# Functional Connectivity Based Decoding Performance on SSVEP Brain-Computer Interfaces

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**Introduction:** The study of brain connectivity by means of complex networks has been well succeeded in the diagnosis of brain diseases such as Alzheimer and Parkinson, and, more recently, in investigations concerning the functional organization of brain regions under motor imagery in brain computer interfaces (BCIs) [1,2]. Nevertheless, a deeper investigation of functional connectivity within the steady state visually evoked potential (SSVEP) BCI paradigm is still lacking, which outlines the main objective of this work.

**Materials and Methods:** EEG data were collected from 15 healthy volunteers, using a g.SAHARAsys dry-electrode cap with 16 channels and g.USBamp biosignal amplifier. Subjects focused for 6 seconds on one of four visual stimuli frequencies (10Hz, 11Hz, 12Hz and 13Hz), twelve times for each frequency. The project was approved by the local ethics committee. Signals were segmented in 2 s epochs and functional connectivity was estimated by Pearson correlation. An adjacency matrix was defined using $\rho = 0.71$ as correlation threshold. Four graph-based metrics were computed (degree, clustering coefficient, betweenness and eigenvector centralities). Decoding performance was compared with feature extraction based on the fast Fourier transform (FFT) coefficients estimated on the stimuli frequencies (first scenario) and also considering coefficients up to the third harmonic (FFT-harmonic – second scenario), as usually employed in SSVEP-BCIs. In all feature extraction procedures, 24 features were used after selection by the Davies-Bouldin index and discriminated by a linear least squares classifier in a leave *M* out cross validation scheme.

**Results:** Figure 1 shows the mean accuracy for FFT, FFT-harmonic and for the functional connectivity approach. The FFT-harmonic approach exhibited the best performance, obtaining an accuracy of 0.91 ± 0.10, significantly better than the FFT (0.77 ± 0.19) and graph measures (0.56 ± 0.12) – Kruskal-Wallis test (*p*-value < 0.01) with Dunn's multiple comparison test.

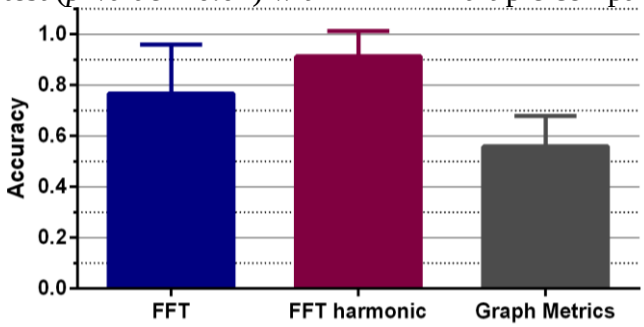


Figure 1. Accuracy of FFT, FFT- harmonic and graph functional connectivity measures.

**Discussion and Conclusion:** The traditional SSVEP BCI approach (FFT-harmonic) obtained the best performance, being significantly better than the graph-based metrics obtained from functional connectivity estimated by Pearson correlation. Nevertheless, there is relevant information in connectivity measures that were able to identify differences between classes, which encourages the use of more robust measures of similarity in this context.

**References:** [1] 10.1016/j.media.2016.03.003; [2] 10.1162/NECO_a_00838.

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