A Mixed Modeling Framework for Analyzing Multitask Whole-Brain Network Data

The emerging area of brain network analysis considers the brain as a system, providing profound clinical insight into links between system-level properties and behavioral and health outcomes. Network science has facilitated these analyses and our understanding of how the brain is structurally and functionally organized. While network science has catalyzed a paradigmatic shift in neuroscience, methods for statistically modeling and comparing groups of networks have lagged behind. To address this knowledge gap for cross-sectional network data, we developed a mixed modeling framework that enables quantifying the relationship between phenotype and connectivity patterns in the brain, predicting connectivity structure based on phenotype, simulating networks to gain a better understanding of normal ranges of topological variability, and thresholding individual networks leveraging group information. Here we extend this comprehensive approach to enable studying system-level brain properties across multiple tasks. We focus on rest-to-task network changes, but this extension is equally applicable to the assessment of network changes for any repeated task paradigm, including interrelated task designs such as those employed in multisensory studies. Our approach allows: 1) assessing the relationships between population state changes and health outcomes; 2) assessing the relationships between individual variability in state changes and health outcomes; and 3) deriving more accurate and precise estimates of the relationships between phenotype and health outcomes within a given task state by leveraging information from other states.