BOLD correlates of human alpha and beta rythms: a simultaneous EEG-fMRI study

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Introduction

Previous studies demonstrated the possibility of studying the topography of brain generators of alpha (8÷12 Hz) and beta (13÷30 Hz) rhythms by means of simultaneous fMRI/EEG acquisition. These rhythms are supposed to be involved in the modulation of neural synchronization within thalamo-cortical and cortico-cortical loops. Previous studies mostly looked for BOLD correlates of the power fluctuations of spontaneous alpha and beta rhythms. Overall, negative correlation of the BOLD signal with the alpha power was observed in occipital, parietal and frontal areas. In a few cases, positive correlation was observed in the thalamus [1-4]. However a large inter-subject variability was observed, as well as outliers with different correlation patterns. One study in particular focused on the inter-subject variability of correlation maps [5]. It should be noted that previous studies used the same frequency interval across subjects to select the oscillation bands of interest (for example 8 -12 Hz for the alpha band). We considered the possible variability of the frequency spectrum across individuals. Consequently, we divided the alpha and beta bands into sub-bands, on the basis of the value of the peak frequency of the alpha band, namely the Individual Alpha Frequency (IAF) [6].

Materials and methods

14 right-handed healthy volunteers (mean age 24.8±5 years) were enrolled in the experiment. The subjects were asked to lay and relax in the MRI scanner with their eyes closed. EEG recordings were collected for 4 minutes with an MRI-compatible EEG amplifier (BrainAmp) and a 32 channel electrode cap (10/20 system; cephalic reference). BOLD contrast functional images were acquired at 1.5 T by means of T2* weighted sequences. 200 fMRI volumes (9 slices) were acquired with a TR of 1.2 s. MR gradient artifacts that contaminate the EEG signal were removed off-line with the algorithm implemented in the Brain Vision Analyzer software (Brainproducts) [7]. After gradient artifact correction, ballistocardiogram artifacts due to the cardiac pulse were removed [8]. Data were visually inspected for a final check and digitally filtered between 0.5 and 50 Hz. The IAF was obtained for each subject using the FFT. The following sub-bands were defined: alpha-2 (from IAF – 2Hz to IAF), alpha-3 (from IAF to IAF + 2Hz), beta-1 (from IAF + 2Hz to IAF + 10Hz), and beta-2 (from IAF +10Hz to IAF + 20 Hz). The power spectrum in each frequency sub-band was calculated in a 4 second window every 1.2 seconds. The average power spectrum time series for the parietal-occipital electrodes (O1-O2-P3-PZ-P4) was obtained for each sub-band. The average power spectra timeseries were then convolved with a standard hemodynamic response function. Analysis was performed using the Brain Voyager software package. Preprocessing: motion correction, linear detrending and Talairach normalization of functional and structural images. The convolved power time series were then used as regressors in a correlation analysis of the BOLD signal. The obtained statistical activation maps were thresholded at $p < 0.01$ (corr.).

Results

The correlation of the BOLD signal with the power time course in the thalamus was negative for alpha-2, and positive for beta-1. No significant correlation was observed for alpha-3 and beta-2. We observed a positive thalamo-cortical correlation for alpha-2 and a negative thalamo-cortical correlation for beta-1. These results suggest a positive thalamo-cortical correlation for the alpha-2 sub-band, and a negative thalamo-cortical correlation for beta-1. The results for the beta-1 sub-band (Rolandic beta) suggest that the thalamus is activated for inhibition of cortical oscillators mainly in somatomotor areas. This correlation indicate an inhibition of somatomotor activity for immobility. In conclusion, we propose an improved approach for studying fMRI correlates of EEG rhythms. The use of individual sub-bands takes into account inter-subject variability.

References

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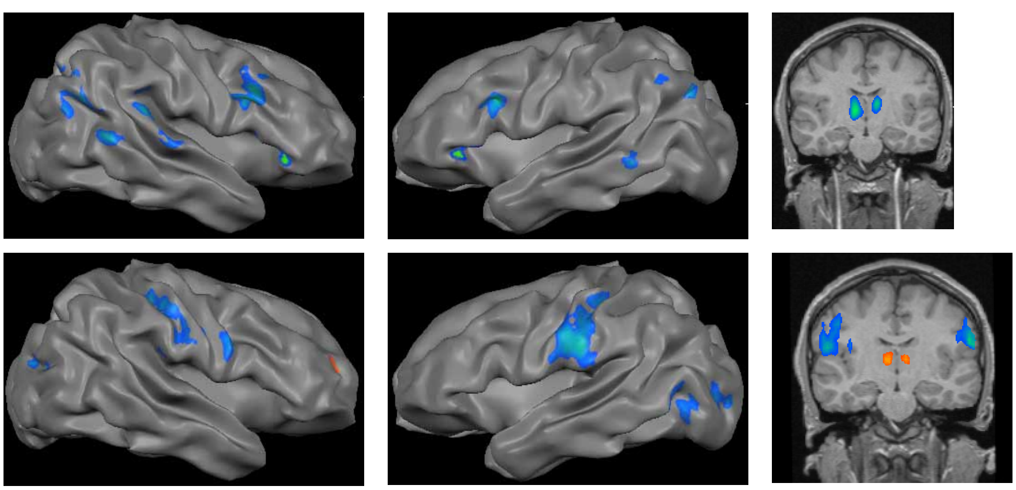

Correlation maps with alpha-2 (upper) and beta-1 (lower) power time course.