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Test-retest reliability of graph theoretical metrics derived from functional magnetic resonance imaging

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The brain is arguably one of the most complex systems whose function is thought to rely on the interaction of its 100 billion nerve cells. The last decades have been successful in mapping out associations of particular brain regions with particular brain functions, but support for a view that brain regions do not work in isolation and more complex mental functions require a dynamically interacting, highly interconnected network is rapidly growing. Still, fundamental questions remain such as how individual brain regions dynamically interact to form large-scale brain networks and how these networks ultimately enable human cognition, emotion and behavior. Answers to these questions require the development and application of methods to extract meaningful organizational principles from complex interacting systems.

Characterizing the brain connectome using neuroimaging data and measures derived from graph theory emerged as a new approach that has been applied to brain maturation, cognitive function and neuropsychiatric disorders. For a broad application of this method especially for clinical populations and longitudinal studies, the reliability of this approach and its robustness to confounding factors need to be explored. Here, the test–retest reliability of graph metrics of functional networks derived from functional magnetic resonance imaging recorded in 33 healthy subjects during rest was investigated. Constructing undirected networks based on the Anatomical-Automatic-Labeling atlas template and calculating several commonly used measures from the field of graph theory, this work focused on the influence of different strategies for confound correction on test-retest reliability of these measures. For each subject, method and session the following graph metrics were computed: clustering coefficient, characteristic path length, local and global efficiency, assortativity, modularity, hierarchy and the small-worldness scalar. Reliability of each graph metric was assessed using the intraclass correlation coefficient (ICC).Overall ICCs ranged from low to high (0 to 0.763) depending on the method and metric. Methodologically, the use of a broader frequency band (0.008–0.15 Hz) yielded highest reliability indices(mean ICC=0.484), followed by the use of global regression (mean ICC=0.399). In general, the second order metrics (small-worldness, hierarchy, assortativity) studied here, tended to be more robust than first order metrics. In conclusion, this study provides methodological recommendations which allow the computation of sufficiently robust markers of network organization using graph metrics derived from functional magnetic resonance imaging data at rest.