A big role for the little brain: Investigating sequence learning in the cerebellum using tDCS and fMRI

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A big role for the little brain: Investigating sequence learning in the cerebellum using tDCS and fMRI

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Background

Sequence learning is defined as the ability to acquire information and learn how to properly organise it in successive actions. Everyday life employs a series of sequential actions required for daily tasks, such as speech, skill acquisition and physical activities such as sports and driving.

Although sequencing has been proposed as the basic mechanism of cerebellar functioning, there is a stark discrepancy in empirical research in the domain of motor sequence learning, which generally attributes this role to the basal ganglia and association motor cortices, while the cerebellum is often overlooked.

To elucidate the role of the cerebellum in motor sequence learning we will combine the serial reaction time task (SRT task), with transcranial direct current stimulation (tDCS) and functional magnetic resonance imaging (fMRI).

Aims

1. **Does anodal stimulation of the cerebellum** exert a faciliatory effect on the acquisition and consolidation of sequential knowledge in the SRT task? We will investigate this using **multiple sessions** of repeated tDCS (5 sessions) and determine the impact after each session and after a one-week delay.

2. Conversely, does **cathodal tDCS** exert the opposite effects to anodal stimulation, **hindering sequence learning**?

3. Is the cerebellum only involved in the **early stages** of learning, or also in the **later stages** of consolidation and automatization?

4. What is the nature of the **functional and effective interactions** between the cerebellum, basal ganglia and cerebral cortex during sequence learning?

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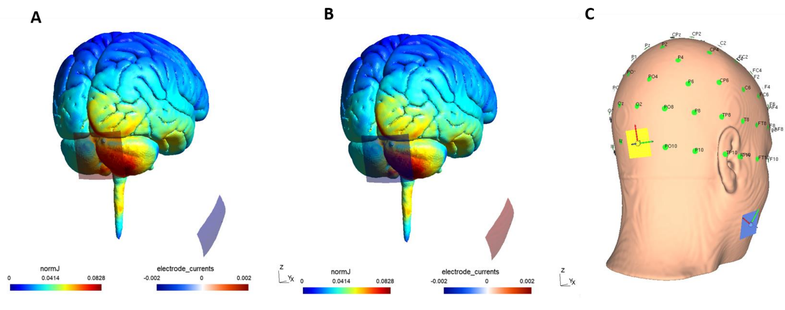
Methods and study design

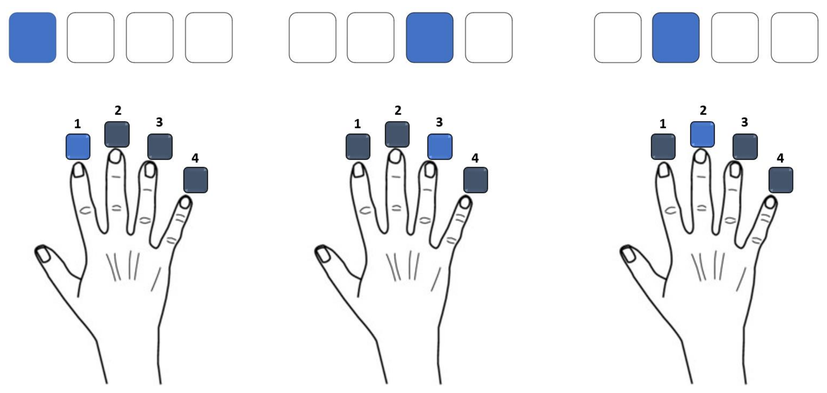
Two double-blind, sham-controlled, within-subjects experiments in healthy young adults.

Experiments 1 and 2 will investigate the behavioral and neurobiological effects of tDCS on sequence learning. Experiment 1 will employ anodal cerebellar tDCS during fMRI scanning, concurrent with the SRT task; Experiment 2 will employ the same design, but using cathodal cerebellar tDCS instead. All stimulation sessions will last 20 minutes (the same duration as the SRT task), at a current intensity of 2 mA.

Dynamic causal modelling (DCM) will be used to study the interconnections between cerebellar, basal ganglia, and cerebral regions.



tDCS montage



SRT task

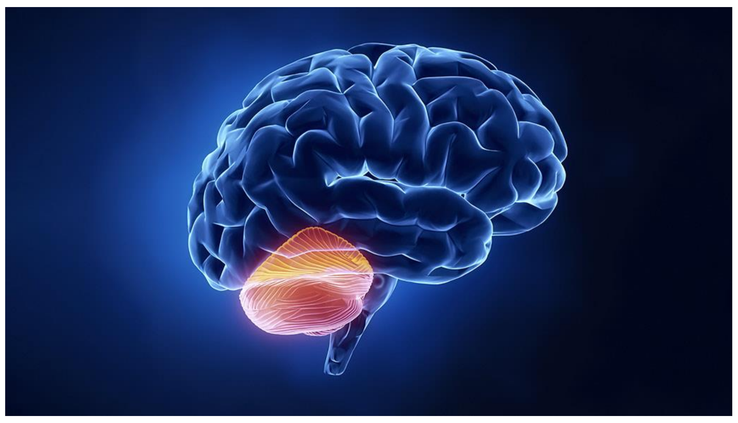
Expected results

Experiment 1 – anodal cerebellar tDCS + SRT task + fMRI

- Positive modulatory effect of anodal cerebellar tDCS on sequence learning
- Positive cumulative effect of number of sessions.
- Effects of cerebellar tDCS to be most pronounced during consolidation of learning.
- Anodal cerebellar tDCS will increase brain activation at stimulation sites (+ other areas of learning network – striatum, motor cortical regions, frontal and parietal cortices).

Experiment 2 – cathodal cerebellar tDCS + SRT task + fMRI

- Negative modulatory effect of cathodal cerebellar tDCS on sequence learning.
- Negative cumulative effect of number of sessions.
- Cathodal cerebellar tDCS will decrease brain activation at stimulation sites and in other areas associated with the learning network.



Experiment 1 and Experiment 2 study design – anodal and cathodal cerebellar tDCS + fMRI