FMRI correlates of fast and slow alpha-rhythm fluctuations during total darkness

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Introduction

Conflicting data on fMRI correlates of the human alpha-rhythm based on simultaneous EEG-fMRI recordings (1-4) were reported recently. We and others (1, 3, 4) found negative correlations of the posterior alpha rhythm predominantly in occipital brain regions and positive correlations in thalamic areas. Conversely, Laufs et al. (2) reported fronto-parietal brain areas to be inversely correlated with alpha-activity.

Here we present a study (based on newly acquired data of 11 subjects) under the condition of total darkness (to exclude any effects of visual activation by diffused light) aiming to verify our findings (3) and to analyze effects of slow and fast alpha-rhythm fluctuations.

Methods

EEG and fMRI recordings of 11 healthy volunteers (23-30 years) with eyes closed were acquired simultaneously. Photo resistant goggles were used for blinding subjects to exclude visual activation by diffused light. No stimuli were presented.

MR Recording: fMRI acquisition was performed on an 1.5 T Siemens Vision scanner using echo planar pulse sequences (TR 2.2 s, FOV 210 mm, voxel size 3.3 x 3.3 x 5 mm, 0.5 mm gap, 20 slices). 750 scans were acquired for each volunteer.

EEG Recording: EEG was recorded with a 32-channel MR-compatible EEG (Brain Products) with 5000 Hz sampling frequency.

Analysis: MR-acquisition related artefacts in the EEG-signal were corrected (see fig. 1 a) using an algorithm proposed by Allen et al. (5). To obtain time resolved frequency components of electrode O2 (according to the 10-20 system), data were analysed using a Morlet wavelet (fig 1 b). The wavelet spectrum was averaged over the alpha range of 8-12 Hz to estimate the alpha power (fig 1 c).

Resulting alpha power was filtered with a 3rd order butterworth filter with a cut of time of 20sec to get high (Model H) or low (Model L) frequency components of the alpha power (fig 1 d). For comparison a model without filtering was also calculated (Model N)

Timecourses were convolved with the hemodynamic response function to define a predictor for statistical parametric mapping with SPM2 (fig 1 e).

Realignment parameters and second derivatives of alpha regressors were included for model estimation. A second level analysis based on the contrast images of the single subject analysis was done to correct for random effects.

Results

As in our previous study BOLD signal of visual brain areas were negatively correlated to the alpha activity. Figure 2, shows the result of a random-effects group analysis based on 11 subjects ($p<0.03$). Positive correlations were found as in our previous study in the thalamus as well as in adjacent ventricles. High pass filtered alpha power showed more widespread negative correlations but no positive correlations (Figure 3, top). Low pass filtered alpha power correlated negatively only in visual brain areas. Positive correlations kept to be significant (Figure 3, bottom).

Discussion

With the presented study we reproduced our former results. Maximal negative correlations occured in occipital areas and additionally in frontal areas and positive responses occurred in parathalamic areas.

A similar pattern was revealed with the 20 sec low pass filtered alpha-regressor, however with lower significance and less spatial extension, indicating the unfiltered regressor to be superior in explaining BOLD variance.

High pass filtered alpha predictor results in more diffuse and widespread negative correlations extending occipital, parietal and frontal regions, with a center of gravity however in the occiput.

However positive correlations in areas around thalamus and ventricles disappear in high-pass filtered data indicating low frequency oscillations of neuronal activity to cause thalamic BOLD response.

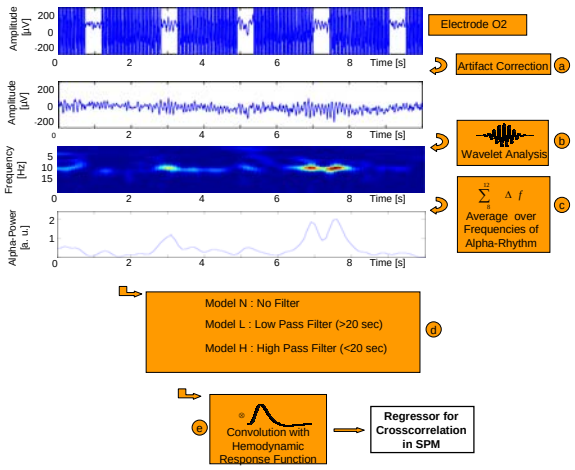

Fig 1: From EEG signal to statistical parametric maps. See Methods/ Analysis section for details.

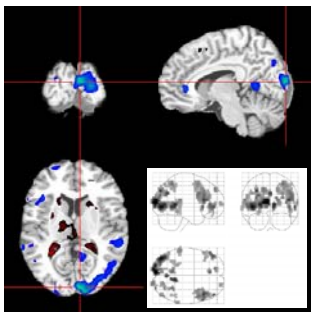

Fig 2. RFX analysis of alpha band under rest (n=11, $p<0.03$ uncorr.) No temporal filter was Applied (Model N)

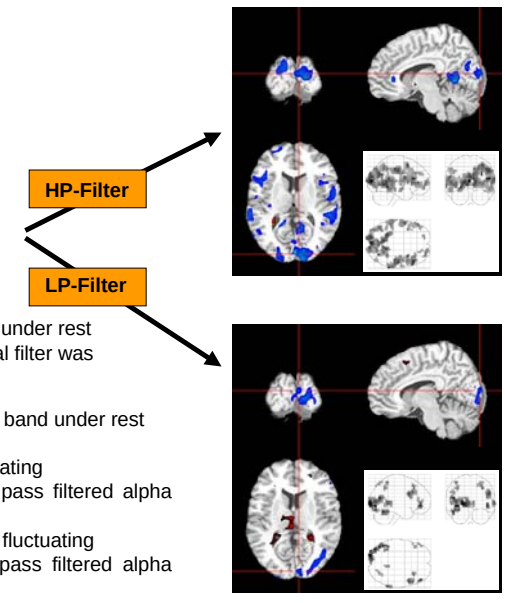

Fig 3. RFX analysis of alpha band under rest (n=11, $p<0.03$ uncorr.)
Top: Correlates of fast fluctuating alpha rhythm (20 sec high pass filtered alpha power, Model H)
Bottom: Correlates of slowly fluctuating alpha rhythm (20 sec low pass filtered alpha power, Model L)

Abbreviations

BOLD Blood Oxygen Level Dependent
EEG Electroencephalography
fMRI functional Magnetic Resonance
SPM Statistical Parametric Mapping

References

1. Goldman RI et al. (2002) 2002 20;13(18):2487-92
2. Laufs H et al. (2003) Neuroimage 19(4):1463-76
3. Moosmann M & Ritter P et al. (2003) Neuroimage 20(1):145-58.
4. Goldman RI et al. (2003) SFN New Orleans 401.419
5. Allen PJ et al. (2000) Neuroimage 12(2): 230-9.

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