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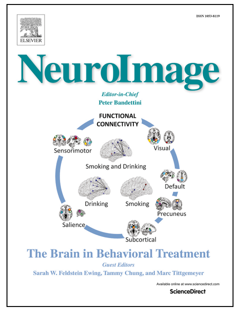

Mapping and interpreting the dynamic connectivity of the brain

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Mapping and interpreting the dynamic connectivity of the brain

The brain's complex, multi-scale activity assesses external input, regulates internal physiology, gives rise to cognition and enables every conceivable behavior. Our efforts to understand this most critical organ often simplify activity in space or in time, or in both. For example, a number of localized, specific neural circuits have been characterized at the cellular level using staining and recording technology. At significantly larger spatial scales, neuroimaging methods have identified distributed networks of brain areas within and across which population-level activity is persistently coordinated. This long-range coordination is termed functional connectivity, and the resulting functional networks have typically been identified from a rather static perspective, based on activity averaged over long time-scales. However, in recent years, tools to acquire and analyze time-resolved network activity throughout the whole brain have begun to appear, allowing a new perspective on dynamic brain activity at a systems level. This special issue of NeuroImage is devoted to the characterization of the dynamics of brain connectivity and networks using noninvasive neuroimaging methods including MRI, MEG and EEG.

Dynamic Graphs

One of the challenges in dynamic analysis of neuroimaging data is how to handle the explosion of data that results. One promising approach is provided by graph theory, a framework in which the brain's functional connectivity is described in terms of *nodes* that map to discrete regions of the brain, which are connected by weighted *edges* that describe the strength of the connection. The graph can then be described by summary measures (e.g., modularity, efficiency), providing an economical description of the state of the brain. In this issue, Khambhati and colleagues review recent advances in using graphs that are calculated in a time-varying manner to capture connectivity and activity patterns across the brain. Yuan et al. then describe how brain networks can be integrated and pooled across subjects using dictionary learning, with their dynamics modeled by a time-varying graph that allows the identification of network interactions.

One of the many attractions of a dynamic graph approach is that it can provide insight into the fundamental principles of the organization of brain activity. For example, based on this approach, a number of studies have found that key areas of the cortex interact with multiple functional networks. De Pasquale and colleagues describe these "dynamic core" regions and the methods and statistical approaches that are used to identify them. They report that across modalities, these cores exhibit periods of strong and weak centrality that are related to periods of strong and weak global efficiency. Cavanna et al. suggest that such "dynamic core" states arise from the metastability of the brain and that their configuration changes across different levels of consciousness. In a complementary view, the state of the brain can be described in terms of integration vs. segregation. Shine and Poldrack review recent fMRI and electrophysiological studies that examine these features across a range of brain states; while Fukushima et al. examine the spatial connectivity, temporal homogeneity and test-retest reliability of low vs. high modularity periods. To facilitate further studies of the brain's network properties, Sizemore and Bassett survey tools that are available for the analysis and visualization of dynamic graphs and highlight the use of a publicly-available toolbox.