

Spectral Changes in Resting-state fMRI Connectivity Induced by Corpus Callosum Transection

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INTRODUCTION

Resting-state fMRI (rsfMRI) has been increasingly used in understanding brain functional connectivity under normal and pathological conditions¹. Correlated fluctuations in rsfMRI signal are mostly confined to frequency below 0.1 Hz², so spectral filtering is routinely performed to retain low frequencies before further analysis. Moreover, changes in the connectivity strength or spatial map of these low-frequency fluctuations are the common focus when comparing the normal and diseased brains. However, limited work has studied the underlying spectral alterations. In this study, we investigated the spectral changes of resting-state connectivity in a rat model of complete corpus callosum (CC) transection.

METHODS

Animal Preparation: Adult Sprague-Dawley rats (230~270g) were subjected to a complete transection of CC (N=6) or sham surgery (N=6). After 7 days of recovery, animals were MRI scanned under mechanical ventilation with isoflurane anesthesia (1-1.5%). **MRI Protocols:** All MRI experiments were conducted using a 7 T Bruker scanner with a surface coil. Four to six rsfMRI acquisitions were performed using a single-shot GE-EPI sequence with TR/TE=1000/18ms, FOV=32×32mm², 64×64 matrix, nine 1-mm-thick slices and a total of 400 data points. **Data Analysis:** All rsfMRI data was slice-timing corrected, co-registered, detrended and temporally band-pass filtered (0.005Hz<f<0.1Hz). Resting-state connectivity of caudate putamen (CPu), somatosensory cortex (S1) and visual cortex (VC) were examined using independent component analysis (ICA) in GIFTv1.3h Toolbox. The spatial maps of independent components were scaled to z scores with a threshold of z>2. The time courses of independent components covering CPu, S1 and VC were extracted to calculate power spectra. The time courses without prior band-pass filtering were used for time-frequency analysis using short-time Fourier transform in Matlab.

RESULTS AND DISCUSSION

CC connects most areas of the cerebral cortex to contralateral homologous areas that share similar functions³. In this study, the primary callosal connections of S1 and VC were severed by complete CC transection. Fig. 1 shows that interhemispheric connectivity seen in S1 and VC of sham group was prominently absent in complete CC transection group while the intrahemispheric connectivity was preserved. The interhemispheric connectivity of subcortical network in CPu was not affected and served as an internal control. Fig. 2 shows the power spectral comparison between the two groups. S1 and VC of transection group showed stronger power at relative high frequency (arrows) below 0.1 Hz with respect to that of sham group. Similar results were found using time-frequency analysis of the unfiltered time courses (Fig. 3). Higher power of frequencies around 0.1 Hz was observed in S1 and VC of transection group. These spectral changes were observed in brain regions showing predominately intrahemispheric connectivity and therefore may arise from the faster intrahemispheric communication⁴. In conclusion, these experimental findings indicate that spectral characteristics of rsfMRI connectivity can be modulated by neural disruption and spectral analysis of rsfMRI data may provide a new dimension of information regarding the brain organization and connectivity.

REFERENCES

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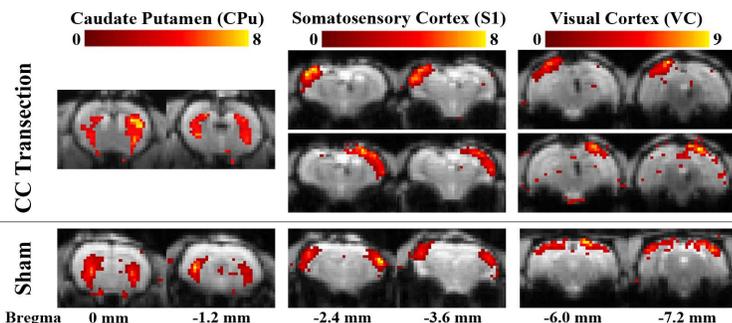


Fig. 1 Typical ICA maps of rsfMRI data from animals with complete corpus callosum (CC) transection and sham surgery. CC contains axonal projections interconnecting bilateral S1 and VC. Loss of interhemispheric connectivity was observed in cortical areas (S1 and VC) but not in subcortical area (CPu) of transection group compared to that in sham group, while the intrahemispheric connectivity was preserved.

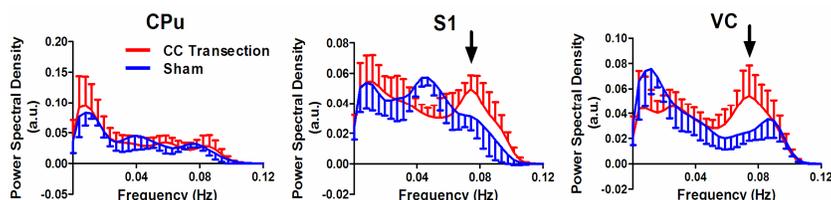


Fig. 2 Spectral comparison between complete CC transection group and sham group. Power spectra were computed from the time courses of ICA components in CPu, S1 and VC. Power spectral density (PSD) was presented in mean \pm SD. S1 and VC of transection group showed stronger power at relative high frequency (arrows) with respect to that of sham group.

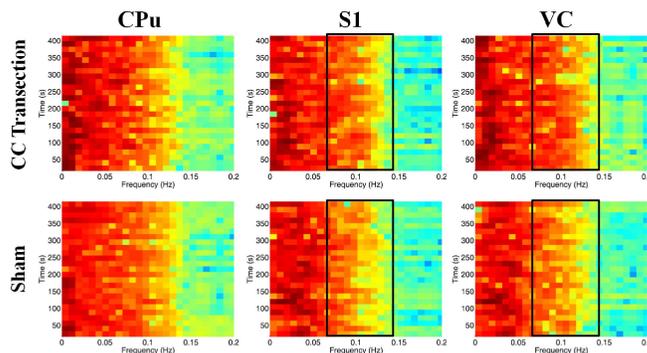


Fig. 3 Time-frequency analysis of rsfMRI time courses without prior band-pass filtering. Higher PSD of frequencies around 0.1 Hz (black boxes) was observed in S1 and VC of transection group compared to that of sham group.