Functional Correlation between Human Sensorimotor Oscillations and Motor Cortical Excitability During Overt and Covert Hand Movements.

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Introduction

The practice of motor imagery (MI) has been suggested to improve motor recovery after stroke, by inducing plastic changes in the lesioned hemisphere [1]. The Transcranial Magnetic Stimulation (TMS) technique has become a valuable tool to map motor cortex excitability during MI [2]. A modulation of the EEG oscillatory activity within the alpha and beta ranges of frequency (i.e. sensorimotor EEG rhythms) occurs during voluntary execution as well as imagination of simple motor tasks [3]. This phenomenon has been exploited to operate some types of EEG-based brain computer interfaces (BCI). In the perspective of developing a BCI-based rehabilitation tool grounded on EEG monitoring of MI, we investigated by means of TMS, if and how the EEG sensorimotor rhythms modulation functionally correlates with the changes in motor cortical excitability during covert hand motor tasks.

Methods

The scalp EEG and TMS data were collected from 13 healthy volunteers (mean age 25±10 years) who were verbally instructed to either execute (ME) or imagine (MI) a simple motor task with their non-dominant hand. EEG data were acquired through a 64 channels EEG cap, filtered (band-pass 0.1-70 Hz; sample frequency 200 sample/s) and stored for offline analysis. Single TMS pulses were delivered (at 120% of motor threshold) through a figure-of-eight coil over the right hemisphere in the optimal position to elicit Motor Evoked Potentials (MEPs) in the contralateral Opponens Pollicis (OPP) and Extensor Digitorum Communis (EDC) muscle. EEG epochs (1 s duration) preceding each TMS shock were analyzed; power spectral density for each channel and each frequency bin (2 Hz resolution) was computed. The ME and MI tasks were contrasted with baseline condition (Rest). Mean MEP amplitudes and EEG spectrum power from channels with highest r² values of all subjects were compared. EEG spectral features and MEP amplitudes were aligned and time series were correlated on a trial by trial basis for each subject.

Results

The performance of ME and MI task induced, in all subject, a significant increase in MEP amplitude recorded from the OPP muscle (ME: p=0.00006; MI: p=0.0001) concomitantly with a significant reduction in EEG spectrum power (ME: p=0.0001; MI: p=0.00007; frequency range 12-26 Hz; ME: r² values from 0.15 to 0.5; MI: r² values from 0.1 to 0.5) [see fig.1] localized over the scalp sensorimotor areas. During ME, the increase in MEP amplitude significantly correlated with the decrease in the EEG power spectrum (p<.01), in 12 out of 13 subjects. A similar tendency to countervary was observed, in all subjects, for the MEP amplitude and EEG features under MI condition; this tendency reached significance (p<.03) only in 3 subjects who were previously exposed to a MI-based BCI training [see fig.2].

Discussion

The present EEG and TMS findings mainly indicate that MI facilitation effect on motor cortical excitability is variable among subjects, but it becomes very robust in subjects previously trained to perform this cognitive motor task to operate a BCI system. Thus, we suggest that BCI technology and TMS can be successfully adopted to tailor the development of a novel post-stroke “rehabilitation intervention” based on the practice of MI.

References: