# Anodal tDCS of the premotor cortex enhances the effects of motor imagery training on a finger tapping task

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## Introduction

There is ample evidence that motor imagery (MI) training – *i.e.* the mental repetition of movements without corresponding actual execution – contributes to enhance motor performance. Such positive effects are greater when MI is associated with anodal transcranial direct current stimulation (tDCS) applied over the primary motor cortex (Foerster *et al.*, 2013; Saimpont *et al.*, 2016). While it has been repeatedly shown that the premotor cortex is active during MI (Hetu *et al.*, 2013), its involvement in motor learning through MI remains poorly understood.

*Objective*

To test whether anodal tDCS applied over the premotor cortex enhances the benefits of MI training on a finger tapping task.

## Methods

Participants and design

The experiment was conducted in a double-blinded sham-controlled crossover design. Nineteen right-handed adults (mean age = 22.3 ± 2.5 years, 8 females) participated in two experimental sessions whose order was counterbalanced across participants.

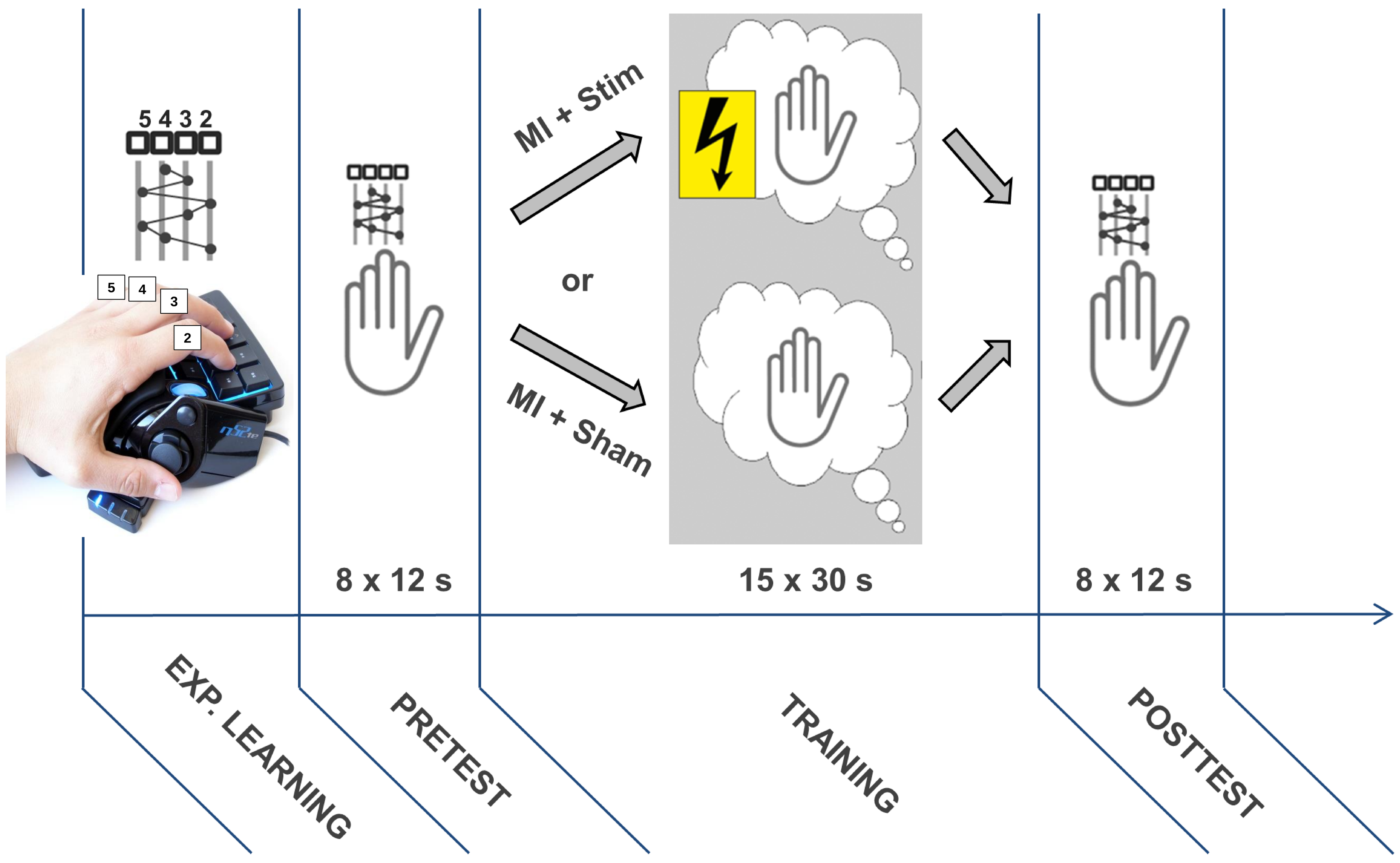



**Figure 1. Schematic view of one session of the experiment.**

EXP. LEARNING: explicit learning of an 8-item finger tapping sequence performed with the left hand on a gaming keypad (Razer Nostromo), *i.e.* performing the sequence three times consecutively without any error. Two sequences of equal difficulty were performed, one for each session: *4 3 5 2 3 5 4 2* and *2 4 5 3 2 5 3 4.*

PRETEST and POSTTEST: repetition of the sequence as fast and accurately as possible during eight blocks of 12 s. Responses were recorded by E-Prime software.

Dependent variables:

- Total number of correct responses, to indirectly assess movement speed.
- Proportion of correct responses (total number of correct responses / total number of responses), to assess movement accuracy.

TRAINING: mental repetition of the sequence during 15 blocks of 30 s interspaced with rest periods of 20 s, with either concomitant (depending on the session):

- Anodal tDCS applied over the right premotor cortex (*MI + Stim* Condition).
- Sham tDCS applied over the same region (*MI + Sham* Condition).

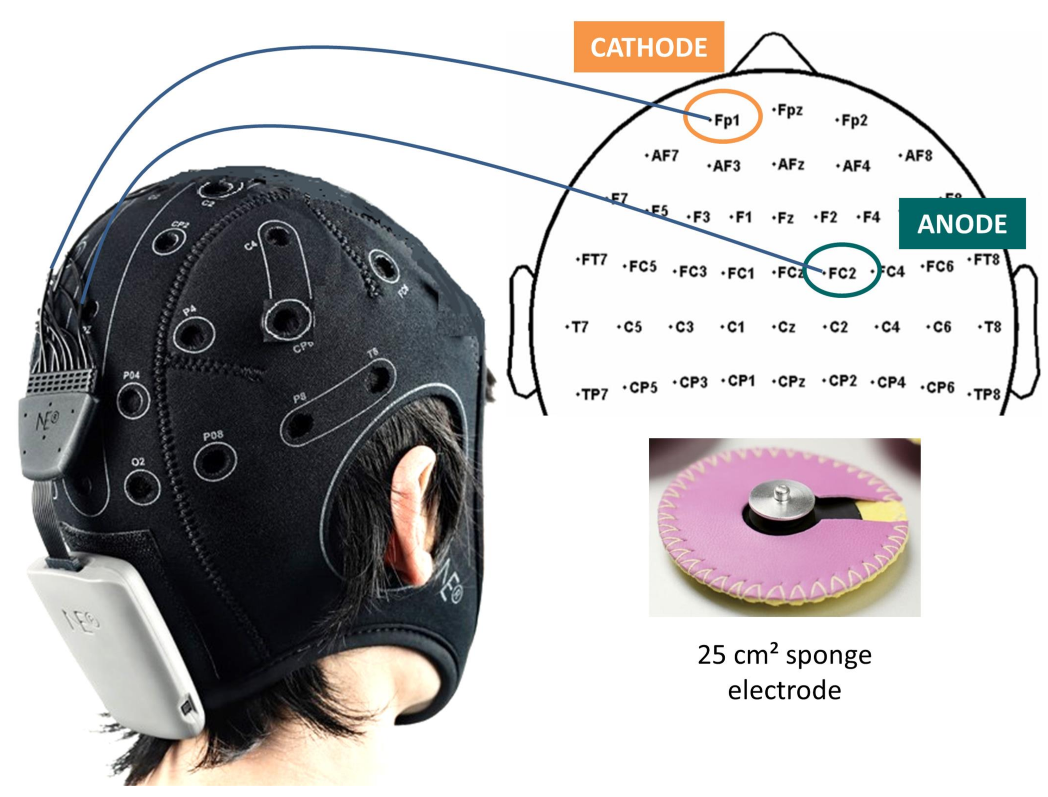
Dependent variable: self-reported level of MI vividness (1 to 5 scale) during MI training, to investigate its relation with performance improvement.

**Figure 2. Stimulation.**

Current of 1.5 mA applied during 13 min using a stimulator (Neuroelectrics) through two 25 cm² conductive-rubber electrodes.

Anode over the right premotor cortex (FC2).
Cathode over the left supra-orbital region (Fp1).

Active tDCS: current ramped up over 45 s until reaching 1.5 mA, then remained constant.
Sham tDCS: current ramped up over 45 s, then faded out to zero.




*Statistical analyses*

Repeated measures ANOVA with Condition (*MI + Stim, MI + Sham*) and Test (*Pretest, Posttest)* as within-subjects, and Friedman test for, respectively, the numbers of correct responses and the proportions of correct responses.

Spearman correlation for the relation between performance improvement and self reported level of MI vividness.

## Results

Movement speed

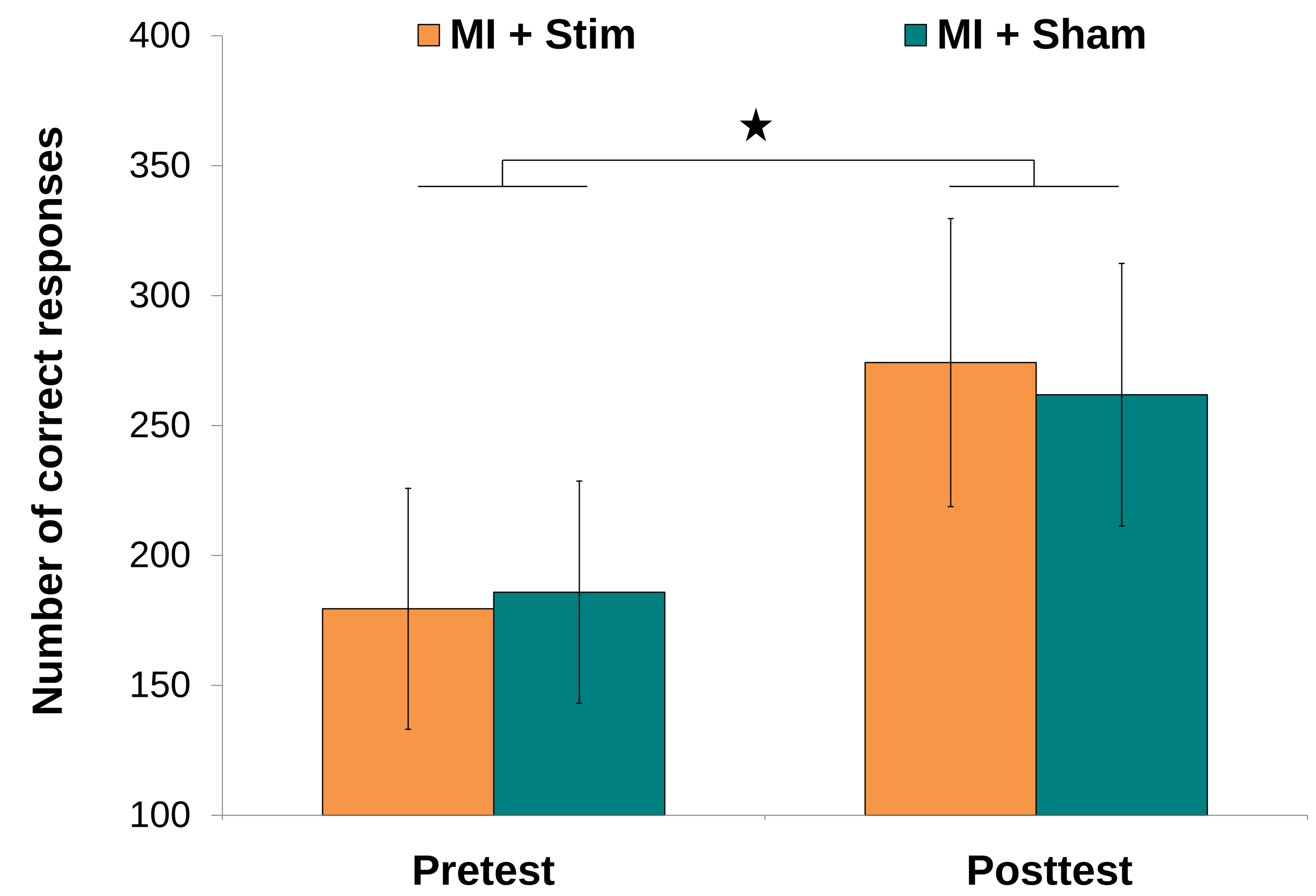



**Figure 3. Mean number of correct responses.** The effect of Test was significant: the number of correct responses was greater during the *Posttest* than during the *Pretest* ($p < .05$, $\eta^2 = 0.89$). Bars are ± standard deviations.

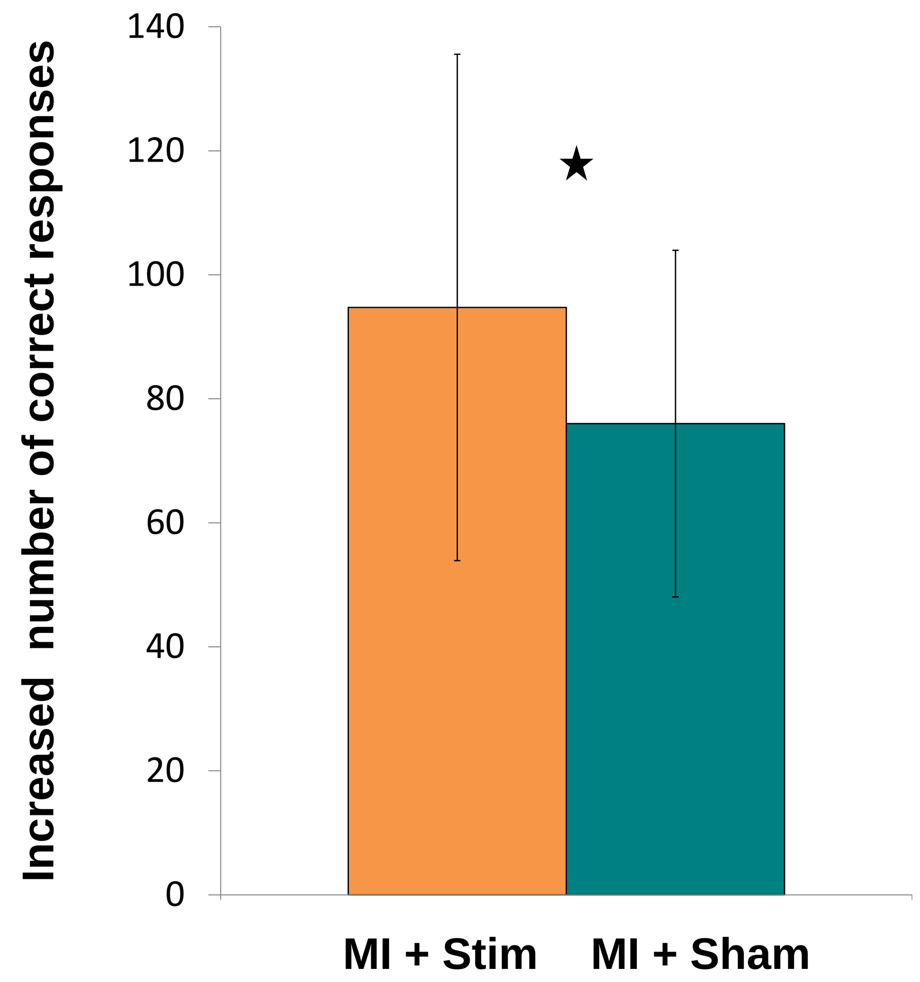



**Figure 4. Mean increased number of correct responses from the Pretest to the Posttest.** There was a significant Test x Condition interaction : the increased number of correct responses after training was greater in the *MI + Stim* condition compared to the *MI + Sham* condition ($p < .05$, $\eta^2 = 0.23$). Bars are ± standard deviations.

Movement accuracy

The average proportion of correct responses was 0.98 and did not significantly differ between conditions and tests (p = 0.44), indicating that the advantage for speed found for the *MI + Stim* condition was not at the detriment of accuracy.

Motor performance and MI vividness

There was no significant correlation (p = 0.18) between performance improvement and self-reported level of MI vividness during MI training.

## Conclusions

The present results provide evidence that MI training combined with anodal tDCS over the premotor cortex yield greater improvement in motor performance compared to MI training alone.

These results extend those by Foerster *et al.* (2013) and Saimpont *et al.* (2016) who stimulated the primary motor cortex concomitantly to MI training; they suggest that the premotor cortex may also be a key region for motor learning through MI, at least during the early learning process.

The relation between performance improvement via MI training and MI compliance / ability needs to be further explored.

## References

Foerster A., Rocha S., Wiesiolek C., Chagas A.P., Machado G., Silva E., Fregni F. & Monte-Silva K. (2013). Site-specific effects of mental practice combined with transcranial direct current stimulation on motor learning. *European Journal of Neuroscience,* 37 (5), 786-794.

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