Correlation between simultaneously recorded Full-band EEG and BOLD at rest

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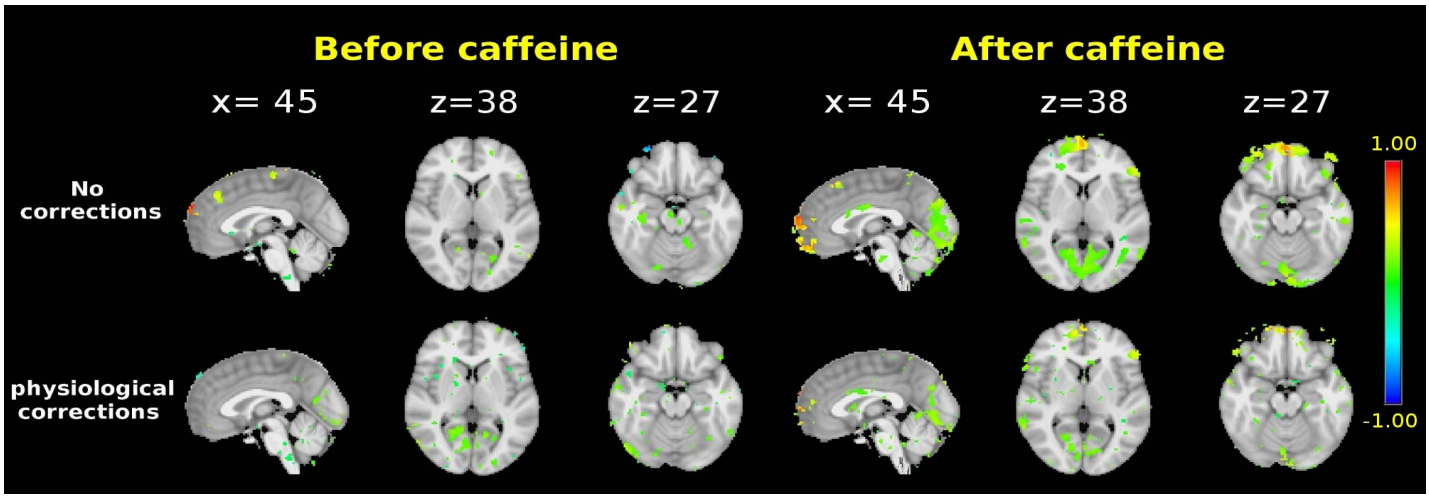
Introduction Several studies have found correlations between EEG bands and BOLD signal (1,2). Full-band EEG (FbEEG) enables investigation of very low (0.01- 0.1 Hz) brain fluctuations which modulate cortical excitability and interictal epileptic activity (3). In this study we investigated the correlation between FbEEG and BOLD signal fluctuations recorded simultaneously. We have hypothesized that low frequency FbEEG recordings at rest correlate to the most active brain network at rest, i.e. default mode network (DMN). We also investigated how the amplification of vasomotor waves by caffeine alters the FbEEG vs. BOLD correlation. Finally we investigated how physiological correction of respiratory and cardiac signals affects the results.

Methods Twelve healthy subjects (age 24 ± 3.3 years, 2 ♀, 10 ♂) underwent 2 resting state scans, with simultaneous recorded EEG. Recordings were performed for each subject before and 30 min after administration of caffeine (200 mg). The MRI scanning was performed using EPI GRE sequence (TR 1.8 s, TE 40 ms, 28 slices 4mm thick with 0.4 mm slice gap, FOV 25.6 cm x 25.6 cm with a 64 x 64 matrix, flip angle 90°). A 32-channel MR-compatible BrainAmp system was used for EEG recordings, with 32 Channel BrainCap MRI. Physiological correction (RETROICOR and RVT) was performed with AFNI software. BOLD data preprocessing (motion correction, slice time correction and normalization) were carried out in FSL. Imaging and ballistocardiographic (BCG) artifacts were removed offline using the Brain Vision Analyzer (4). Infinite impulse response (IIR) Filter was used to filter the data 0.002-0.5 Hz. Correlation between BOLD and low frequency filtered FbEEG was performed using AFNI with statistical threshold of $p < 0.05$, t-value > 2.2.

Results Detectable correlations between FbEEG and resting state BOLD were located in the dorsomedial prefrontal cortex (dMPFC), left superior medial and precentral gyri. Caffeine administration augmented the correlations in dMPFC and more correlating areas were observed in; ventromedial prefrontal cortex (vMPFC), cuneus, lingual, middle occipital, middle temporal gyri and right anterior cingulate. These correlations were reduced after physiological corrections. Group-mean images comparing before to after caffeine administration with and without physiological corrections are shown below (Fig.1).



Discussion Low frequency fluctuations recorded using FbEEG correlate to the anterior compartment of DMN. Caffeine increases the strength of FbEEG & BOLD correlations, which may be due to increased vasomotor waves and altered neurovascular coupling (5). Physiological corrections showed a decrease but not total removal of the correlation between FbEEG and BOLD. This was interpreted as a sign of *partial* physiological origin of the detected fluctuations. These findings suggest that the correlation between FbEEG and BOLD in the anterior compartment of DMN is of a neurophysiological origin. We conclude that a correlation between BOLD and FbEEG was detected specifically in the anterior compartment of DMN.

References

1. D. Mantini et al. Proc Natl Acad Sci USA 2007.
2. Laufs et al. Proc Natl Acad Sci USA 2003.
3. Vanhatalo et al. Proc Natl Acad Sci USA 2004.
4. Allen et al. NeuroImage 1998, 2000.
5. Perthen et al. NeuroImage 2007.