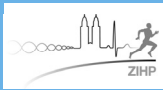




Frontal theta activity modulates resting state activity in the 'default network': a simultaneous EEG-fMRI study



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Introduction

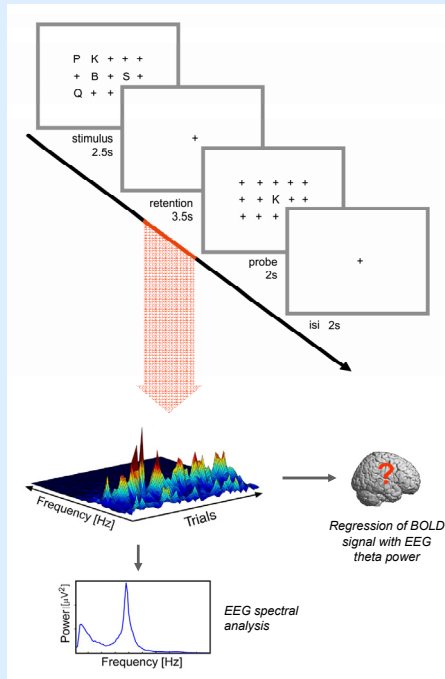
- In the current fMRI literature much attention is given to the default mode of brain function, a mode of brain function during rest, which is suspended during tasks [1].
- Frontal theta EEG power correlates negatively with the fMRI (BOLD) signal within the default network during rest [2].
- Frontal theta EEG power increases with working memory load during retention [3].

Goal:

- In this study we aim to investigate whether theta power fluctuations during the retention interval of a working memory task are related to the default network using fully simultaneous EEG-fMRI measurements.

Methods

Subjects: 16 healthy adults (20-31 years, 8 females)



Working memory task:

Sets of either 2 or 5 consonants (stimulus, memory workload L2 and L5) were presented for 2.5s and had to be retained in memory for 3.5s. After the retention interval a probe letter was shown. Subjects indicated by button press whether the probe was part of the stimulus. Trials were presented in blocks of 40s, the baseline fixation condition in six blocks of 24.5s.

Simultaneous EEG-fMRI:

- EEG: 60 EEG, 2 EOG and 2 ECG channels recorded at 5kHz and 32mV input range.
- fMRI: 3T MR Scanner, EPI (33 slices, TR = 1815ms, voxel size = 3.44 x 3.44 x 3.8mm³).

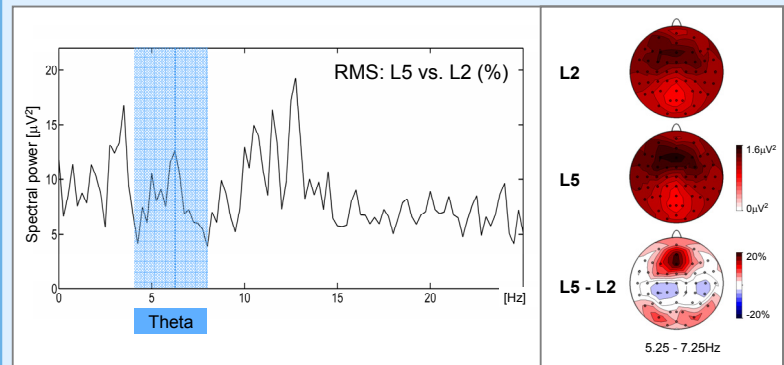
Analysis:

- EEG: cardioballistic and MR gradient artifact correction, filter (0.5-50Hz), manual and ICA based artifact rejection, average reference, spectral power of theta (5.25-7.25Hz) frequency band during the last 2.5s of retention interval (Figure: red line).
- fMRI image processing: realignment, normalization, smoothing (SPM5).
- fMRI design included the conditions: stimulus, retention and probe for each workload (L2, L5). Additional regressor for retention: RMS of EEG theta power.

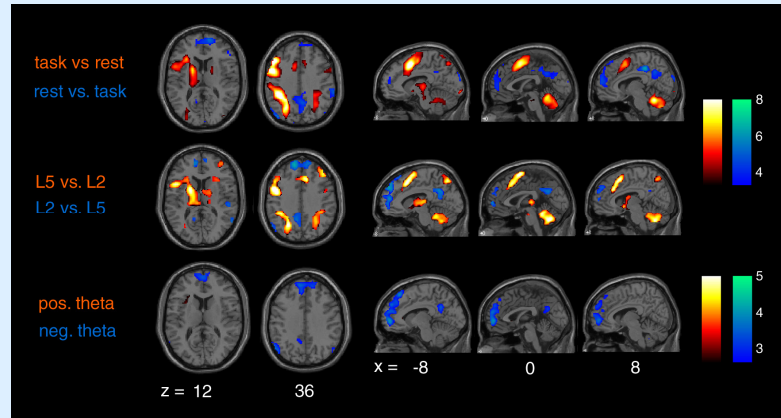
References:

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- Scheeringa, R. Int J Psychophysiol 67 (2008) 242-251.
- Michels, L. Neuroimage 40 (2008) 1296-1310

Results



Left: EEG power spectrum (RMS) for the difference 'L5 vs. L2' (in percent) during retention. Theta range 4-8Hz is shown in blue. The blue line indicates the peak of 'L5 vs. L2' at 6.25Hz. Right: Topographical maps of spectral power for L2, L5 and 'L5 vs. L2'.



BOLD activation evoked by the comparison of task and rest (top) and memory workload L5 and L2 (middle) (FDR corrected, $p < 0.005$, $k > 10$). Bottom: Brain regions where BOLD fMRI signal is positively (red) or negatively correlated (blue) with spontaneous theta power fluctuations during retention (uncorrected, $p < 0.005$, $k > 10$).

Right: The similarity between task- and EEG-related responses was tested by a conjunction analysis: contrasts 'rest vs. task & L2 vs. L5 & negative theta' (uncorrected, $p < 0.005$, $k > 10$).

Discussion

- Both workload related activation and deactivation were found during encoding, retention and retrieval. The contrast 'L5 vs. L2' mainly activated regions that showed task related activation, whereas the contrast 'L2 vs. L5' activated regions within the default network (posterior cingulate, middle temporal and frontal gyrus).
 - The default brain function is gradually suspended during a working memory task, depending on workload.
- Frontal theta activity during retention correlated negatively with the BOLD signal in the default network. The overlap of these effects was proven by a conjunction analysis.
 - Activity in the default network is controlled by suppression of frontal theta EEG.
 - Interestingly, frontal EEG theta power increases are known as a „task marker“. However, only sparse positive correlations of theta power with BOLD signal were found.
- For task-related modulation in other EEG frequency bands, see poster nr. x.