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Binary and weighted network analysis and its applications to functional connectivity in subjective memory complaints: A resting-state fMRI approach

Abstract:

Introduction: Despite normal cognitive abilities, subjective memory complaints (SMC) are common in older adults and are linked to mild memory impairment. SMC may be a sign of subtle cognitive decline and underlying pathological changes, according to research; however, there is not enough data to support the use of resting-state functional connectivity to identify early changes in the brain network before cognitive symptoms manifest.

Materials and methods: In this study, the topological structure and regional connectivity of the brain functional network in SMC individuals were analyzed using graph theoretical analysis in both weighted and binarized network models, alongside healthy controls. Resting-state functional magnetic resonance imaging data was collected from 24 SMCs and 39 cognitively normal people. Analysis of both binary and weighted graph theory was done using the Dosenbach Atlas as a basis based on area under curves (AUCs) for the graph network parameters, which comprised of six node metrics and nine global measures. We then performed group comparisons using statistical analyses based on Network-Based Statistics functional connectomes. Finally, the relationship between global graph measures and cognition was examined using neuropsychological tests such as the Mini Mental State Examination (MMSE) and the Alzheimer Disease Assessment Scale (ADAS score).

Results: The topologic properties of brain functional connectomes at both global and nodal levels were tested. The SMC patients showed increased functional connectivity in clustering coefficient global ($P < 0.00001$), global efficiency ($P < 0.00001$), and normalized characteristic path length or Lambda ($P < 0.00001$), while there was decreased functional connectivity in Modularity ($P < 0.04542$), characteristic path length (0.00001), and small worldness or Sigma ($P < 0.00001$) in binary networks model. In contrast, SMC patients only exhibited decreased functional connectivity in Assortativity identified by weighted networks model. Furthermore, some brain regions located in the default mode network, sensorimotor, occipital, and cingu-

lo-opercular network in SMC patients showed altered nodal centralities. No significant correlation was found between global metrics and MMSE scores in both groups using binary metrics. However, in cognitively normal individuals, negative correlation was observed with weighted metrics in global and local efficiency and Lambda. While in SMC patients, a significant positive correlation was found between ADAS scores and local efficiency in both binary and weighted metrics.

Conclusion: The findings suggest that functional impairments in SMC patients might be associated with disruptions in the global and regional topological organization of the brain's functional connectome, offering new and significant insights into the pathophysiological mechanisms underlying SMC.

Biography

Sobhan Khodadadi Arpanahi, is set to begin his PhD in Medicine at the University of Cambridge in October 2025, having been awarded the prestigious Cambridge Trust Scholarship—granted annually to a select group of top-performing international candidates. His doctoral research at the Department of Medicine will center on integrating multimodal neuroimaging with AI-driven analysis, aiming to enhance the diagnosis and treatment of traumatic brain injuries and neurodegenerative diseases. He previously earned a Master's degree in Biomedical Engineering, graduating top of his class with a perfect GPA of 4.0/4.0. Additionally, he achieved a national ranking within the top 1% in Iran's highly competitive Master's entrance examinations. Beyond his academic achievements, he has taught advanced courses in medical imaging, signal processing, medical devices, and neuroscience/neuroimaging at both undergraduate and postgraduate levels. He remains deeply committed to a career that bridges research, clinical application, and education