ORAL SESSION: Modeling and Analysis - Variability in Brain Activation

Yanchao Bi Chair
Bejing Normal University

Caterina Gratton Chair
Northwestern
Evanston, IL
United States

Oral Sessions

Presentations

Individual Variability in Brain Activity during Cognitive Tasks and Relationship with Cognition

Functional neuroimaging has resulted in a dramatic increase in the understanding of human cognitive processing in the brain. Group statistical analysis remains the main-stay of neuroimaging research in healthy populations and patients groups. This approach considers group-mean patterns of brain activity, and fundamentally assumes within-group homogeneity and consistent between group heterogeneity (i.e. groups being compared differ systematically in specific ways which are common across group members). However, substantial variability exists between individuals leading to violation of these assumptions, and which may exceed the differences observed between clinical populations. Previously in Hawco et al., 2019, 179 individuals (mixed schizophrenia spectrum and controls) performed a social cognitive functional magnetic resonance imaging (fMRI) facial Imitate/Observe task. Hierarchical clustering based on patterns of brain activity revealed three distinct sub-groups which did not differ by diagnostic category: 1) typical activators, showing the expected pattern of activity; 2) hyper-activators with widespread activity; 3) deactivators who minimally activated the appropriate cognitive network while suppressing activity in other social processing regions. This pattern of deactivation was considered an 'efficient' pattern of activity, and was associated with better out-of-scanner cognitive scores. Building on these findings to better capture and understand variable spatial patterns of fMRI task-activity between participants, a clustering based approach was explored to characterize variability across a variety of tasks.

Presenter

Colin Hawco, CAMH Toronto, Ontario
Canada

Segregation of functional territories in individual brains

FMRI provides means to characterize brain activations in response to behavior. However, cognitive neuroscience is limited to group-level effects referring to the performance of specific tasks. To obtain the functional profile of elementary cognitive skills, the combination of brain responses to many tasks is required, by pooling data or results from different studies [6,8]. So far, data pooling relies on meta-analytic methods allowing for the accumulation of knowledge across studies. Yet, as it is directly impacted by inter-subject and inter-site variability, this approach hinders the fine demarcation of brain regions. By contrast, individual mapping is free from this variability, but the resulting topographies have not been integrated into brain function templates, yet. We thus investigate the feasibility of individual functional brain atlasing, by leveraging a collection of brain images from the Individual Brain Charting (IBC) dataset, acquired at high resolution (1.5mm) in a fixed cohort (n=13). We make use of its first release [5] consisting of 12 tasks addressing different cognitive systems, whose majority were developed in former studies [1,2,3,4].

Presenter

Ana Luísa Pinho, PhD, Inria Saclay-Île-de-France
Parietal Team
Gif-sur-Yvette
France

Enhancing Task fMRI Preprocessing via Whole-Brain Neural Modeling of Intrinsic Activity Dynamics

A key goal of task (t-)fMRI preprocessing is to remove components of BOLD signal fluctuations that are not task-related. A known source of non-task related signal fluctuation comes from intrinsic neural activity dynamics. Prior work suggests standard trial-averaging procedures are insufficient to remove this background activity, since intrinsic and task-evoked activation can interact in a nonlinear fashion, consistent with a dynamical-systems [He13]. Despite these concerns, the difficulty of properly characterizing and modeling intrinsic activity dynamics at high spatial resolution has left this component of t-fMRI preprocessing to be neglected. Here we examine the effectiveness of a novel solution to this issue, by introducing a recently developed model of individualized whole-brain neural activity dynamics (MINDy [Singh19]) into a t-fMRI analysis pipeline.

Presenter

Matthew Singh, Washington University University City, MO
United States

Cognitive information differentiates between connectivity and activity across the cortical hierarchy

Many studies have identified the role of localized and distributed cognitive functionality by mapping either local

task-evoked activity or distributed functional connectivity (FC). However, few studies have directly explored the relationship between a brain region's localized task activity and its distributed task-state FC patterns. Establishing a concrete relationship between local activity and distributed FC would provide insight into the nature of localized versus distributed functionality across brain regions. Here we systematically evaluated the differential contributions of localized activity and distributed FC during cognitive tasks by decoding multiple task states using either activity or FC. We found that multi-task decodability of task-evoked activity was high in primary visual and motor areas, but low in association areas. In contrast, we found high decodability of task-evoked FC patterns in association areas, but low decodability in visuomotor areas. This revealed a strong negative association between localized task activity and distributed FC patterns across cortex. Moreover, this dissociation between localized and distributed functionality corresponded to differences in cortical heterogeneity revealed by recent genomic, structural, and computational modeling studies [Burt et al., 2018; Demirtaş et al., 2019]. Together, our results contribute to a growing literature illustrating the differential contributions of a hierarchical cortical gradient representing localized and distributed cognitive functionality.

Presenter

Takuya Ito, Rutgers University
Center for Molecular and Behavioral Neuroscience
Newark, NJ
United States

A High-Resolution In Vivo Atlas of the Human Brain's $GABA_A$ Receptor System

Gamma-aminobutyric acid (GABA) is the main inhibitory neurotransmitter in the human brain, and plays a critical role for brain function and in neuropsychiatric disorders, including anxiety, epilepsy, and depression [1]. Benzodiazepines are well-known for their sedative and anxiolytic effects. They act as agonists on the benzodiazepine binding site (BZR) which is located between the α1,2,3 or 5 and Ɣ subunits in the pentameric constellation of the postsynaptic ionotropic GABA[sub]A[/sub] receptors (GABA[sub]A[/sub]Rs). Here, we present a quantitative high-resolution in vivo atlas of the human brain's distribution of BZRs; this atlas can serve as a reference in future studies investigating disorders or pharmacological intervention effects on the BZR site.

Presenter

Martin Nørgaard, Neurobiology Research Unit, University of Copenhagen
Neurobiology Research Unit, University of Copenhagen
Copenhagen, [Select a State]
Denmark