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MI-BCI Performances correlate with subject-specific frequency band characteristics

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Introduction: Motor Imagery (MI) tasks modulate EEG activity, notably in the α and β frequency bands (8-30 Hz). During BCI calibration, data driven methods are often used to select features in those bands, with little consideration for the resulting human performances. Can this approach reach optimal performances? To answer this question, this study investigated the relationship between the characteristics of subject-specific frequency bands selected by machine learning (mean frequency (FB-Mean) and length (FB-Length)) and online BCI users' performances.

Material, Methods and Results: We analysed the data of 59 healthy MI-BCI naïve subjects from the dataset presented in [1]. Each subject was trained to perform two MI-tasks - imagining right- and left-hand movements - during one MI-BCI session (6 runs of 20 trials/MI-task: 2 calibration runs and 4 feedback runs). From the calibration runs, we selected the most discriminant frequency band in the α-β range using the algorithm introduced in [2]. MI-BCI performance was assessed as the classification accuracy (CA) averaged over all feedback epochs during the feedback runs.

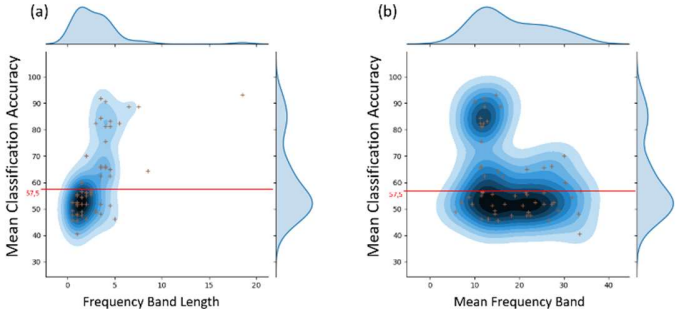

Figure 1. *Bivariate distribution of the frequency band length (a) and the mean frequency of the band (b) with the mean classification accuracy. In red, the chance level for 2-classes, 80 trials per class and α=5%*

We then studied how the FB-mean and FB-length obtained using machine learning were related to online CA, by studying their correlation and distribution. The results showed a significant Pearson correlation between mean CA and both FB-Length ($r = 0.67$, $p<0.001$) and FB-Mean ($r = -0.34$, $p<0.01$) (see also Fig. 1).

Discussion: The characteristics of the frequency band selected by machine learning correlated with online CA. Subjects with the highest CA were the ones for whom the selected frequency bands were narrow (FB-Length: ~[2-6] Hz) and centered in α-lowβ (FB_Mean: ~[11-20] Hz).

Significance: Our study suggests that online MI-BCI performances correlate with the characteristics of the frequency band, selected using machine learning. This raises questions regarding the causality link direction: could we use this frequency band to predict online performances? Could we improve machine learning algorithms with constraints on the band to be selected? Is this correlation due to a covert confounding factor (e.g., mental strategy)?

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