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**Titre** :

Structural basis for healthy human EEG gamma power variability and frequency specific relationship between EEG power and BOLD FMRI

**Resume et advancement:**

EEG measures the broad band signal (0-100+Hz) emanating from the brain, and this signal is commonly divided into multiple non-overlapping frequency bands. Two of the most commonly studied bands are the alpha/beta (8-25Hz) and the gamma (30-80Hz) frequency bands.

Due to advances in EEG hardware and signal processing techniques, it has become more popular recently to examine the gamma range EEG activity. For example, psychological disorders such as schizophrenia and autism have been linked to corresponding changes in the gamma rhythm. However while gamma is commonly observed on the surface of the scalp in EEG recordings, the underlying anatomical basis and hemodynamic correlates remain poorly understood despite a large amount of variability within healthy populations.

We seek to better understand the basis for healthy human EEG gamma power variability by answering two questions 1) what is the relationship between macroscopic structural measures such as cortical curvature and distance from cortex to electrode, and gamma power? 2) what is the relationship between voxel specific hemodynamic fluctuations and gamma power across the brain, and as a function of different stimulus conditions/brain states?

Experimental approach: The experimental approach of this study focuses on taking advantage of the retinotopic organization of the human visual cortex to acquire multiple measures within a single subject, in order to circumvent the problem of acquiring many different participants. If 30 discrete retinotopic areas are stimulated in each subject, and 10 subjects are acquired, a total of 300 (30x10) brain areas and corresponding EEG responses can be isolated, giving much greater statistical power to the experiment.

To make this possible, retinotopic mapping experiments will be performed using simultaneous EEG-FMRI. This will allow to precisely delineate the anatomical region associated to each retinotopic stimulus location, while simultaneously measuring the EEG response. The EEG responses to each stimulus configuration can then be compared with the corresponding anatomical patch isolated by the FMRI. While in principle simultaneous EEG-FMRI is not necessary (EEG and FMRI retinotopic mapping can be performed separately), in practice ensuring that both modalities are acquired in identical stimulus conditions adds value to this type of study, by ensuring that the EEG and FMRI responses originate from the exact same cortical tissue.

Progress so far: experiments have been carried out in two separate groups of subjects, group #1 a cohort of 24 healthy humans where 24 subjects were acquired in separate EEG and FMRI sessions, to examine the relationship between EEG and BOLD FMRI in response to specific stimulus types.

group #2 a cohort of 9 healthy humans where simultaneous EEG-FMRI experiments were carried out, in order to examine the temporal correlation between EEG band-limited power hemodynamic responses as measured with BOLD FMRI.

**Contribution originale:**

original contribution #1: showing that EEG gamma power and BOLD can share very different stimulus response properties depending on the nature of synaptic input to the cortical circuit. Using specially designed visual stimuli, we altered the correlations between synaptic inputs to visual cortex and measured EEG and BOLD responses. In doing so we challenge the widely held assumption (Logothetis et al 2001) that there exists a causal link between gamma power and BOLD FMRI, or that gamma power is the best predictor of hemodynamic responses in a cortical region.

original contribution #2: showing that inter-subject variability in EEG gamma power can be explained primarily by macroscopic cortical anatomical features such as distance between cortex and EEG electrode, and cortical folding patterns which result in different levels of dipole cancellation. This challenges the commonly held assumption that inter-subject gamma power variability is due to differences in microscopic features such as GABA concentration or GABA receptor density (Muthukumaraswamy et al 2007).

original contribution #3: showing that the hemodynamic response function varies widely as a function of cortical region and brain state, and that the canonical hemodynamic response function is a poor predictor of hemodynamic response to neural activity in many if not most cases.

**Travaux a realizer:**

To do #1: collect additional subjects for the simultaneous EEG-FMRI experiment (so far, nine subjects have been collected, but an n of 15 would provide more robust statistics).

To do #2: finalize results for the macroscopic structure vs EEG gamma power study (n=24), and write/submit article. Improve the denoising of the gamma band to ensure that difference measured across subjects are due to neural activity and not myogenic origin.

To do #3: finalize results for the simultaneous EEG-FMRI experiment (n=9, 6 more subjects to acquire), and write/submit article. Improve the denoising of the ballistocardiogram and motion artifacts from the simultaneous EEG-FMRI acquired EEG signal.

**Communications:**

#1

Decorrelated Input Dissociates Narrow Band γ Power and BOLD in Human Visual Cortex

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#2

Application of polymer sensitive MRI sequence to localization of EEG electrodes

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Journal of neuroscience methods