliable and interpretable characterisation of neural activity and interactions.

Presenter

Eugene Duff, Oxford University

Neural correlates of dynamic functional connectivity measures (index.cfm?do=ev.viewEv&ev=1657)

As most fMRI studies of functional connectivity are done during the "resting state," without a stimulus or task acting as a controlled variable, it is difficult to determine whether observed changes are physiologically meaningful. This is exacerbated in studies of dynamically changing functional connectivity, as the number of measurements increases and many non-physiological factors (motion, signal loss, etc.) can cause correlated changes over time across the brain. Multi-modal studies combining neural electrophysiology and fMRI in animal models can provide strong evidence for common underlying mechanisms between fluctuations in neural electrical activity and fluctuations in functional connectivity. However, these studies also suggest that multiple underlying mechanisms exist in the neural activity which are combined in functional connectivity measures. Hypothesis-driven work, especially in animal models, has begun to target both macroscopic connections, such as the corpus callosum, and cellular mechanisms, such as mitochondrial calcium function, which impact functional connectivity.

Presenter

Garth Thompson, ShanghaiTech University

Functional connectivity in human electrophysiological recordings (index.cfm?do=ev.viewEv&ev=1658)

Most functional connectivity studies investigate connectivity over a longer time range which is not necessarily representative of the actual time-scale at which neural events occur. With invasive animal recordings it was shown that sub-second neural events such as ripples from the hippocampus lead to the formation of fMRI networks. However, even where such invasive recordings are possible in human patient populations undergoing neurosurgery, they cannot be combined with fMRI recordings due to safety concerns. Therefore, one can use standalone local field potential (LFP) recordings or combine them with electrophysiological recordings from EEG or MEG. Pure LFP studies in humans are not entirely satisfactory as they usually only cover a small brain area and thus only allow studying local functional connectivity. Recent studies combining MEG and LFP recordings in Parkinson patients have yielded insights on functional connectivity in different frequency bands and thereby allow for electrophysiological interpretations of brain networks. Within this talk, I will discuss the potential of human LFP recordings and combined MEG-LFP to investigate functional connectivity at a local and global level using a temporal resolution commensurate with actual neural activity.

Presenter

Esther Florin, Heinrich Heine University Düsseldorf