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Online Accuracy of Invasive and Non-invasive MI BCI

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Introduction: A brain-computer interface (BCI) allows a person to intuitively interact with the environment without movement. This functionality can be further enhanced by a BCI that delivers continuous signals. Such BCIs are usually based on event-related desynchronization (ERD) extracted either from electroencephalographic (EEG) or electrocorticographic (ECoG) recordings during a motor imagery (MI) task [1, 2]. Common spatial patterns (CSP) have been widely established in multi-channel BCIs with online feedback since the resulting features are highly discriminative and signal dimensionality can be dramatically reduced [1, 2]. Although BCIs based on ECoG are known to provide more powerful control signals than those operating on signals from EEG, it is difficult yet to directly compare these two methods in terms of performance and accuracy. Such a comparison has been conducted within an offline study, where the subjects did not receive any online feedback [3]. As an extension of that study, in this work, we attempt to compare the online accuracy of invasive and non-invasive BCIs with feedback over several runs.

Material, Methods and Results: Four epilepsy patients with temporarily implanted subdural electrode grids and 20 healthy subjects volunteered to participate in a MI BCI experiment with invasive (i.e. ECoG) and non-invasive (i.e. EEG) recordings, respectively. While the healthy subjects were trained to imagine left and right hand movement during EEG recordings, the patients in the invasive experiment were instructed to either remain idle or imagine hand movement of the contralateral side of the implanted sites. During the experiment, the participants were positioned in front of a feedback monitor showing the cue of the current task as well as the classification result. For evaluation, only data from electrodes covering the motor cortex were taken (ECoG: 20-60 channels, EEG: 27 channels). After visual inspection of recorded signals, the data were band-pass filtered at 8-32 Hz. Signals were further epoched and spatially filtered by CSPs determined from the most discriminative time window. A linear classifier was then trained based on the variance of the four most prominent CSP features, computed by means of a sliding window of 1.0 s. Several runs were executed for each subject, where successive data sets were used for training and test (e.g. classifier determined from data set n was tested with data set n+1). As illustrated in Fig.1, the average accuracy for all EEG and ECoG runs is 76.0 % and 94.6 %, respectively.

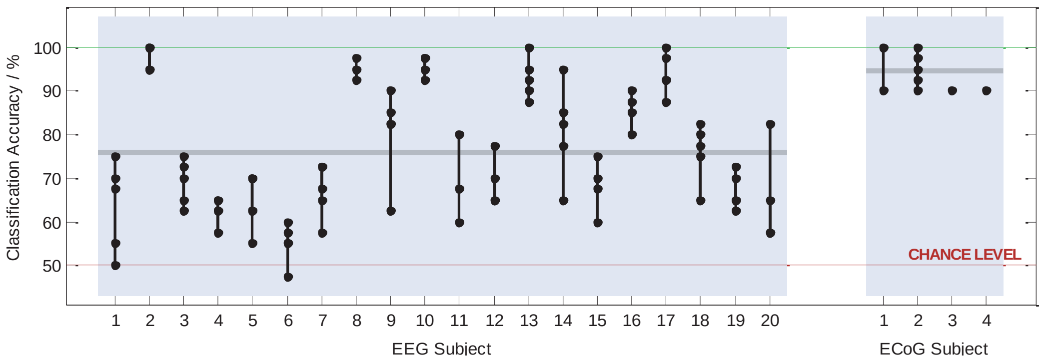

Figure 1. *Online accuarcy of the MI BCI with classification feedback. A filled circle represents the accuracy over 40 trials in total.*

Discussion: Providing a robust idle state is a problem for most BCIs using EEG. The invasive system provides such a state, despite this, the accuracy is higher and seems to be more stable over time. Additionally, for the EEG system, several trials had to be rejected during the calibration, which was not the case for the invasive system.

Significance: MI-based invasive BCIs provide a reliably classifiable idle state, which is crucial for continuous control of a device. Furthermore, compared to EEG, less training is required to achieve a classification accuracy sufficiently high to interact with the environment.

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