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Finding Brain Functional Modules Aids in Alzheimer's disease Identification

Patel Nikhil*

School of Science, Nanyang Technological University, Singapore

Abstract

Brain hubs serve as focal points for the integration of information, whereas functional modules in the human brain support the brain's drive for specialization. A large number of connections between modules and within modules are found in brain hubs. We argue that brain functional networks mistake brain regions for hubs because of weak connections. We propose a brand-new measure known as ambivert degree, which takes into account both the degree of the node and its connection weights in order to identify hubs that have both high degree and high connection weights. We demonstrate that the Human Connectome Project's resting-state functional MRI scans identify brain hubs that are not only essential but also constant across subjects using the ambivert degree. For diseases that are known to have widespread hub disruption, we hypothesize that nodal measures based on ambivert degree can effectively classify patients from healthy controls. We demonstrate through the use of data from patients with Alzheimer's disease and autism spectrum disorder that the hubs in the diseased and healthy groups differ significantly, and that deep feed forward neural networks trained on nodal hub features achieve significantly higher classification accuracy with significantly fewer trainable weights than functional connectivity features. Therefore, the ambivert level can be used as a diagnostic feature to identify neurological diseases characterized by hub disruption and improves the identification of important brain hubs in healthy subjects.

Keywords: Alzheimer's disease; Ambivert degree; Brain modules

Introduction

The brain is made up of functionally distinct systems that coordinate distinct inputs that lead to cognition and behavior, according to a number of anatomical, physiological, and neuroimaging studies. In spite of the fact that a fundamental organizing principle in the brain is functional specialization, there is increasingly evidence of significant dynamic integration among functional regions in order to carry out a variety of cognitive tasks, including language perception and vision [1].

Information flow between neurons in these specialized brain regions, which is coordinated by a particular set of regions, is necessary for this integration, or "coming together," of these regions. These integrative or 'center' regions together structure a spine for data transmission in the cerebrum.

The functional connections (also known as functional correlations) that exist between brain regions are depicted as weighted edges on networks, and brain regions, which are made up of a population of neurons, are used to model the functional brain organization [2]. According to van den Heuvel and Sporns (for a review), previous studies indicate that the human brain connectome includes properties that encourage functional specialization through a modular structure and effective communication through network hubs. According to the findings of a recent study, hubs can be divided into three categories based on how connected they are to various functional modules and how they modulate various tasks [3]. The identification of hubs is an important research issue due to their central role in information processing.

Discussion

Nodes with high nodal degrees, or a large number of connections to other networks, were the initial characteristics of brain hubs. However, subsequent studies argued that simply taking the nodal degree would result in giving excessive weightage to nodes from large modules (typically the default mode network) because the brain modules were of varying sizes and nodes had high connections within modules. As a result, modular hubs are nodes that, when compared to other nodes in the same module, have a high degree of importance for intra-modular communication [4]. On the other hand, connector hubs, or heteromodal nodes that facilitate intermodular communication, were proposed to be identified using the participation coefficient, a measure of the extent to which a node connects to other modules [5]. Nodes with heterogeneous connections and a high intra-modular degree were identified by the weighted average of the scores from the two measures, which are frequently referred to as network hubs. Network scarification steps are used in studies involving brain functional networks to get rid of weak brain functional connections that are affected by experimental noise [6].

Conclusion

Nonetheless, this influences not just the quantity of frail associations in the network yet in addition the organization's basic secluded structure. Because (i) a disruption in the modular structure of the brain results in false hub detection, this can have an impact on the detection of network hubs. (ii) a node can still be considered a hub even if it has a large number of weak connections, whereas a node with fewer but stronger connections can be ignored. We employ the thresholding scheme proposed by Bordier et al. in order to account for (i). 2017), which preserves the modular structure of the network; In addition, in (ii), we propose a novel metric known as the ambivert degree that takes into account both the nodal degree and the quantity of connections. We also think about the gateway coefficient, which is an extension

***Corresponding author:** Patel Nikhil, School of Science, Nanyang Technological University, Singapore, E-mail: patel89@gmail.com

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of the participation coefficient and takes into account information about a node's unique intermodular connections and the significance of its neighbors in their module. We investigate the significance of brain functional hubs in the processing of information in the 589 HCP subjects' resting state brain functional networks by taking into account both of these measures. We discovered that, instead of a node's intra-modular degree, as was previously thought, the ambivert degree combined with participation coefficient produces the most crucial network hubs after considering the effect of artificial lesions in brain functional networks.

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