Exploring the effects of cerebellar transcranial direct-current stimulation on thalamo-cortical networks during command-following

Davide Aloi[a,b], Roya Jalali[a,b], R Chris Miall[a], Davinia Fernández-Espejo[a,b]

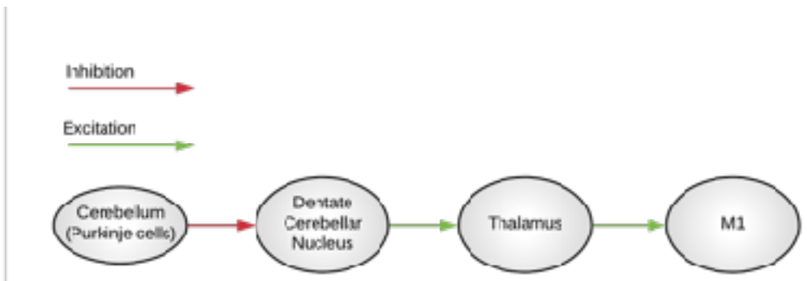
[a]School of Psychology, University of Birmingham, B15 2TT, Birmingham, UK
[b]Centre for Human Brain Health, University of Birmingham, B15 2TT, Birmingham, UK

Giving Early Career Neuroscientists A Voice
brainboxinitiative.com

Background & Hypothesis

- Therapeutic options for patients with prolonged disorder of consciousness (PDOC) are limited;
- Some PDOC patients show a dissociation between cognitive functioning and behavioural responsiveness(1, 2);
- This dissociation seems to be associated with structural connectivity impairments within the motor system -> reduced thalamo-cortical coupling(3);
- Cerebellum exerts inhibitory tone on the motor cortex (Fig. 1) and plays fundamental role in motor control(4)

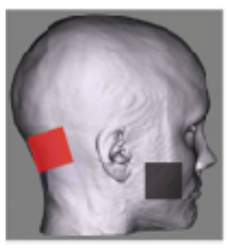
Hypothesis: ctDCS can modulate thalamo-cortical connectivity during command following.

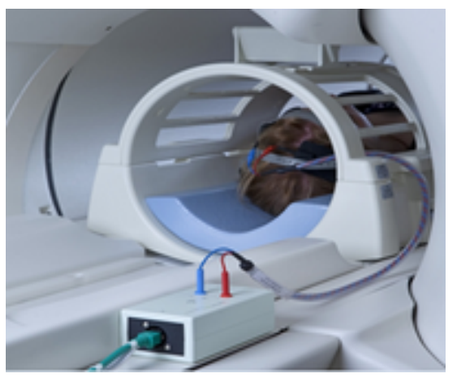


Cerebellar brain inhibition(5)

Methods

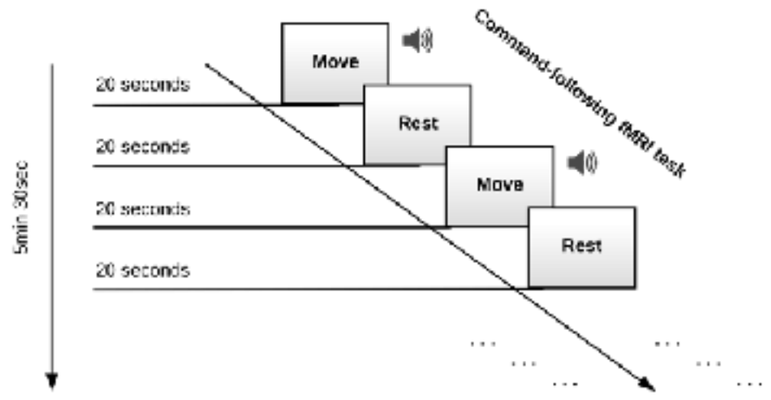
- **Participants**: 21 healthy participants completed all 3 sessions; 14 female, 7 male; mean age = 27.1 (4.2).
- **Design**: within-subjects; 3 ctDCS sessions (anodal/cathodal/sham, counterbalanced)
- **Montage**: right cerebellum (active electrode), right cheek (return electrode),
- **Intensity**: 1.85mA
- at least **6 days** between sessions;



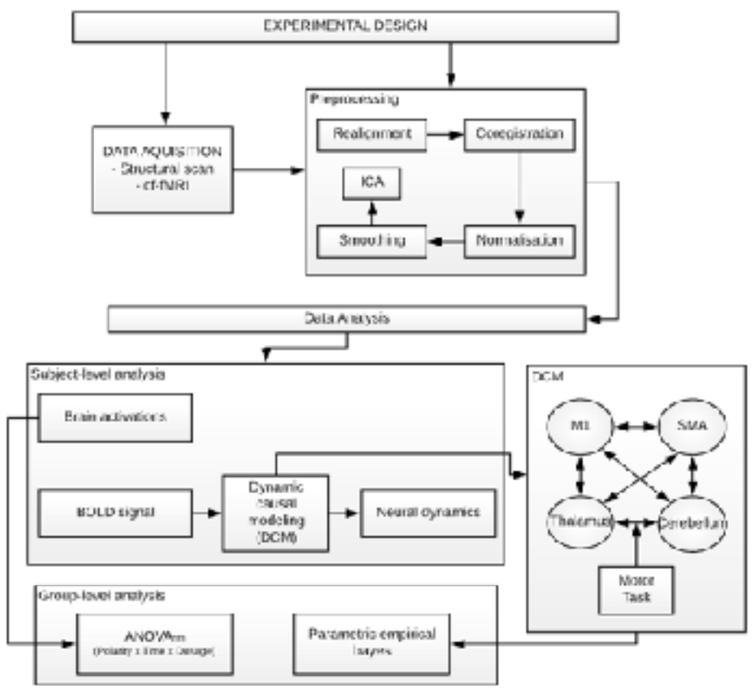


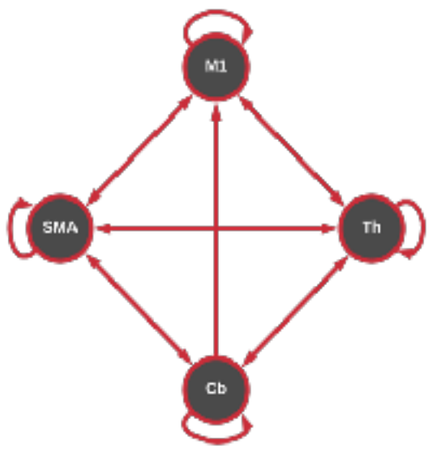
Command-following task:

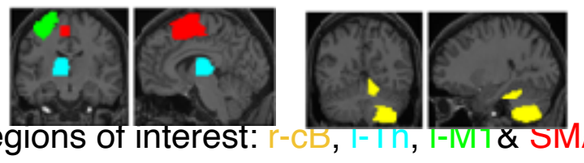
- simple **thumb movements** in response to auditory cues;
- auditory stimuli were grouped in blocks of **~ 20 seconds**;
- total time: **5min 30 sec**.
- Motion tracker device (reaction time, velocity, peak acceleration)



Data analysis







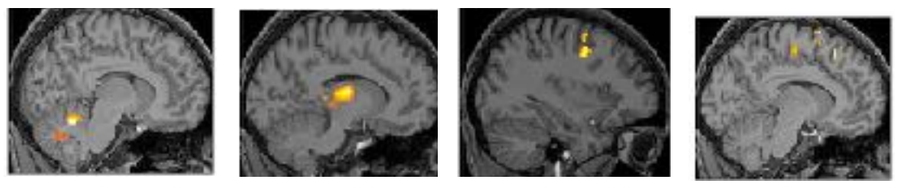
4 regions of interest: r-cB, l-Th, l-M1& SMA

Motion tracking results

No interaction (polarity X time) found

Brain activation

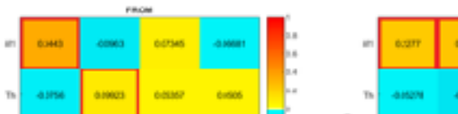
- Interaction (polarityXtime, p<0.001 unc)



right Cb (x=9) Th (x=-21) M1 (x=-30) SMA (x=-9)

- Pairwise interactions (p<0.05FWE, k=10):

1) Increases after cathodal stimulation as compared to sham:



right Cb (x=9) Th (x=-15)

2) No significant increases after anodal stimulation as compared do cathodal
3) No significant increases after anodal stimulation as compared to sham

Effective connectivity analysis

- (free-energy Pp>.99)

Conclusions

- **ctDCS** has long-range polarity-specific effects on thalamo-cortical connectivity
- **Cathodal** ctDCS increases thalamo-M1 excitation
- **Anodal** ctDCS leads to increased inhibition in M1 and thalamus

- In conclusion, ctDCS can modulate **cerebellar-brain inhibition** during command following in a polarity-specific manner. This supports its potential to restore some degree of responsiveness in patients with PDOC.

References
1) Kondziella, D., Friberg, C. K., Frokjaer, V. G., Fabricius, M., & Møller, K. (2015). Preserved consciousness in vegetative and minimal conscious states: systematic review and meta-analysis. Journal of Neurology, Neurosurgery & Psychiatry, 87(5), 485-492. doi:10.1136/jnnp-2015-310958
2) Fernández-Espejo, D., & Owen, A. M. (2013). Detecting awareness after severe brain injury. Nature Reviews Neuroscience, 14(11), 801-809. doi:10.1038/nrn3608
3) Fernández-Espejo, D., Rossit, S., & Owen, A. M. (2015). A Thalamocortical Mechanism for the Absence of Overt Motor Behavior in Covertly Aware Patients. JAMA Neurology, 72(12), 1442. doi:10.1001/jamaneurol.2015.2614
4) Grimaldi, G., Argyropoulos, G. P., Bastian, A., Cortes, M., Davis, N. J., Edwards, D. J., … Celnik, P. (2014). Cerebellar Transcranial Direct Current Stimulation (ctDCS). The Neuroscientist, 22(1), 83-97. doi:10.1177/1073858414559409
5) Kelly, R. M., & Strick, P. L. (2003). Cerebellar Loops with Motor Cortex and Prefrontal Cortex of a Nonhuman Primate. The Journal of Neuroscience, 23(23), 8432-8444. doi:10.1523/jneurosci.23-23-08432.2003

Contact: dxa869@student.bham.ac.uk