Personalized tDCS targeting V5 modulates smooth pursuit initiation

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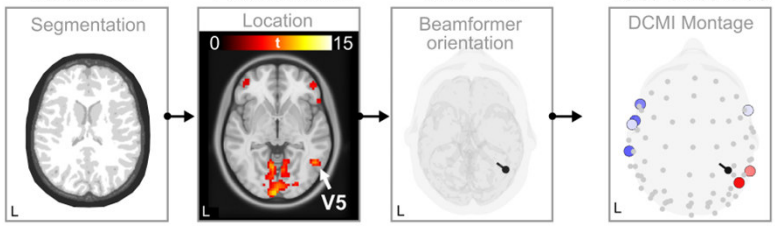
Background

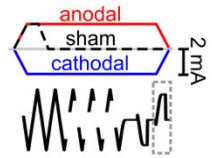
The initiation of smooth pursuit eye movement (SP) have been associated with altered activity in the visual area V5 [1,2]. Transcranial direct current stimulation (tDCS) might serve as a model to transiently modulate V5 activity in the healthy brain to understand SP mechanisms. Since *normative* tDCS, i.e., using the same tDCS montage across participants, in general shows limited replicability, *personalized* tDCS has been introduced to algorithmically optimize tDCS montages based on individual anatomical and functional information. A recent study showed that normative tDCS did not modulate SP but proposed personalized tDCS to yield more effective tDCS electric fields [3].

→ Here we applied *personalized tDCS* targeting V5 in healthy participants to modulate SP initiation.

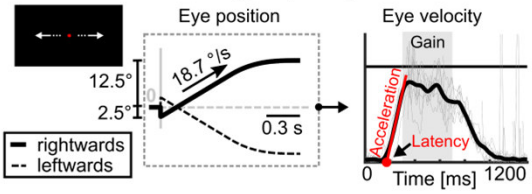
Computation of personalized tDCS montages



TDCS design



Pursuit initiation during step-ramps



Methods

- For N = 19 healthy participants, individual area V5 was defined (fMRI; combined MEG/EEG), and individual head models were computed
- Personalized tDCS was applied targeting right V5 (2 mA, 20 min)
- Eye movements were analysed with respect to SP initiation (foveopetal step-ramp stimuli), overall pursuit performance (ongoing SP stimulus) and top-down modulation of SP (ongoing SP stimulus with blanking; 18.7 °/s target velocity, ±15° amplitude)
- Linear mixed model analysis was performed including tDCS condition (anodal, cathodal, sham), stimulus direction (leftwards, rightwards) and measurement timepoints to assess online-effects (t_{TDCS_5}, t_{TDCS_10}, t_{TDCS_15}, t_{TDCS_20}) and after-effects (t_0, t_{TDCS}, t_{15}, t_{40}) of tDCS

→ Impairing (cathodal) or facilitating (anodal) tDCS effects were hypothesized for pursuit initiation directed ipsiversive to the right V5 [4,5]

Results

Personalized tDCS modulated SP initiation during tDCS (online-effect; interaction effect of tDCS condition x stimulus direction x timepoints): $p = .015$

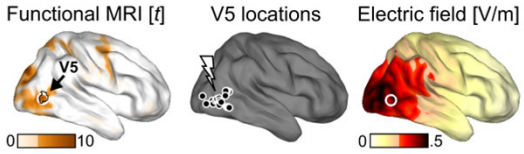
→ Cathodal tDCS delayed oculomotor response latencies, specifically for eye movements ipsiversive to the stimulation target in the right V5…

→…thereby reducing rightward latencies to the level of overall slower latencies observed for leftwards eye movements

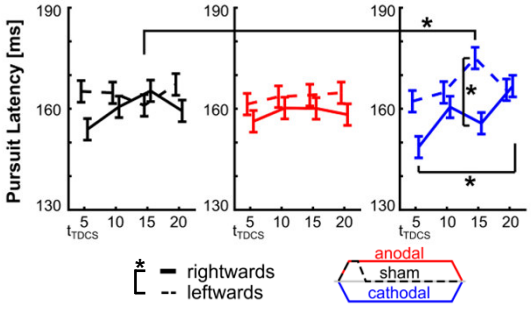
- No tDCS modulation was observerd for after-effects, for any other eye movement task, for sham or anodal tDCS, nor for personalized tDCS targeting the right frontal eye field as a control region
- No tDCS effect was observed in a matched sample using normative tDCS ($p > 0.609$)

→ Electric field simulations for personalized tDCS revealed significantly increased directional intensities, reduced spatial extent and overall reduced electric field intensities in non-target parietal regions

Targeting of visual motion area V5



Modulation of SP during cathodal TDCS



Conclusion

- **SP initiation is modulated by personalized cathodal tDCS targeting V5 …**
  → Cathodal tDCS hampers oculomotor response latencies ipsiversive to the stimulated hemisphere, as described before in lesion studies [4,5]
  → Due to the targeting of tDCS, and the dynamics of the specific effect on pursuit latencies, we conclude that cathodal tDCS affects early sensorimotor transformation, presumably involving a decreased excitability and LTD-like modulation of V5 subregion MT
- **… while normative tDCS did not show an effect**
  → Overall, results indicate an increased efficacy of personalized tDCS that may elevate the individual gain by tDCS, especially in therapeutic applications

References

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