Movement Related Cortical Potentials and Sensory Motor Rhythms during Self Initiated and Cued Movements

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Abstract. In this study we have explored the two EEG phenomena that accompany movement preparation and execution: movement related cortical potentials (MRCP) and event-related desynchronization/synchronization (ERD/ERS). The experiments comprised the two conditions for motor task initiation, self paced and cued. The aim of the study was to explore how the introduction of the cue influences the morphological features of the MRCP and ERD/ERS curves. Preliminary results of the tests in 9 healthy subjects showed statistically significant differences in MRCP components for the two conditions and no significant differences in ERD/ERS morphology. Brain-Computer Interface algorithms for online control of assistive devices for restoration of movement may benefit from these results.

1 Introduction

Brain Computer Interface (BCI) technology has been used to restore lost motor function in stroke patients or other traumatic brain disorders by helping to guide activity-dependent brain plasticity [1]. Treatments that combine functional electrical stimulation (FES) or assistive robots with motor tasks (imagined or attempted) are expected to be more effective than using them separately [2]. EEG
signal acquisition can be used for detecting the changes that accompany these tasks and a BCI device can convert those changes into commands that trigger FES or activate an assistive robotic system [3].

Two types of EEG movement related signals have been investigated as potential candidates for the control of the restorative BCI system based on attempted or imagined movements: event related desynchronization/ synchronization (ERD/ERS) of the sensory motor rhythms and movement related cortical potentials (MRCP) [4, 5]. Although both responses originate in the related cortical regions and display common temporal features, their magnitudes and spatial distributions appear to be independent of each other, which suggests that the physiological mechanisms governing these two signals are different and may represent distinctive aspects of motor cortex activation [6]. Both modalities have certain advantages and disadvantages when used as control signals for BCI that appear to be of a complementary nature. ERD/ERS have often been implemented for asynchronous BCI control since in trained users they can be accurately detected on a single-trial basis [7, 8]. Additionally, mu ERD initiates 0.5-2 seconds prior to movement giving the possibility of online detection of movement intention [9, 10].

Precise temporally synchronized contingent sensory feedback is essential, for Hebbian-based restorative BCI control [5]. The main drawback of ERD/ERS as a potential control signal for such restorative BCI is the fact that they do not provide information on precise timing of the stages during movement preparation/execution [6]. The MRCP, on the other hand, comprises precise phases corresponding to the early preparation, initiation and execution of movement [11]. Therefore, with MRCPs, these phases can be exactly detected, which is crucial for the synchronization of the motor commands with the sensory input (i.e. electrical stimulus, movement of the orthosis) [5]. Recent publications show the possibility of movement intention detection from single trial MRCP [12, 13]. However, in the past they were rarely considered as a control signal for asynchronous restorative BCI due to the low signal to noise ratio, which limits the detection accuracy in online studies [2, 10].

We believe that MRCPs and ERD/ERS can be used in a joint mode considering they are complementary to each other in decoding the real and imaginary motor tasks. A hybrid BCI that complements advantages from both, MRCPs and ERD could make the system more robust and suitable in neural rehabilitation. For example, ERD may be used for asynchronous detection of movement intention followed by MRCP-based FES triggering in a synchronized manner with detection of the following negative peak of the MRCP. The presented results are a part of an ongoing study with the aim of exploring features of both MRCP and ERD/ERS to be used for the control of restorative BCI device.

The treatment of combining motor imagery (MI) or motor attempt with precisely temporally synchronized sensory feedback requires repetitive executions of attempted/imagined motor tasks. This can be accomplished in an asynchronous (self-paced) or synchronous (cue-based) mode. Within this study the two paradigms often used in BCI control have been investigated and compared, namely the cued and the self-paced real movements.