 DOI: 10.3217/978-3-85125-962-9-37

A feasibility study on the development of a movement related cortical potential based brain-computer interface for communication in patients with amyotrophic lateral sclerosis

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Introduction. Besides the implemented algorithms and hardware, a key component of a brain computer interface (BCI) is the brain signal used to control the external device. There are several brain signals that have been implemented such as evoked potentials e.g. the P300 signal, but also spontaneous potentials such as the movement related cortical potential (MRCP) [1, 2]. The MRCP is a slow cortical potential that arises during the preparation and execution of movements or only during movement imagination [3]. In contrast to the P300-based BCI, an MRCP-based BCI may provide with several advantages. The MRCP develops naturally without external stimuli and can be retrieved immediately without extensive practice. In this study, we investigated the feasibility of controlling an MRCP-based BCI speller. The aim was to quantify the morphology of the MRCP of individual subjects during a simple movement task either performed alone or in combination with the cognitive task of selecting letters presented as a visual cue.

Materials, Methods, and Results. Electroencephalography (EEG) signals from 10 channels (FP1, Fz, FC1, FC2,C3,Cz,C4,CP1,CP2 und Pz) were recorded from ten healthy volunteers (3 female and 7 male , 37 ± 13 years old) during a simple motor task (30 dorsiflexions - DF) and during a combination of a cognitive (spelling) and motor task guided by a visual cue (DF+spelling). The DF+spelling task comprised spelling two sentences with 14-15 letters per sentence presented to each subject in randomized order. To select the appropriate letter, the subject had to perform a dorsiflexion when the desired line and letter appeared. Between each sentence the subjects were allowed to rest for 1-5 minutes. The DF task was performed at the beginning and at the end of the session and served as the control MRCP. EEG signals were subsequently analysed offline; bandpass filtered between 0.05 to 5 Hz using a Butterwortth bandpass filter and segmented into epochs from 2s before to 2s after task onset. Eleven temporal features obtained from each trial by extracting the time and amplitude of the peak negativity of the MRCP and the slopes of different time intervals of the MRCP, including their variability were then extracted and used to compare the individual MRCPs for all conditions. A paired t-test with a Bonferroni correction was applied with significance level of p=0.0045.

The results showed that the extracted MRCP signals had the typical morphology for all conditions. Therefore, the additional cognitive task had no effect on the quality of the MRCP. With a threshold of p=0.0045, no difference was found between the DF and DF+spelling tasks. However, a significant difference was found for the variability of the late negativity of the MRCP when comparing the last DF+spelling task to all other tasks, indicating a possible adaptation and training effect. In addition, a decrease in amplitude was observed in the last DF task compared to the first DF task, which may have been induced by fatigue.

Discussion and Significance. Since the morphology of the MRCP and most of the extracted features did not show significant differences across tasks, the development of an MRCP-based BCI speller is possible and feasible. However, some aspects such as fatigue and adaptability need to be considered in future studies.

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