# The effects of transcranial direct current stimulation and feedback on learning a novel bimanual coordination pattern

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## Introduction

- There are two inherent interlimb coordination patterns: inphase and antiphase. Individuals must overcome the intrinsic tendency towards inphase and antiphase, as a result 90° continuous relative phase requires practice to learn.
- The amount of feedback provided during practice influences retention.
  - Reduced frequency of Lissajous feedback improves bimanual performance (3).
- The supplementary motor area (SMA) plays a vital role in inter-limb coordination. SMA neurons respond more than movements with either hand individually.
- Through the use transcranial direct current stimulation (tDCS), the excitability of cortical areas can be altered by passing small electrical currents between the electrodes on the scalp (2). This stimulation will influence motor behaviour and learning.
  - Activation in SMA is associated with the planning of self-initiated and externally generated movements (1).

## Research Question

Will changes be made in performance and/or the learning of a novel bimanual coordination pattern with modulation of SMA excitability and feedback?

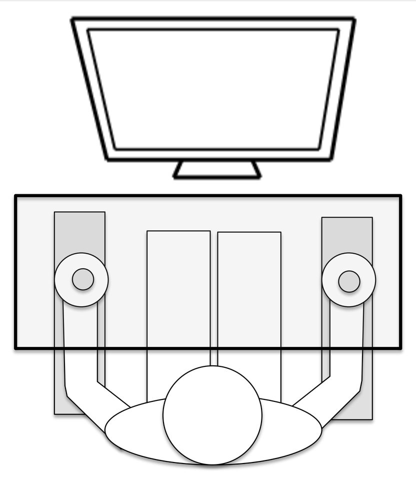

*Figure 1.* Participants sat facing a computer screen with both arms fixed to perform the 90° relative phasing task. Participants could not view their limbs.

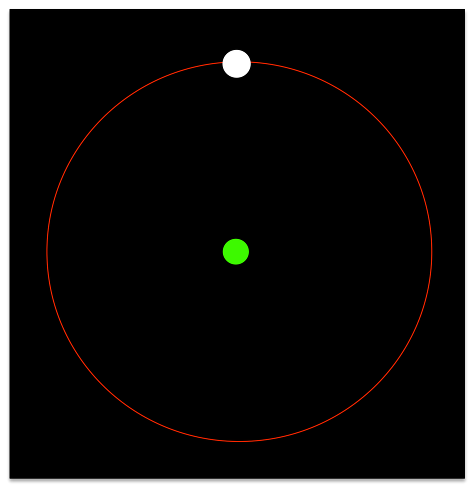

*Figure 2.* Lissajous feedback projected on the computer screen. The white circle is the pacing circle while the green circle is the participants cursor.

## Methodology

- 20 right-handed participants were randomly assigned to one of four groups:
  - Anodal full feedback (100%)
  - Sham full feedback (100%)
  - Anodal faded feedback (50%)
  - Sham faded feedback (50%)

- Participants were instructed to attempt to continuously flex and extend their arms in a pattern that produces a relative phasing of 90° between the limbs with a cycle frequency of 1 Hz.
  - The 90° relative phasing is achieved by leading with the right limb and having the left limb lagging by a quarter of a cycle.

- The apparatus (Figure 1) consisted of two horizontal levers, a computer display and a cover that prevented participants from viewing their limbs.

### Testing

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|---|---|
| Pre-test | • Two 15 second trials: one with no feedback and the other with Lissajous feedback (Figure 2). |
| tDCS protocol | • Two scalp electrodes were placed on the SMA and the forehead of participants.<br>• Direct current of 1 mA was applied for 10 minutes, with an 8 minute wait afterwards. |
| Practice | • 10 trials, 30 seconds each.<br>• Either full feedback or faded feedback<br>o Faded feedback schedule: 25-25-20-20-15-15-10-10-5-5 seconds, then disappears for each consecutive trial. |
| Post-test | • Two 15 second trials identical to pre-test. |
| Retention test | • Two 15 second trials identical to pre-test performed 24-hours later. |

## Results

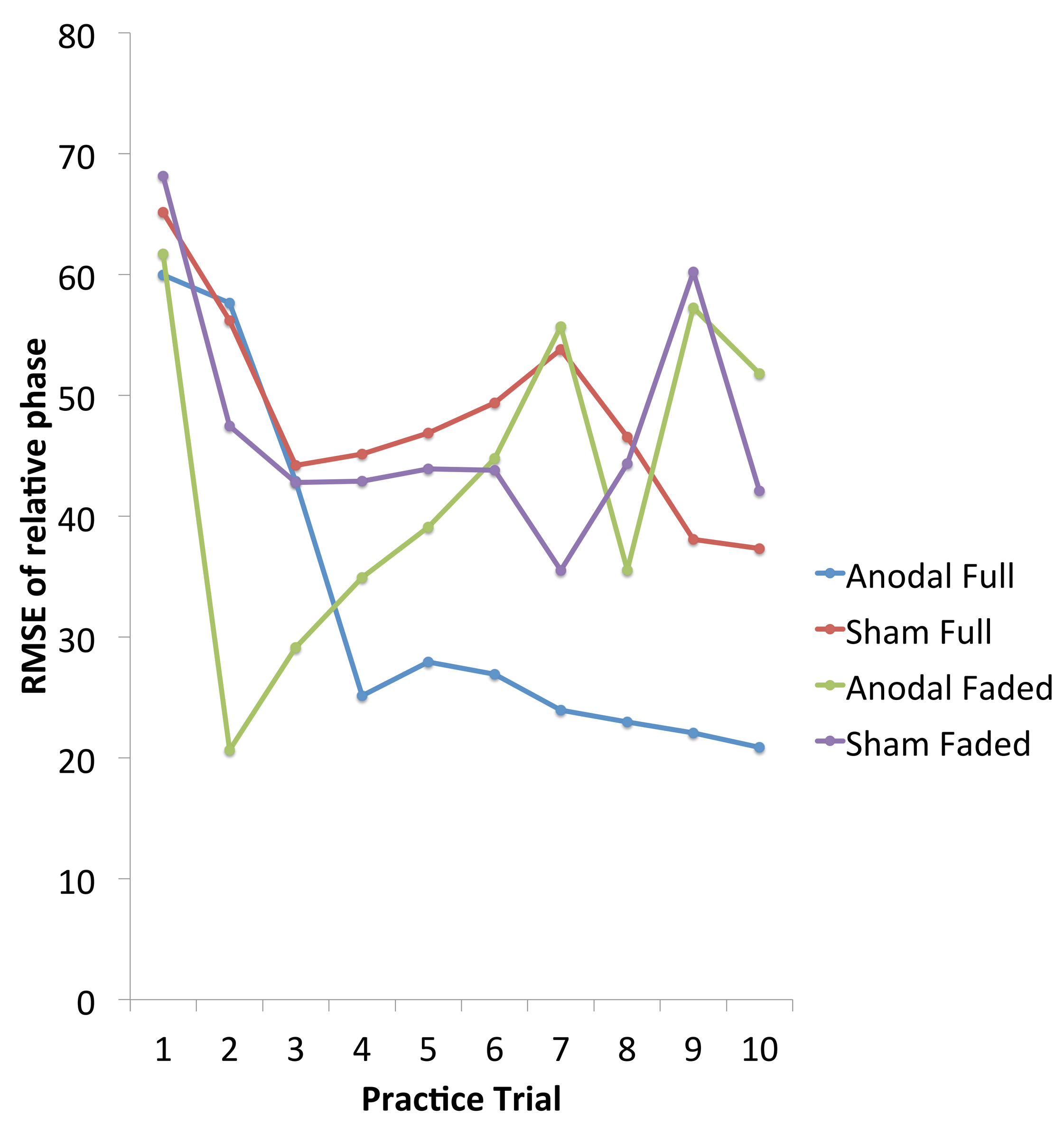


*Figure 3.* Root mean square error (RMSE) for the ten practice trials performed by four different groups (anodal full, sham full, anodal faded, and sham faded). Performance improves in all four groups from initial trials.

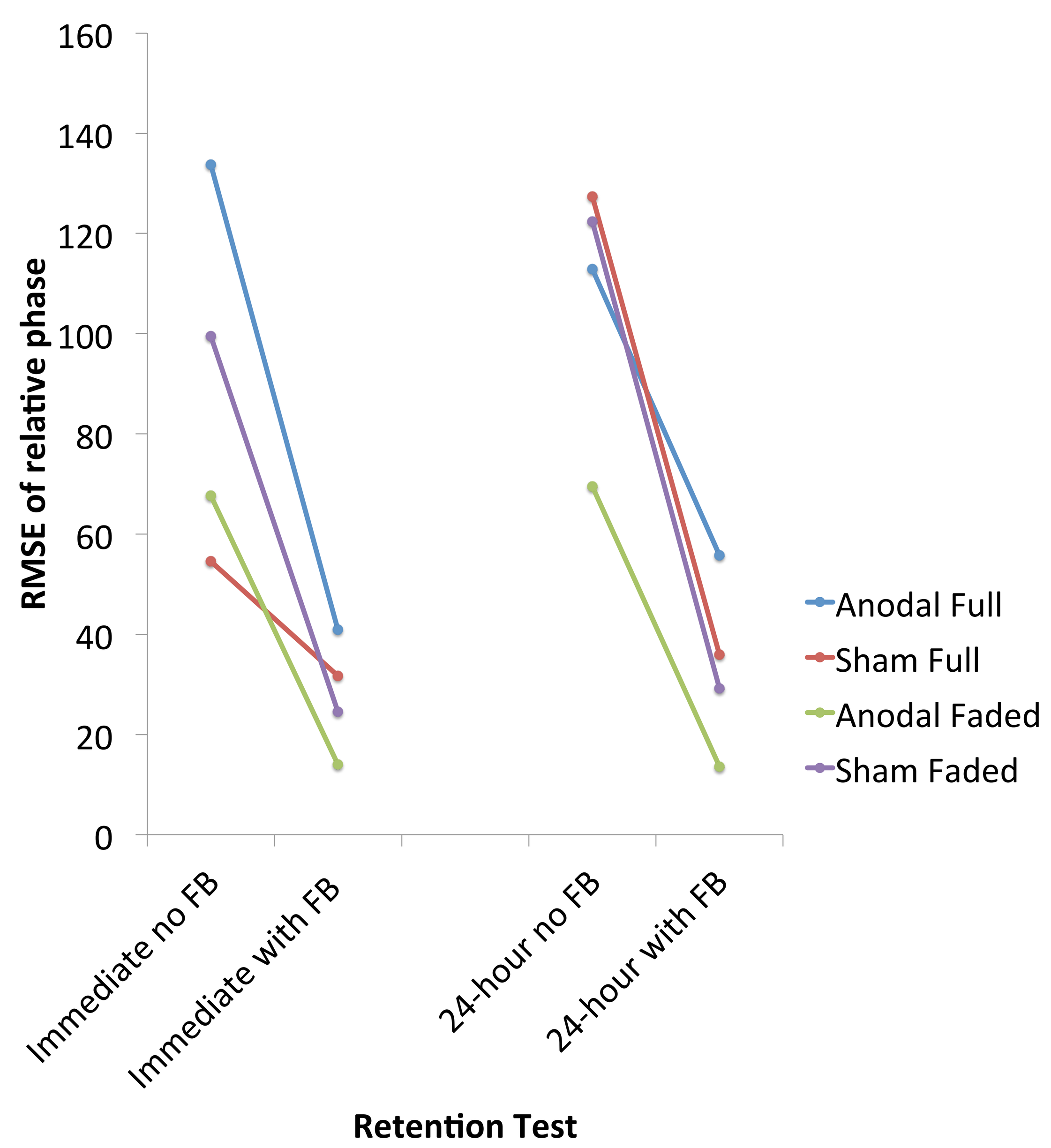


*Figure 4.* Root mean square error (RMSE) for the four retention tests (immediate with no feedback, immediate with feedback, 24-hour with no feedback, and 24-hour with feedback) performed by the four groups (anodal full, sham full, anodal faded, and sham faded). Performance improves as feedback becomes available.

## Discussion and Conclusion

- During practice trials (Figure 3), tDCS appears to have a strong effect on learning, especially when paired with full feedback.

- When performing a 24-hour retention test, Lissajous feedback presented in a faded schedule facilitated the retention of the bimanual coordination pattern with a 90° relative phase, demonstrating a stronger effect on learning.

- In conclusion, the effects of tDCS appear to be temporary as the effects are predominant on the same day as the tDCS protocol. However, the influence of the feedback schedule presented became more evident on the second day (24-hour retention).

## Further research

- Extend practice time from 5 minutes to 20 minutes, or extending practice over multiple days.
- Unilateral stimulation of left or right SMA
  - Determine differences in performance when one hemisphere is stimulated

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**References**

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