BRAIN RHYTHMS ALTERATIONS AND THEIR EFFECT IN FUNCTIONAL NETWORKS: A SIMULTANEOUS EEG/FMRI STUDY IN FIXATION-OFF EPILEPSY

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Introduction

Fixation-off sensitivity (FOS) denotes the forms of EEG abnormalities, which are elicited by elimination of central vision or fixation. The phenomenon seems to depend on variables that modulate the alpha rhythm, however, the cerebral mechanisms underlying FOS remain unclear [1]. The scarce previous fMRI findings related to FOS have shown activation in extrastriate cortex [2] and also in frontal areas [3][4]. On the other hand, simultaneous EEG-fMRI technique has been used to assess the relationship between spontaneous power fluctuations of electrical rhythms and associated fMRI signal modulations. These studies have identified that lateral frontoparietal networks show a negative correlation with alpha band in healthy subjects. This neuroanatomical pattern is related to attentional processes and cognitive resources. Moreover, a sub-beta band (17-23 Hz) has been identified with posterior cingulate, temporoparietal junction and dorso-medial prefrontal cortex activations, which correspond to the DMN [5][6].

Material and Methods

Patients. We studied two female patients (24 and 18 years) with FOS. Both of them have seizures refractory to medication and present cognitive impairment. Previous EEG after the elimination of fixation showed different patterns for both patients. High voltage beta activity (18 Hz) joint to generalized 3 Hz spike-wave more prominent in frontal areas were detected for patient 1. Beta activity (15 Hz) and high voltage 3Hz spike-wave were found more prominent in left hemisphere for patient 2.

Data Acquisition. **EEG data** were recorded using a Brain Products MR-compatible EEG system with 32-channels EEG. **fMRI data** were collected using a General Electric Signa 3.0 T MR scanner using a GE EPI fMRI sequence. An optimal synchronization scheme between EEG and MR systems was used to improve the EEG artefact removal [6]. Three fMRI series were performed: resting state (rs) with open and close eyes (120 vol.) and a block design with 20-sec epochs alternating open-close eyes (70 vol.)

Data preprocessing. **EEG data** Brain Vision Analyzer 2.0 was used to remove MR scanner artefacts in the EEG. **fMRI data** Standard preprocessing was preformed on MR images using FSL.

Data analyses. **EEG data** i) The power time series from three bands of interest -alpha (8-12 Hz), theta (2-4 Hz) and beta (14-19 Hz)- were computed for each corresponding fMRI sequence (one EEG power value per fMRI volume) using Matlab 2008. The power time series were calculated as the mean power of the EEG electrodes showing higher than 80% from the maximum mean power electrode for each band [7]. Regressors for the fMRI analyses were calculated using these time-series convolved with the Canonical HRF (Matlab and SPM8). **fMRI data** ii) Three GLM designs per fMRI series were computed using these power time series regressors as variables of interest including the movement parameters as confound variables to obtain spatial statistical maps (SPM8). The statistical analyses were considered significant for a $p<0.05$ (FWE corrected, cluster 10). iii) Independent Component Analyses on the resting-state fMRI series were computed to obtain functional networks using a model-free approach.

Results

Figure 1(A) shows the fMRI regressors per band of interest extracted from the EEG data corresponding with the open-close eyes fMRI series for patient 1 and patient 2. It can be observed that whilst all three bands of interest increase with the eyes closure in patient 2, the only band that follows the experiment is beta band in patient 1. In Figure 1(B-C), it is shown the brain activation related to the beta regressor for patient 1 (B) and for patient 2 (C). For patient1, positive correlation with the beta band was found in bilateral temporoparietal areas including precuneus, frontal and occipital areas. In contrast, for patient 2 the correlation with the beta regressor (which was quite similar to alpha and theta regressors) shows both positive and negative correlations. Positive correlations were found in bilateral superior parietal lobes, precuneus, posterior cingulum and occipital lobes whileas negative correlations were observed in temporal and lateral parietal lobes and frontal areas. Analyzing the rs-fMRI with ICA these same brain regions could be identified as rs networks.

Conclusion

The methodology in this work has given us new results, not previously found, related to the FOS epilepsy effects in two patients. On one hand, EEG points out the different brain rhythms alterations for both patients after eye closure indicating different FOS. This might help to improve the diagnosis and treatment of these patients and to explain the different fMRI activation pattern. The patient's positive and negative correlations with beta band, in regions that overlapped with areas related to alpha band in control subjects [5][6], might shed light in the underlying mechanisms and their effects in FOS epileptic patients. This latter finding suggests an alteration in the attentional network in these patients as a consequence of their epilepsy. Further analyses have to be done in a larger population to deepen in the knowledge of the generators and, also, in the underlying effects of this syndrome.

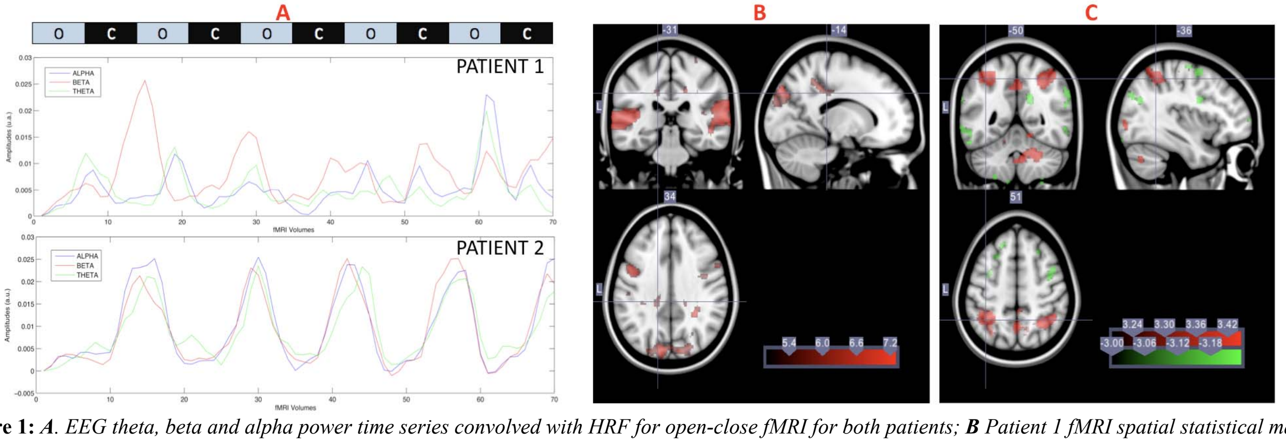

Figure 1: ***A***. *EEG theta, beta and alpha power time series convolved with HRF for open-close fMRI for both patients;* ***B*** *Patient 1 fMRI spatial statistical map using beta power regressor;* ***C*** *Patient 2 fMRI spatial statistical map using beta regressor*

Bibliography

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