Changes in the Efficiency of Whole-Brain Network in Spinal Cord Injury: a Resting-State fMRI study using Graph Theory

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Introduction

The application of a graph theoretical framework divides the resting-state functional MRI (rs-fMRI) dataset into “nodes” and “edges” that allows for the calculation of quantifiable network metrics. These metrics can be compared between the clinical population of interest and controls to evaluate connectivity alterations in brain networks. The present analysis highlights changes to the efficiency of whole-brain network in patients with spinal cord injury (SCI).

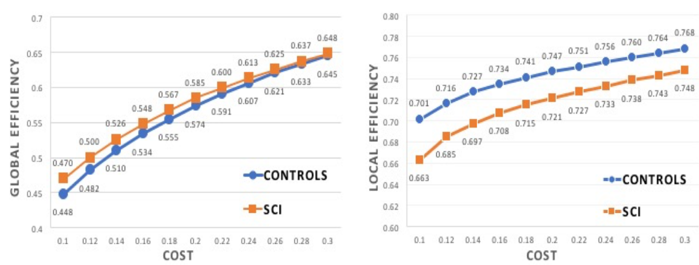
Methods

Subsequent to the IRB approval, 15 subjects with chronic, complete cervical SCI and 15 neurologically intact controls were scanned. The raw imaging datasets were preprocessed and then parcellated into 264 regions of interest (ROIs) based on the functional atlas from Power et al. Correlation analysis was performed between the average time series of every pair of ROIs to construct connection matrices. Local efficiency (LE) and global efficiency (GE) were then calculated at incremental cost thresholds (% of total possible connections) and compared between the study groups.

Results

The whole-brain resting-state network showed significant differences for GE and LE, measuring the ability to transmit information at global and local level, respectively, between the two groups at multiple cost thresholds (Figure 1). GE was increased while LE was reduced in SCI compared to controls.

Figure 1



Comparison of Global Efficiency (GE) and Local Efficiency (LE) between spinal cord injury (SCI) and neurologically intact controls at different cost thresholds. Orange and blue lines designate SCI and controls, respectively. The values of GE and LE metrics at each cost threshold are significantly different between the two groups.

Conclusions

The differences in GE and LE, evaluating network attributes of integration and segregation, respectively, highlights the applicability of graph theory in conducting large-scale network analysis in clinically relevant neurosurgical patient populations. The findings illustrate the inherently plastic nature of the brain, which manifest in the form of persistent connectivity alterations, causing global and local changes to information transmission following distant injury to the spinal cord. This speaks to the potential of quantitative metrics in the development of noninvasive imaging biomarkers for improving prognostication after SCI and measurement of functional recovery.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Appreciate the utility of resting-state fMRI and the role of graph theory in studying brain networks.

2) Understand that spinal cord injury is associated with alterations to network efficiency at the local and the global level.

3) Notice that spinal cord injury is associated rostrally with persistent connectivity alterations indicative of the inherent plastic nature of the brain.

References