Peer Community In Registered Reports

Increasing stimulation intensity does not affect motor learning

A recommendation by ***Christina Artemenko*** *based on peer reviews by 1 anonymous reviewer of the STAGE 2 REPORT:*

Gavin Hsu, Zhenous Hadi Jafari, Abdelrahman Ahmed, Dylan J. Edwards, Leonardo G. Cohen, Lucas C. Parra (2024) Dose-response of tDCS effects on motor learning and cortical excitability: a preregistered study. OSF, ver. 2.1, peer-reviewed and recommended by Peer Community in Registered Reports. https://osf.io/a42uy

Submitted: 05 September 2024, Recommended: 08 November 2024

Cite this recommendation as:
Artemenko, C. (2024) Increasing stimulation intensity does not affect motor learning. *Peer Community in Registered Reports*, 100891. 10.24072/pci.rr.100891

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In neurostimulation research, the parameters of a stimulation protocol crucially impact on the effects of the stimulation. Transcranial direct current stimulation (tDCS) is a neurostimulation technique that typically uses current intensities about 1-2 mA in human research to modulate motor and cognitive behavior. The current sham-controlled study by Hsu et al. (2024) applies current intensities not only of 2 mA but also of 4 mA and 6 mA and thus extends our understanding of stimulation parameters while ethical standards are preserved. The influence of tDCS over the primary motor cortex was evaluated for neural plasticity during motor learning. Stimulation effects were tested not only behaviorally but also physiologically by motor evoked potentials elicited by transcranial magnetic stimulation (TMS). The presented pilot data were promising and underlined the feasibility of the proposed research design. The study contributes to tDCS research by uncovering reasons for controversial findings and thus increases reproducibility. The results of the study unexpectedly revealed no stimulation effects on motor learning, neither for behavioral outcomes nor for physiological outcomes by motor evoked potentials. No evidence was found that stimulation effects linearly increase with increasing intensity. Interestingly, higher intensities were relatively well tolerated - but did not have any impact. The current findings underline the purpose of preregistrations and registered reports to act against publication bias, particulary in the field of neuromodulation. In the current case, failed replication and null findings - revealed by a methodologically sound study - are crucial to inform future research using similar stimulation protocols with the aim to modulate motor or cognitive behavior. The Stage 2 manuscript was evaluated over one round of review. Based on detailed responses to reviewers' and the recommender's comments, the recommender judged that the manuscript met the Stage 2 criteria and awarded a positive recommendation.
URL to the preregistered Stage 1 protocol: https://osf.io/jyuev **Level of bias control achieved:** Level

2. *At least some data/evidence that was used to answer the research question had been accessed and partially observed by the authors prior to Stage 1 in-principle acceptance, but the authors certify that they had not yet observed the key variables within the data that were used to answer the research question.* **List of eligible PCI RR-friendly journals:**

- Brain and Neuroscience Advances
- Imaging Neuroscience
- NeuroImage: Reports
- Peer Community Journal
- PeerJ
- Royal Society Open Science
- Studia Psychologica

References:

Hsu, G., Jafari, Z. H., Ahmed, A., Edwards, D. J., Cohen, L. G., & Parra, L. C. (2024). Dose-response of tDCS effects on motor learning and cortical excitability: a preregistered study [Stage 2]. Acceptance of Version 2.1 by Peer Community in Registered Reports. https://osf.io/a42uy

Reviews

Evaluation round #1

DOI or URL of the preprint: https://osf.io/kxrdb
Version of the preprint: 2.0

Authors' reply, 25 October 2024

Dear Dr. Artemenko,

Here we submit the latest version of our Stage 2 manuscript with the requested minor revisions. Please note that we made a correction to the statistics for one of our exploratory analyses (correlation between performance and sensation) that was wrong due to a previous mistake in the analysis code. We also added a statement about how EEG may have affected the results (under "Comparison to our previous results and pilot data"). We are very grateful for the thoughtful feedback!

Best regards,
Gavin Hsu and Lucas Parra

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Decision by Christina Artemenko, posted 09 October 2024, validated 09 October 2024

Minor Revision

Dear Gavin Hsu and Lucas Parra,

Thank you for submitting your Registered Report ”Dose-response of tDCS effects on motor learning and cortical excitability: a preregistered study” for stage II. One of the original reviewers evaluated your registered report, without any critical remarks. The positive feedback you can find below. I also read the added parts of the manuscript. Taken together, I would like to accept your registered report - pending (really) minor revisions.

Please upload a manuscript without marked changes. In this manuscript, please consider this last point:

- In the discussion, after summarizing all results, please add a central paragraph on what the main finding means - that there are no stimulation effects independent of the used tDCS intensity. On the one hand, you might discuss the missing stimulation effects (stimulating with 4/6 mA was not different than sham stimulation) in the context of the replication crisis in the field of brain stimulation, strengthened by the point that all analyses were planned in your registered report. On the other hand, you can discuss why 6 mA did not modulate motor learning more or less than 4 mA tDCS - and what this means for future research. In my view, the discussion of null findings can be central - before you discuss all the other reasons that might explain the missing effects due to differences to previous studies (this discussion is substantial and already in the manuscript, no need for change there).

Small edits to consider when producing the manuscript without marked changes:

- In the methods, add ”years” when stating the age of the participants.
- In the results, please write all statistical variables in italics (F, p, ...), add both degrees of freedom to F-analyses, use subscripts for 01 in BF01, instead of expressions such as ”1.91×10-23” use p < .001, and consider adding effect sizes such as partial eta squared.
- In the discussion, add ”.” after ”abovementioned order effect”.
- In the discussion, consider rephrasing ”Our results seem in variance with previous reports”, as ”in variance” seems ambiguous.

Looking forward to the final version of your manuscript!
Best regards,
Christina Artemenko

Reviewed by anonymous reviewer 1, 08 October 2024

The data appear adequate to test the proposed hypotheses. The study employed well-established methods to measure motor performance (NCS) and corticospinal excitability (MEP amplitudes) while manipulating tDCS dose. The statistical models (linear models, Bayes factors) were appropriate for addressing the hypotheses, and the study included quality checks such as examining correlations between typing speed and motor skill learning, confirming that the groups were homogeneously assigned.

Moreover, the data do not seem to suffer from floor or ceiling effects, as performance gains were visible, and the measures used captured a range of responses across subjects. The study also conducted positive controls, such as confirming an overall increase in MEP amplitudes and motor learning gains, suggesting that the task was suitable for assessing the effects of tDCS and motor learning in general. Thus, the data were able to appropriately test the hypotheses under the study’s framework, though they ultimately revealed null results.

The authors’ conclusions are largely justified based on the evidence presented in the results section. The primary hypotheses (H1: effect of tDCS dose on motor performance; H2: effect of tDCS dose on corticospinal excitability; H3: correlation between motor performance and MEP changes) were rigorously tested using appropriate statistical methods, and all three hypotheses failed to show significant effects. Additionally, the exploratory analyses involving TEPs revealed interesting post-stimulation cortical changes (e.g., at the 45ms

peak), which correlated with motor learning gains, albeit independently of tDCS intensity. These analyses were justified since they provide further insights into the neural mechanisms underlying motor learning and are methodologically sound.

In conclusion, the lack of tDCS effects on motor performance and MEPs, along with the exploratory findings regarding TEPs, are consistent with the presented data and statistical analyses. The authors' careful interpretation of their null findings is methodologically sound and informative.