The Dynamic Human Brain

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Brain activity is intrinsically dynamic, whether at rest or on task. Although the term “dynamic” is used broadly in the current literature, there are many different dimensions of dynamic processes that require careful definition and differentiation to enable (1) a comprehensive view of measurable brain dynamics, and (2) optimal resulting theoretical development and integration. In one key dimension, it has become increasingly apparent that the structure of intrinsic functional networks changes dynamically from moment to moment (on msec and sec scales), and relates to cognition and disease. Thus, long held assumptions about network stationarity are under increasing scrutiny. Importantly, network dynamics are often calculated after time series normalization, effectively and intuitively removing the influence of the magnitude of these variations across moments so that subjects can be compared. However, a bourgeoning body of work on the importance of amplitude fluctuations provides a complementary second dimension of dynamics; both node- and network-based brain signal variability/complexity magnitudes themselves have important functional implications for cognitive performance, development, aging, and disease. Thus, brain dynamics can emerge across a number of theoretically and mathematically separable dimensions, but these are rarely examined simultaneously in the literature.

In particular, our four confirmed speakers will present their latest results on how brain dynamics relate to (a) physiological measures; (b) the relationship between EEG and fMRI; (c) fluctuation amplitudes of dynamic brain signals as information-carrying measures that relate to neurotransmission, age, cognition, and connectivity; and (d) how we can identify “atoms” of dynamic functional connectivity as either states or building blocks. This body of work argues that the various dimensions of non-stationarity of brain signals should not be ignored, and importantly, highlights new challenges for analysis and interpretation of dynamic brain data.

Learning Objectives:

1. Understand the various emerging approaches in the study of functional brain dynamics, and how they complement each other.
2. Recognize the functional and predictive implications of brain signal dynamics across task types, cognitive domains, and developmental and clinical groups.
3. Appreciate the various definitional and computational constraints when examining brain dynamics.

EEG and physiological correlates of resting-state fMRI connectivity dynamics
Catie Chang, NINDS/NIH, Advanced MRI section, LFMI, Bethesda, USA

Multivariate methods for characterizing variability in spatial and temporal connectivity among intrinsic brain networks
Vince Calhoun, The Mind Research Network and UNM, ALBUQUERQUE, NM, USA

Bring the 'noise:' Variability as 'signal' in the human brain
Douglas Garrett, Center for Lifespan Psychology, Max Planck Institute for Human Development, Berlin Germany

Decomposing dynamic functional connectivity: states or building blocks?
Dimitri Van De Ville, UniGE/EPFL, Lausanne, Switzerland