Baseline CBF correlation with individual alpha peak frequency

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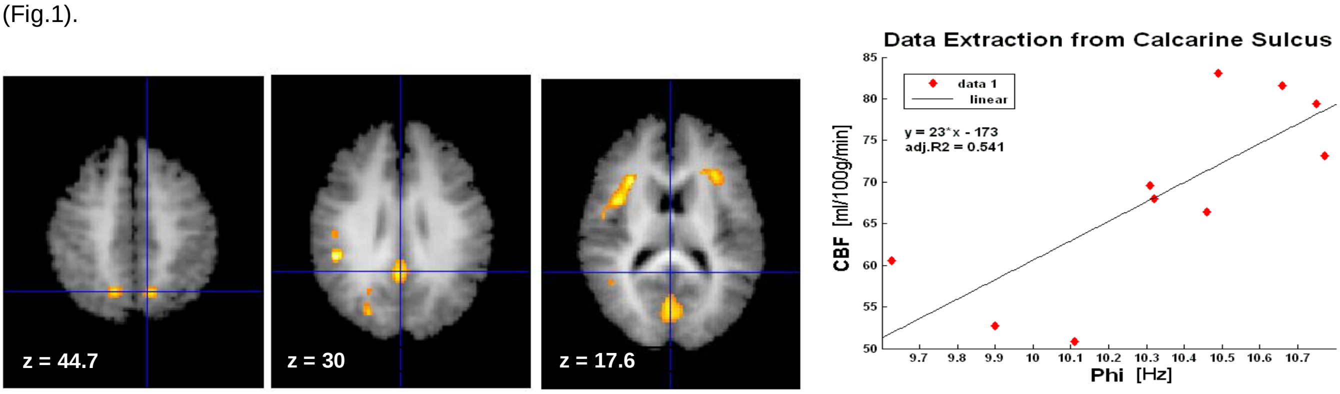
Introduction: The level of arousal and vigilance of a subject is important for its reactivity and responsiveness to environmental changes. The level of vigilance is reflected in the electrical brain activity: the faster the EEG oscillations the more vigilant is the subject [1]. One parameter for the frequency of EEG oscillations is the Individual Alpha Frequency (IAF; [2]). Many studies report on individual differences in vigilance and IAF during the performance of a task that influences performance (i.e. speed of information processing, memory performance; [3]). Accordingly, the level of responsiveness as measured by IAF should be linked to cerebral metabolism. Cerebral blood flow (CBF) can serve as a direct measure of metabolic demand according to the "Balloon-Model" [4, 5]. However, to our knowledge, no study so far has addressed the question of a putative relationship between IAF and baseline CBF in humans. In the present study we therefore aimed to compute correlations between IAF and CBF measures in order to test the following hypotheses: i) we expect a positive relationship between IAF and CBF since higher baseline CBF would represent an increased preparedness of the cerebral areas to respond to external stimuli and ii) we expect that these putative correlations may delineate sensory regions and regions associated with vigilance control.

Methods: Ten healthy subjects (4 female, 6 male, mean age ± SD 25.7 ± 2.5 years) were investigated in this exploratory study. All subjects were measured in the morning and had refrained from nicotine, caffeine and alcohol. No subject reported any psychiatric or neurological disorder or use of psychoactive substances.

Prior to imaging, a 92 channel scalp EEG (5kHz sampling rate, bandpass filter 0.1-250Hz, impedance at electrode positions below 20kΩ) was acquired during 6 minutes. In a first step, the raw EEG data were downsampled to 500Hz and subsequently the subject's individual IAF was computed using a measure of global frequency in a state-space model (Phi; [6]) after band-pass filtering the EEG in the alpha frequency (8-13Hz). Then, Perfusion Weighted Imaging using a PASL was performed using a Fair QUIPSSII perfusion mode [7] (14 slices, voxel size=3.4×3.4×6.0 mm, TA=5min 9sec, lambda=0.9 mL/g, alpha=95%, TE/TR/post label delay [ms] =11/3000/1000. The subjects were instructed to avoid any motion and any structured thoughts but to not fall asleep. All imaging was performed on a 3T MR scanner using an 8 channel head coil. Absolute CBF maps for ASL were calculated using MATLAB/SPM programs. SPM2 was used for preprocessing of PASL data. Voxelwise correlation between the Phi and the CBF were computed across subjects in SPM. To account for individual differences in perfusion, we used the subjects' global mean CBF as covariate in the analysis.

Results: We found mainly positive correlations between the CBF and Phi. Regions involved were the calcarine sulcus, posterior cingulate gyrus, bilateral superior parietal lobe, bilateral anterior insula and left inferior frontal gyrus including the angular gyrus (Fig.1).



a) b)

Figure 1: a) SPM maps showing the positive correlation pattern between IAF and CBF ($p<0.05$, uncorrected). b) Scatter-Plot shows correlation between Phi and CBF (data extraction of voxel within calcarine sulcus [MNI=1,-76, 18]).

Conclusions: In the present explorative study we observed a positive correlation between IAF and baseline CBF. The regions yielding positive correlations can be associated to sensory areas (calcarine sulcus, superior parietal lobe), areas assumed to play a role in monitoring of the internal and external environment (insula) and areas associated with selective attention (inferior frontal lobe and supramarginal gyrus). Accordingly, subjects with a higher IAF demonstrated a higher baseline CBF that could be interpreted as a preactivation of these areas. Hence, one may speculate that inter-individual differences in task performance and/or speed of information processing may be due to increased baseline states (state dependent stimulus processing, [8]).

References:

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