Cerebellar Contributions to Higher Order Cognition:
A tDCS and fMRI Study

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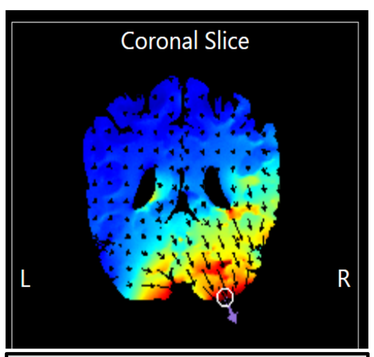
Introduction

- The cerebellum may act as a supportive mechanism for cognitive processing via internal models. Indeed, increased cortical activation in aging may be due to decreased cerebellar involvement & scaffolding.
- Transcranial direct current stimulation (tDCS) allows us to investigate cerebellar contributions to behavior.
- Cerebellar Purkinje cells have inhibitory action on the dentate nucleus, the primary output region to the cortex.
- We predict that anodal tDCS will reduce cerebellar output via an increase in inhibitory Purkinje cell firing on the dentate, and in turn, increasing cortical activation.

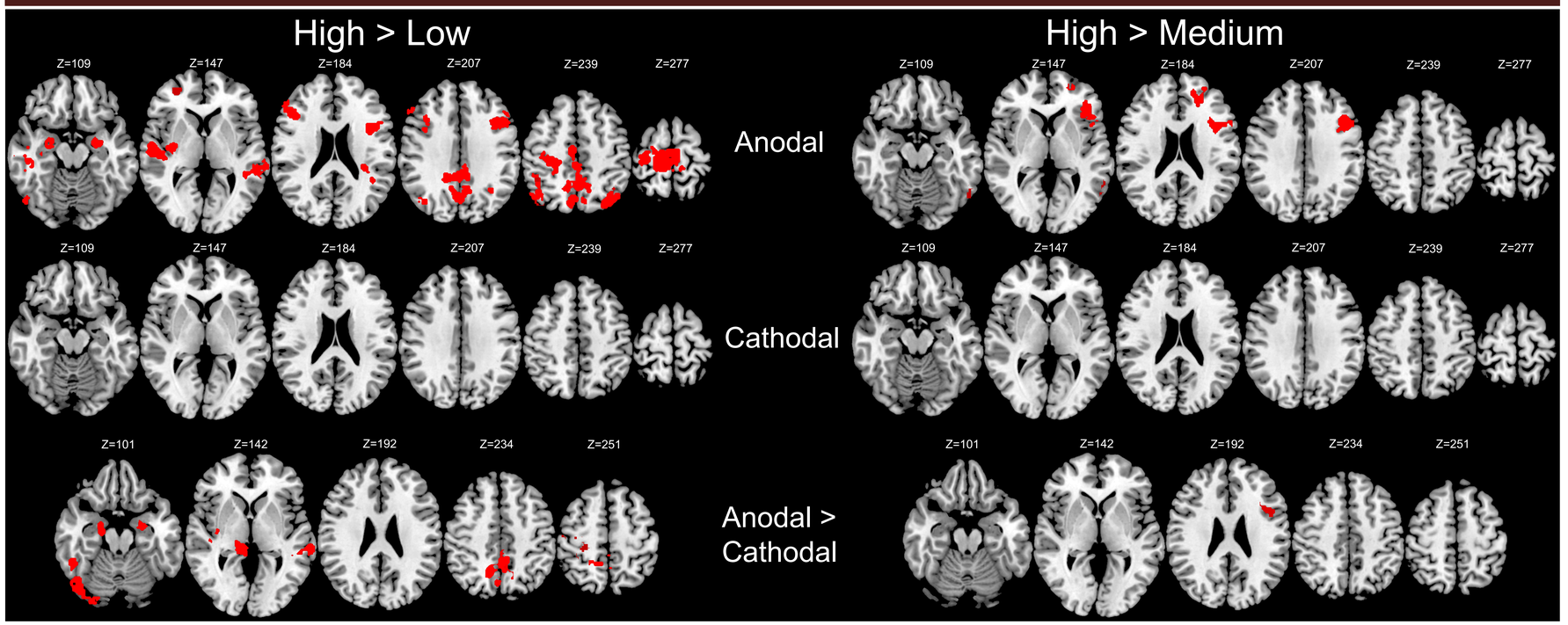
Methods

- 49 healthy young adults (21.87 ± 3.29 years)
- 1x1 tDCS
  - 20 minutes
  - Cathodal (n=17), Anodal (n=16) or Sham (n=16)
- Acquired multiband functional and structural images using a block design
  - Preprocessing and analysis was completed using FSL pipelines
  - Sternberg task (1, 5, and 7 letters)

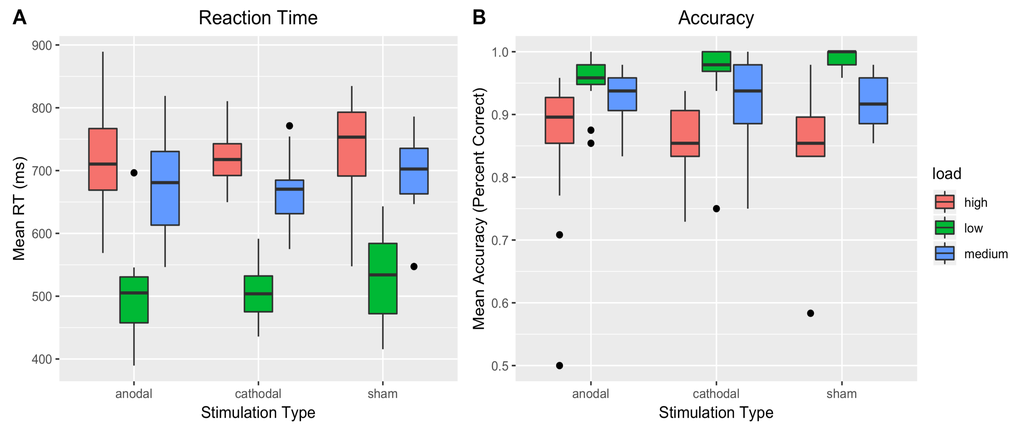


Above: intensity map demonstrating the direction and intensity of the current targeting the cerebellum.

Results



Increased activation in frontal and parietal lobes on high working memory compared to low and medium working memory trials, following anodal stimulation. No such affect following cathodal stimulation. Further, anodal greater than cathodal stimulation contrasts show similar bilateral activation patterns, particularly in parietal and subcortical regions.



We used mixed effects models for all analyses, with load (high, medium, and low) measured within participants and stimulation type (sham, anodal, and cathodal) measured between subjects.

A) Reaction Time: effects of load (p<0.001) and marginal effects of stimulation (p=0.061). RT was significantly slower following cathodal stimulation (p=0.026), compared to sham.

B) Accuracy: an effect of load (p<0.001) and a significant stimulation by load interaction. Stimulation affected accuracy, but only under low load, such that accuracy was worse following both anodal (p<0.001) and cathodal stimulation (p<0.01), relative to sham.

Discussion

- tDCS seems to impact cognitive performance under low load, perhaps suggesting that the cerebellum is more critical when processing is automatic but becomes less involved under higher load when processing is more prefrontally-dependent.
- Imaging data suggest anodal stimulation creates a decrease in cerebellar function which results in a greater need for bilateral cortical processing under high load.
  - This is consistent with offloading of cortical processing. That is, when the cerebellum is not processing effectively, the prefrontal cortex engages more cortical area to compensate.

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