EEG mu rhythm and TMS induced motor evoked potentials in the measurement of the perception/execution matching system: A neuronavigated study

Lepage, JF; Saint-Amour, D & Théoret, H

Centre de Recherche en Neuropsychologie et Cognition, Université de Montréal, Canada

Centre de Recherche CHU Ste-Justine, Montréal, Canada.

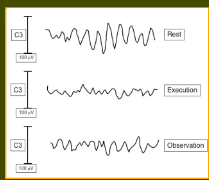
INTRODUCTION

Recent data suggest a link between the amplitude of TMS-induced motor evoked potentials (MEPs) and ongoing EEG oscillatory activity preceding the TMS pulse in motor cortex. Indeed, a significant negative correlation between MEP amplitude and power in the alpha frequency has been reported at rest[1].

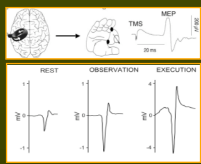
During action observation, the amplitude of TMS-induced MEPs increases[2] while the EEG mu rhythm (part of the alpha band) is attenuated[3], possibliy reflecting mirror neuron system (MNS) activity[4] at the motor cortex level.

To determine the relationship between TMS-induced MEPs and mu desynchronization as they relate to MNS function, simultaneous TMS-EEG was performed while participants executed or passively observed simple hand actions.

EEG Mu rhythm: Sensorimotor rhythm of maximal amplitude at central sites at rest. It is suppressed during the execution and observation of motor actions.



Motor Evoked Potentials (MEPs): MEPs are produced by stimulating primary motor cortex transcranially with TMS. Observation of motor actions increases MEP amplitude



METHODOLOGY

Participants

8 right handed adults (24-29 year-old) with no history of neurological disorders.

Procedure

EEG recordings were sampled at 1024 Hz, with a 1 to 50Hz bandpass filter. Carbon electrodes were placed at central sites (C3-Cz-C4) to record motor cortex activity. TMS was performed with an 80-mm figure-of-eight coil and a Magpro X100 magnetic stimulator (Medtronic) to induce MEPs in the contralateral FDI muscle.

Simultaneous EEG and TMS was performed while participants:

1. Rested with eyes open (Rest)
2. Performed a grasping movement (Execution)
3. Passsively observed a model performing a grasping movement (Observation).

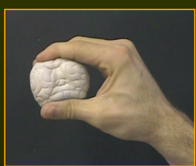
Conditions were run in blocks of 40 trials. A TMS pulse was delivered in the last second of each trial and a minimum of 6 seconds was present between trials. A neuronavigating system (Brainsight) was used to ensure stable coil positioning throughout the experiment.

Analysis

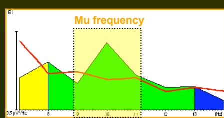
EEG. Signals were analyzed in the 1000 ms epoch preceding the TMS pulse. FFTs were performed on each segment and averaged for each trial across conditions. Two electrodes located at central sites (C3-C4) were pooled and considered for statistical analysis. One participant was rejected because we were unable to define a mu band.

TMS. Peak-to-peak amplitudes of the collected MEPs were measured and averaged for each condition.

TMS and EEG data were submitted to correlational analysis at the individual trial level for each condition.



Hand Movement



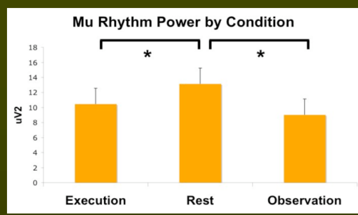
Rest Vs Execution conditions

DISCUSSION

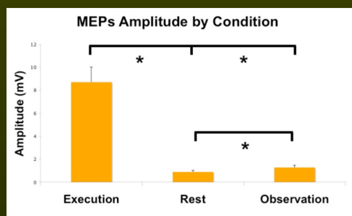
In line with previous studies[2,3], our data have shown 1) a significant increase in MEP amplitude during action observation and execution compared to rest; and 2) a significant attenuation of the EEG mu rhythm during action observation and execution compared to rest. This shows that our simultaneous TMS-EEG approach can detect changes in brain activity presumably related to MNS function. Surprisingly, no relationship was found between the level of MEP amplitude increase and mu rhythm decrease in any of the experimental conditions. Although both techniques appear to be sensitive to MNS activity, our data suggest that they reflect different components of the observation-execution matching process.

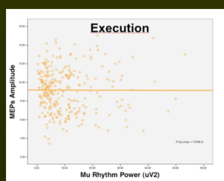
RESULTS

EEG data. A repeated measures ANOVA revealed a **significant main effect of condition** ($F = 6.28$; $p = 0.014$). Post hoc analysis revealed significant decreases in mu rhythm amplitude in the Observation and Execution conditions compared to rest ($p<.05$). There was no significant difference between the Observation and Execution conditions.

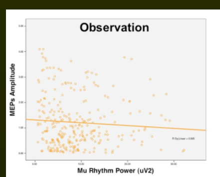


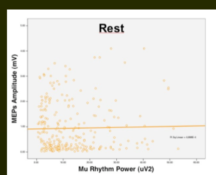
TMS data. A repeated measures ANOVA also revealed a **significant main effect of condition** ($F = 148.83$; $p < 0.001$) . Post-hoc analysis revealed significant differences **between all three conditions**.





TMS and EEG data were not correlated at the individual trial level for any of the three conditions.





1-Zarkowski P, Shin CJ, Dang T, Russo J and Avery D. (2006) EEG and the variance of Motor Evoked Potential Amplitude. *Clinical EEG and Neuroscience* 37: 247-251.

2-Fadiga L, Fogassi L, Pavesi G and Rizzolatti G (1995) Motor facilitation during action observation: a magnetic stimulation study. *Journal of Neurophysiology* 73: 2608-2611.

3- Muthukumaraswamy SD, Johnson BW, McNair NA (2004) Mu rhythm modulation during observation of an object-directed grasp. *Cognitive Brain Research* 19: 195-201.

4-Rizzolatti G and Craighero L. (2004) The Mirror-neuron System. *Annual Review of Neuroscience* 27: 169-192.