The Relationship of Resting State fMRI Correlation and Anticorrelation to Electrically-Evoked Potentials in the Human Brain

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Introduction
Functional MRI studies carried out during rest (R-fMRI) suggest a functional architecture of spatially distributed networks that is represented in low-frequency (<0.1 Hz) spontaneous fluctuations of the blood oxygen level-dependent (BOLD) signal. Functional connectivity analysis of this signal reveals both correlated and anti-correlated areas. In order to examine the neurophysiological underpinnings related to the direction of correlation, we investigated the relationship of these correlations to electrophysiological measures. Studies were carried out using direct electrical stimulation of the cerebral cortex with intracranial electrodes in patients undergoing invasive electrode implantation for seizure monitoring.

Methods
We performed systematic bipolar stimulation of all electrodes by administering a single pulse electrical current (10mA, 0.5Hz, 0.2 msec pulse width, 20 trials per electrode pair) on six patients undergoing intracranial monitoring for intractable epilepsy. Electrodes were localized using post-operative CT and MRI and aligned upon the reconstructed cortical surface of a pre-operative MRI scan. Resting state fMRI scans (3T) were performed prior to electrode implantation.

Results

> Probing Language Areas

> Probing Sensorimotor Areas

Co-localization of CCEPs and RSFC across brain

> In 5/6 subjects, significant CCEPs exhibited higher RSFC than non-significant CCEPs.

> A similar finding was observed when local electrodes (within 3cm of stimulation site) were removed from analysis.

> Group analysis for N1 (10-70ms) and N2 (70-500ms) time windows.

> Each timeline represents 1 stimulation site (80-120 responses/stim).

> Regressing-out distance from stimulation site yielded similar results.

Comparison of positive and negative RSFC and CCEP

> No significant difference between CCEP waveforms whose region had negative RSFC or non-significant RSFC.

> Regions with more positive RSFC showed stronger CCEPs but regions with more negative RSFC did not.

Spectral analysis of CCEP and RSFC

> CCEPs converted to frequency domain and power during N1 (10-70ms) and N2 (70-500ms) was compared to RSFC correlation.

> One subject, all stimulation sites, all electrode responses.

> Sample sizes for each group are noted in white text.

Conclusions

> Correlated fluctuations of the BOLD signal at rest reliably predict electrically-evoked potentials.

> Positively correlated regions exhibit higher CCEP power in all frequencies during the N1 and low frequencies (<11Hz) during N2.

> Anticorrelated regions exhibit higher CCEP power in high frequencies (>25Hz) during N1 / N2.

> Further investigation is warranted with regard to the spatial and temporal relationship between CCEPs, RSFC, and spontaneous ECoG.

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