The role of the supplementary motor area and the cerebellum in absolute timing

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Introduction

Absolute timing is a timing mechanism that measures the duration of discrete intervals[1].

Absolute timing tasks activate the supplementary motor area (SMA)[2] and cerebellum.[1]

SMA is associated with both sub- and supra-second timing[3], whereas the cerebellum is associated with sub-second timing.[1]

Aim: To assess the role of SMA and cerebellum in absolute timing using anodal transcranial direct stimulation.

Hypothesis: The SMA and cerebellum both play a role in absolute timing, which will be demonstrated by a change in interval discrimination performance when anodal tDCS is applied to either area.

Methods

Participants

36 participants randomly assigned to either cerebellar (n=18) or SMA (n=18) stimulation

Electrode location

	SMA site	Cerebellum Site
Anode electrode	2cm rostral of vertex	3 cm right of the inion
Reference electrode	Right supraorbital	Right buccinator

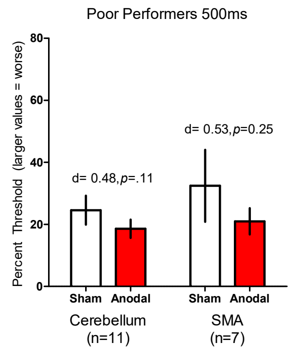
Task (Single-interval discrimination task)

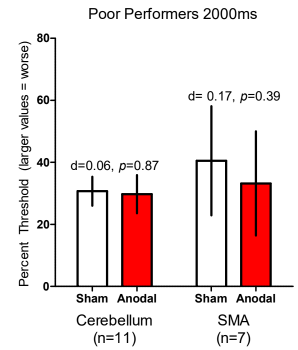
- Participants listened to two intervals: a reference interval and a target interval.
- Participant determined which interval was longer. Order of the reference and target interval was randomized.
- Participants completed one block with a 500 ms reference interval, and one block with 2000 ms reference interval.

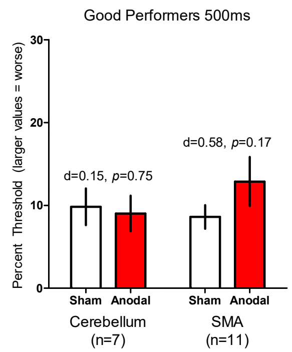
Data analysis

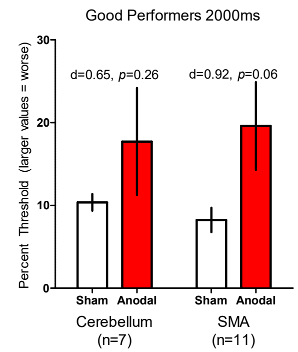
- Dependent variable: Percent thresholds = (average of the final 6 reversals-reference interval)/reference interval.
- tDCS often has opposite effects on good and poor perfomers[4]. To evaluate if tDCS differentially affected poor and good performers, a median split was used to separate participants into poor and good performers. We first averaged the sham percent threshold at both intervals, and then obtained the median of this average percent threshold.
- Performance x Site x Interval x Stimulation ANOVA. Where significant, separate follow-up Site x Interval x Stimulation ANOVAs were used to examine good and poor performers separately.

Results









- Performance x Site x Interval x Stimulation ANOVA showed that stimulation had different effects on participants based on their performance [$F(1,32)=8.13, p=0.01, \eta p2=0.20$]
- Follow-up ANOVAs of poor and good performers showed that in poor performers, stimulation tended to improve performance [$F(1,16)=3.89, p=0.07, \eta_p^2=0.20$] while in good performers stimulation tended to impair performance [$F(1,16)=4.39, p=0.05, \eta_p^2=0.22$]
- Good SMA participants performed **worse** with stimulation in both the sub-second interval (d=0.58, p=0.17) and the supra-second interval (d=0.92, p=0.06)
- Good cerebellum participants performed **worse** with stimulation in the supra-second interval
- Poor SMA and cerebellum participants performed **better** with stimulation in the sub-second interval (Cerebellum: d= 0.48, p=.11, SMA: d= 0.53, p=0.25)

Discussion and Conclusion

- Overall, data suggests both SMA and cerebellum may play a role in absolute timing
- Previous studies have similarly shown that tDCS can have different effects in good and poor performers[4,5]. This may explain why good performers were worse with anodal tDCS.
- Future studies may look at more sensitive task manipulations

Acknowledgements

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