Individual differences in TMS sensitivity influence the effect of tDCS in a motor adaptation task

Labruna L[1,2], Dabit M[1], Vanderschelden B[1], Stark-Inbar A[1,3], Nitsche M[4], Ivry R.B.[1,2]

1 Department of Psychology and, 2 Helen Wills Neuroscience Institute, University of California, Berkeley, California; 3 Dept. of Research and Development, Posit Science Corporation, San Francisco,California, 4 Leibniz Research Center for Working Environment and Human Factors, Dortmund, Germany.

lulabrun@berkeley.edu

INTRODUCTION

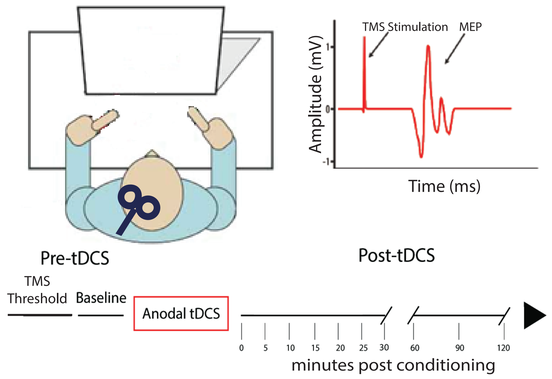
tDCS is a promising tool to non-invasively manipulate neural function.
As with any new tool, there are concerns with the reliability and consistency of tDCS-induced effects. One source of variability may reflect individual differences in the sensitivity to brain stimulation.

Unlike TMS where the stimulation level if usually tailored on an individual basis, tDCS protocols use a fixed stimulation level.

We ask here if the efficacy of tDCS in modulating physiology and behavior may be related to individual differences in sensitivity to brain stimulation.

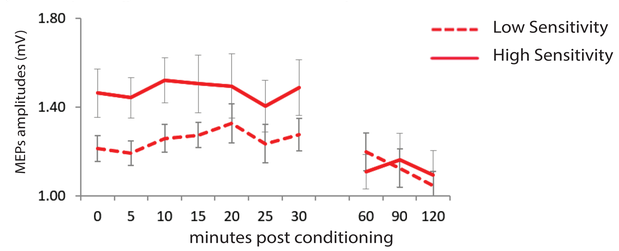
PHYSIOLOGY (Labruna et al., 2015)

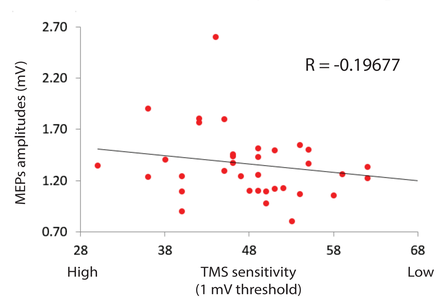
Logic: Use TMS threshold for producing motor-evoked potentials as proxy for sensitivity to brain stimulation. Assess if individual variation in this measure predicts efficacy of tDCS-induced changes in cortico-spinal excitability.



Individual Differences in Sensitivity to Brain Stimulation:

High Sensitivity Group: Low TMS stimulation required for TMS threshold (1 mV).
Low Sensitivity Group: High TMS stimulation required for TMS threshold.



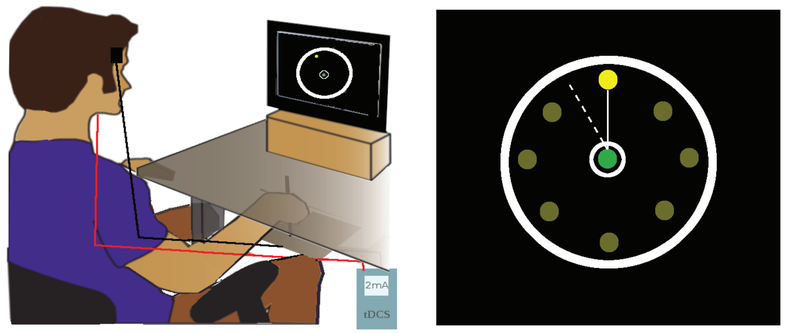


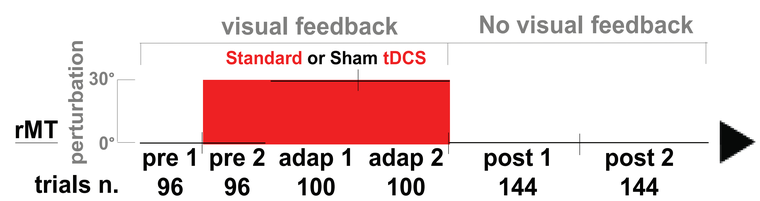
- High Sensitivity group shows greater increase in TMS-induced MEPs after anodal tDCS over motor cortex.
- Modest correlation between sensitivity and efficacy of tDCS across the group of individuals.

BEHAVIOR

Can we predict the effectiveness of tDCS on motor learning from TMS sensitivity?

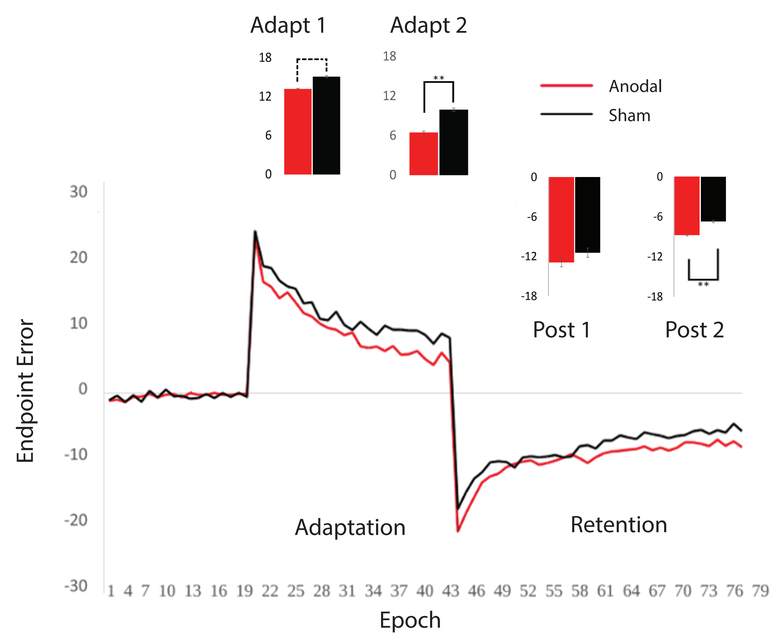
Motor Learning Task





Participants: 27 receive anodal tDCS; 14 receive sham tDCS.
Anodal tDCS: 2 mA on M1 during Adapt phase (approximately 20 min).

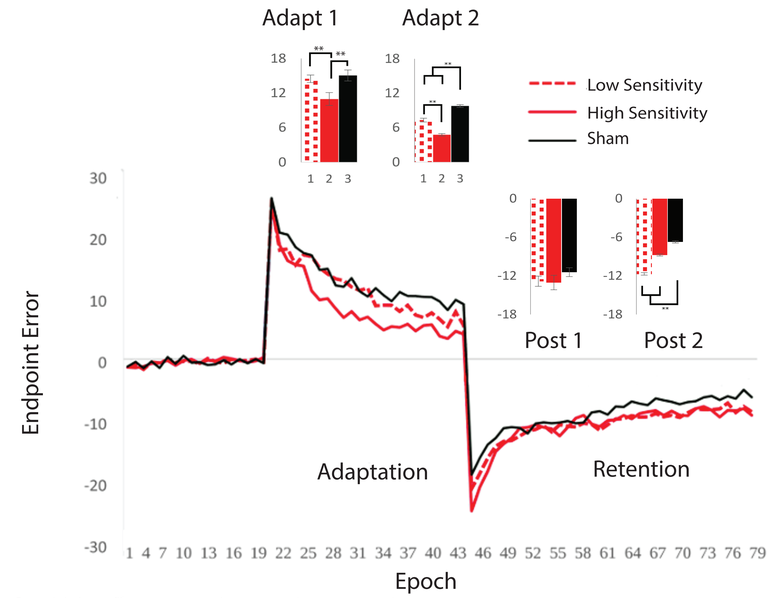
Result



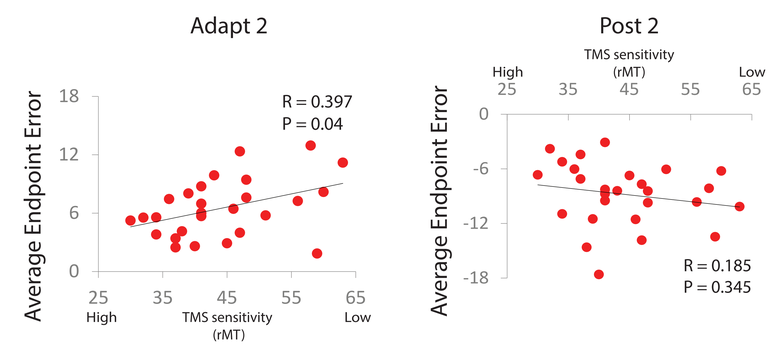
- Anodal tDCS over M1 enhances learning:
  - Acquisition: Reduced error at end of adaptation phase
  - Retention: Larger persistent error at end of washout phase (no feedback)
- Partial replication of Galea et al. (2011): That study only observed M1 effect on retention.

Individual Differences in Sensitivity to Brain Stimulation:

High Sensitivity Group: Low TMS stimulation required for TMS threshold (rMT).
Low Sensitivity Group: High TMS stimulation required for TMS threshold.



- Sensitivity effect most evident during adaptation.
  - Adaptation: High sensitivity group shows faster reduction in error.
    By end of Adapt phase, both High and Low groups > Sham
  - Retention: High and Low groups both show stronger retention at end of washout.
    Note: Forgetting is similar across all three groups.



Positive correlation between TMS-measured sensitivity to brain stimulation and efficacy of tDCS in improving acquisition (High sensitive individuals show smallest error at end of Adapt phase).

Weak correlation, and in wrong direction, between sensitivity and retention (greatest retention for those with low sensitivity).

CONCLUSIONS

- Anodal tDCS over M1 enhances both acquisition and retention
- Sensitivity to brain stimulation can predict efficacy of tDCS for enhancing acquisition.

FUTURE DIRECTIONS

- Can TMS-defined sensitivity be used to adjust tDCS intensity on an individual basis?
- Does TMS-defined sensitivity (at M1) predict efficacy of tDCS at other brain regions?