Building an EEG-fMRI multi-modal brain graph: a concurrent EEG-fMRI study

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Introduction

The topological architecture of brain connectivity has been well characterized by graph theory based analysis (Pessoa, 2014; Yu et al. 2012). However, previous studies have primarily built brain graphs based on a single modality of brain imaging data. Here we develop a novel frame work to build both static and dynamic concurrent EEG-fMRI brain graphs which nodes are EEG electrodes and ICA brain components. By applying it to a data set collected during eyes open and eyes closed resting states, we show that this multi-modal graph can combine brain information with high temporal resolution of EEG signal and information with high spatial resolution of fMRI signal.

Methods

Figure 1. Pipeline for building concurrent EEG-fMRI multi-modal brain graphs. ① Segment EEG signal into 2 s time windows, and compute the spectral Power of 5 frequency bands (delta: 1-4 Hz; theta: 4-8 Hz; alpha: 8-13 Hz; beta: 13-30 Hz; low gamma: 30-55 Hz) for each time window. ② Perform group ICA on fMRI data. ③ Compute the correlation coefficient within and across the EEG spectral power and ICA time courses, generating an EEG-fMRI connectivity matrix. ④ Segment EEG spectral power and ICA time courses into time windows, then compute the correlation between each pair of time windowed times to get dynamic EEG-fMRI brain graphs.

Results

Figure 2. Spatial maps of the 54 ICs which were identified as resting state networks (A), and structure of the group mean static EEG-fMRI brain graphs in the five frequency bands for eyes open, eyes closed, and difference between eyes conditions (B). Connectivity between SM and VIS brain components are much stronger during eyes closed then eyes open. (EO: eyes open; EC: eyes closed; SC: sub-cortical; AUD: auditory; SM: somatomotor; VIS: visual; CC: cognitive control; DM defaul mode; CB: cerebellum)

Conclusions

This work makes an important beginning step in characterizing EEG-fMRI associations within a graph theory framework. The results revealed spatial locations and temporal frequencies about the change of graph properties across different brain states (eyes open VS eyes closed). This study provides a novel approach for assessing the associations among concurrent EEG-fMRI signals.