A tale of parcels & gradients: individual differences & behavioral associations

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Symposium

Improved methods to characterize human brain organization promise to better capture inter-individual variability, and ultimately the brain basis of cognitive functions and insights into brain disorders. One of the key tools to capture brain organization in single individuals is resting-state fMRI, which lends a powerful window into intrinsic functional network organization. Since the early days, resting-state fMRI analyses have focused on deriving decompositions of the brain into multiple discrete areas (i.e., brain parcellations) to interrogate brain network organization. Recently, several analytical methods have emerged that instead exploit more continuous representations (i.e., gradients).

In this symposium, we seek to reconcile these two views on brain organization, with a specific focus on modeling inter-individual differences in network organization and cognition. This is a timely topic given burgeoning interest within the neuroimaging community in characterizing brain topography with smooth gradients and uncertainty about the relative pros and cons of using gradients and parcels. This symposium will appeal to the broader neuroimaging community and will showcase cutting-edge methodologies, as well as how they can be applied to reveal fundamental insights into brain organization in health and disease.

Objective

Having taken part in this symposium, participants should better understand:
1. Cutting-edge gradient and parcellation techniques, and use them to predict individuals' behavior.
2. Test which of these two complementary representations provides the most parsimonious representation for a given brain area.
3. Methods to study network idiosyncrasy in typical and atypical brain development.

Target Audience

The human brain mapping community. This symposium combines methodological and neurobiological aspects and will be of interest to connoisseurs of methods on functional connectivity, gradients, parcellations and behavioral prediction, as well as cognitive and clinical neuroscientists interested in potential applications and interpretation.

Presentations

Representing brain organization: Smooth gradients, discrete regions or a bit of both?

Topographic variation in brain structure, function and connectivity can be parsed into discrete regions or represented with smooth gradients. In this talk, I will introduce principled approaches to reconcile these two complementary representations of brain topography and demonstrate how doing so can reveal new insight into the organization of the human cerebral cortex and subcortical nuclei. In particular, I will introduce the concept of gradientography, which is an fMRI analogue of diffusion MRI tractography that yields striking visualizations of brain gradients and enables identification of abrupt gradient transitions (gradient magnitude peaks). I will present a new model selection process to determine which regional peaks are sufficiently large to warrant boundary delineation. In the second part of my talk, I will showcase a new hierarchical atlas of the human subcortex that I have delineated by applying this approach to 3 and 7 Tesla functional MRI data acquired in more than 1000 individuals. The new atlas can be incorporated in existing cortex-only MRI parcellation atlases to enable holistic connectome mapping. Time permitting, I will also present some new insights into the functional connectivity architecture of the human insular cortex in individuals with schizophrenia and healthy comparison individuals. I will specifically show that the insula's connectional diversity is best represented as a continuum of gradual change, from dorsal-posterior to ventral-anterior, with relatively weak evidence for hard boundaries within this continuum.

Presenter

Ye Tian, University of Melbourne Carlton South, Victoria
Australia

Comparing gradients, soft-parcellations and hard-parcellations for RSFC behavioral prediction

There has been significant interest in using resting-state functional connectivity to predict behavior. Most studies have utilized functional connectivity from group-level parcellations for predicting behavior. Here, using data from the Human Connectome Project, we compare two gradient techniques (Gordon et al., 2016; Margulies et al., 2016), two soft-parcellation techniques (Beckmann and Smith, 2004; Bijsterbosch et al, 2018) and two hard-parcellation techniques (Schaefer et al., 2018; Kong et al., under review) for predicting cognitive, personality and emotional measures in individuals.

Presenter

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Macroscale brain organization and cognitive dynamics

Cognition is flexible and changes with the passage of time. The current talks reviews studies that examine whether naturally occurring changes in ongoing thought that occur with the passage of time are rooted in macroscopic functional and structural cortical organization, as measured with a variety of approaches, including gradients. Using both state of the art machine learning and novel experience sampling methods, we demonstrate that the

emergence of spontaneous thought in both tasks and at rest can be understood as reflecting transitions between neural motifs seen during complex task performances and at rest. Together this suggests that the same macroscale neural architecture governing external task performance, also constrains spontaneous cognition even when there is no requirement for external action.

Presenter

Jonathan Smallwood, University of York York, North Yorkshire
United Kingdom

Studying idiosyncratic connectome organization using gradient and parcellation techniques in typical and atypical development

Neurodevelopment is a complex process shaping the function and structure of multiple brain networks, with important variability across individuals reflective in diverse cognitive and social outcomes. This complexity is also echoed in the high heterogeneity of individuals affected by common neurodevelopmental conditions, such as autism spectrum disorders. In my talk, I will present a novel framework to study inter-individual differences in functional network organization - network idiosyncrasy - that fuses parcellation as well as gradient-based techniques. I will also present an application of the approach in the characterization of typically developing individuals and cohorts with autism spectrum disorders, and present data supporting its utility in capturing inter-subject variations at the level of behavioral symptoms.

Presenter

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