Multimodal personalization of tDCS for modulation of sensorimotor integration

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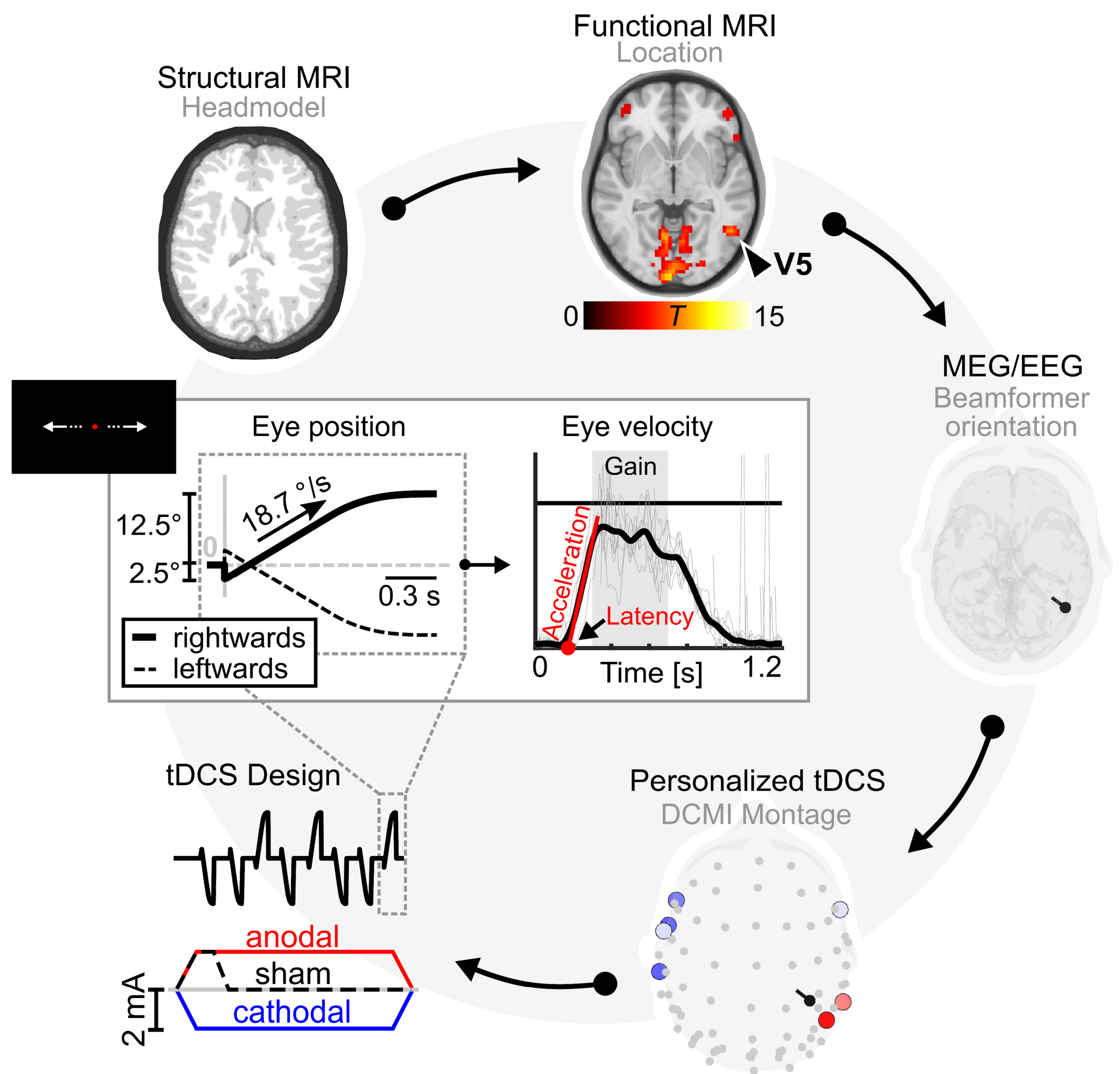
Background

Transcranial direct current stimulation (tDCS) for the modulation of smooth pursuit eye movements provides an ideal model to assess the role of neural networks underlying sensorimotor integration and long-known eye movement deficits in psychosis patients. However, the reliability of conventional *normative* tDCS, i.e., using the same tDCS montage across participants, is challenged by inter-individual variability of brain anatomy and function [1].

Here, we applied *personalized* tDCS to modulate pursuit behaviour based on individual anatomical head models and algorithmic targeting of visual area V5, a core hub providing motion processing information for pursuit [2,3].

Methods

- Finite-element head models (six compartments, calibrated skull conductivity, white matter anisotropy) were computed for healthy participants (N = 19)
- Individual area V5 was defined (location: fMRI; orientation: MEG/EEG)
- Personalized tDCS was applied targeting right V5 (2 mA, 20 min), while participants' eye movements were recorded during a foveo-petal step-ramp task and ongoing pursuit (18.7 °/s target velocity, ±15° amplitude)
- Leftwards and rightwards pursuit eye movements were analysed with respect to pursuit initiation latency, initial eye acceleration and pursuit velocity maintenance (gain)
- Linear mixed model analysis including tDCS condition (anodal, cathodal, sham), stimulus direction (leftwards, rightwards) and timepoints to assess online-effects (four timepoints during t_{TDCS}) and after-effects (t_0, t_{TDCS}, t_{15}, t_{40}) of tDCS on smooth pursuit
- Results were compared to two control experiments, targeting the right FEF and applying normative tDCS over V5

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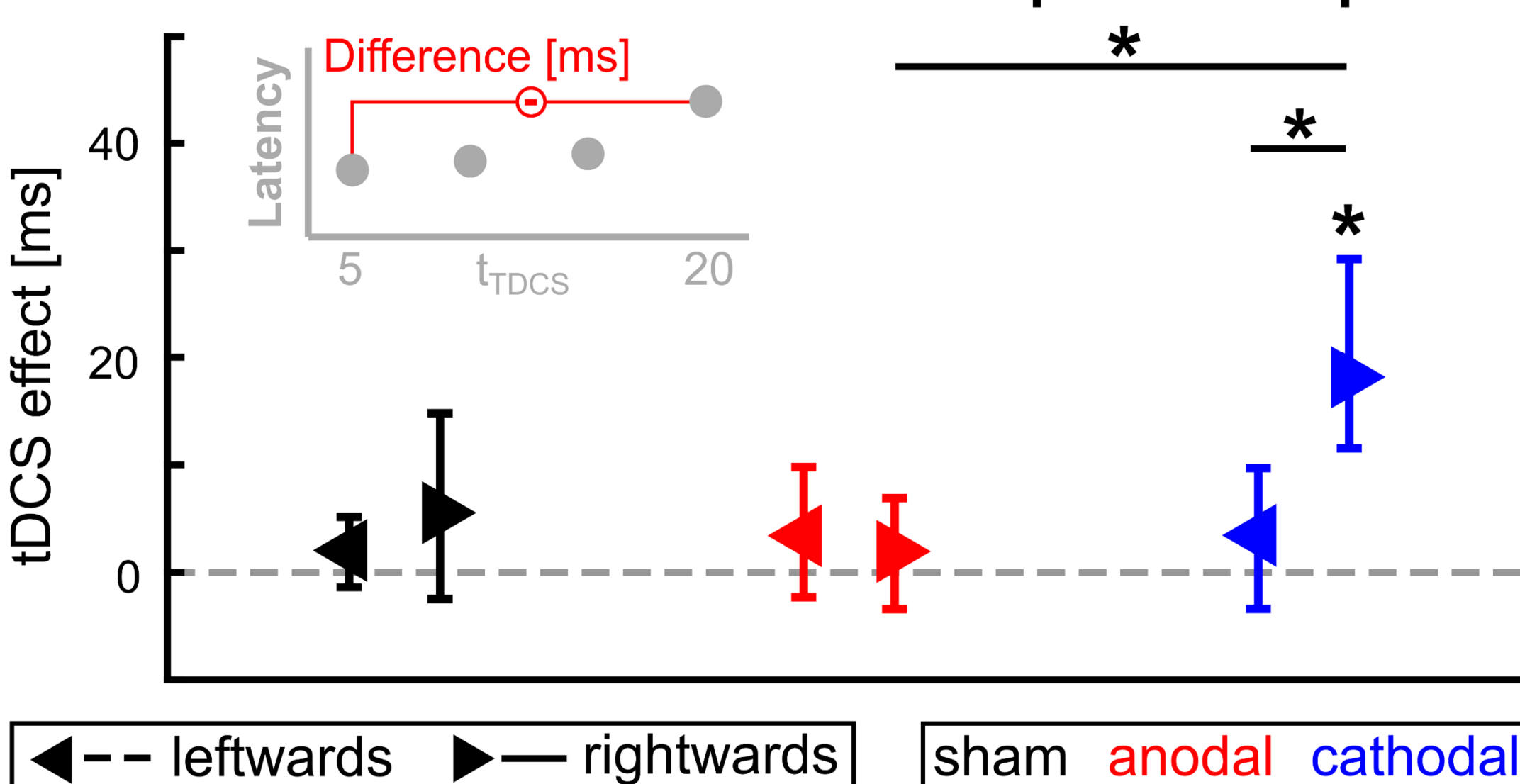
Personalized tDCS targeting V5 to modulate pursuit (initiation)

Targeting of visual area V5

Functional MRI [t]   V5 locations   Electric field [V/m]
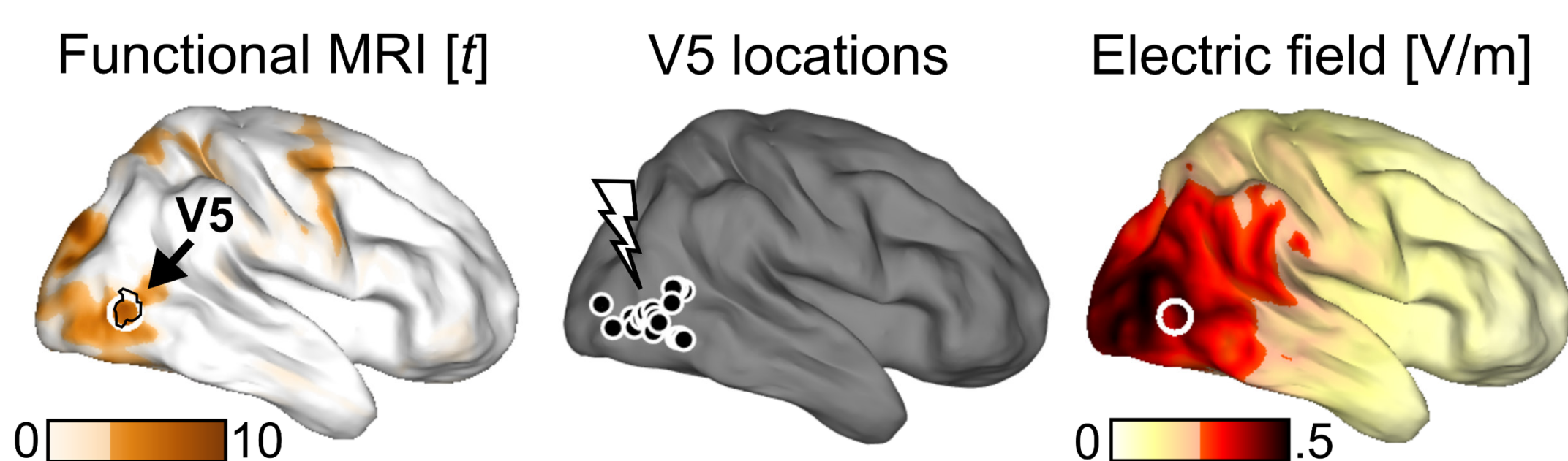
Modulation of pursuit initiation during cathodal tDCS
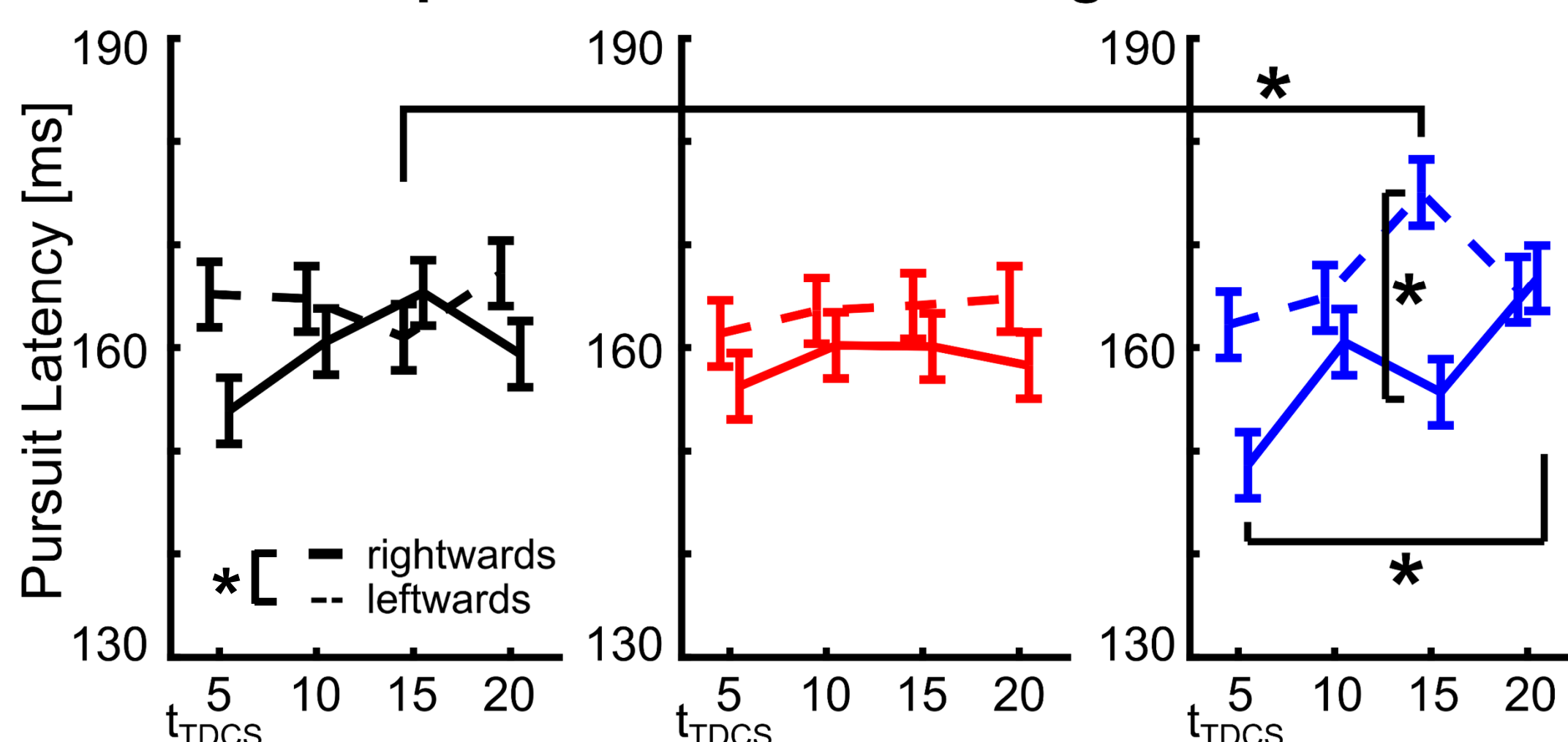
Personalized cathodal tDCS affects ipsiversive pursuit

◄ - - leftwards   ►—— rightwards   sham anodal cathodal

Results and Conclusions

In healthy subjects, personalized cathodal tDCS specifically delays ipsiversive pursuit initiation latencies in line with lesion studies [4,5]…

- …and affects early perceptual aspects of sensorimotor transformation, presumably involving decreased excitability and LTD-like modulation of V5 subregion MT

- No tDCS effect during ongoing pursuit or control experiments targeting right FEF or applying normative tDCS of V5

→ For details, see full article:
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Specific effect by cathodal tDCS targeting V5
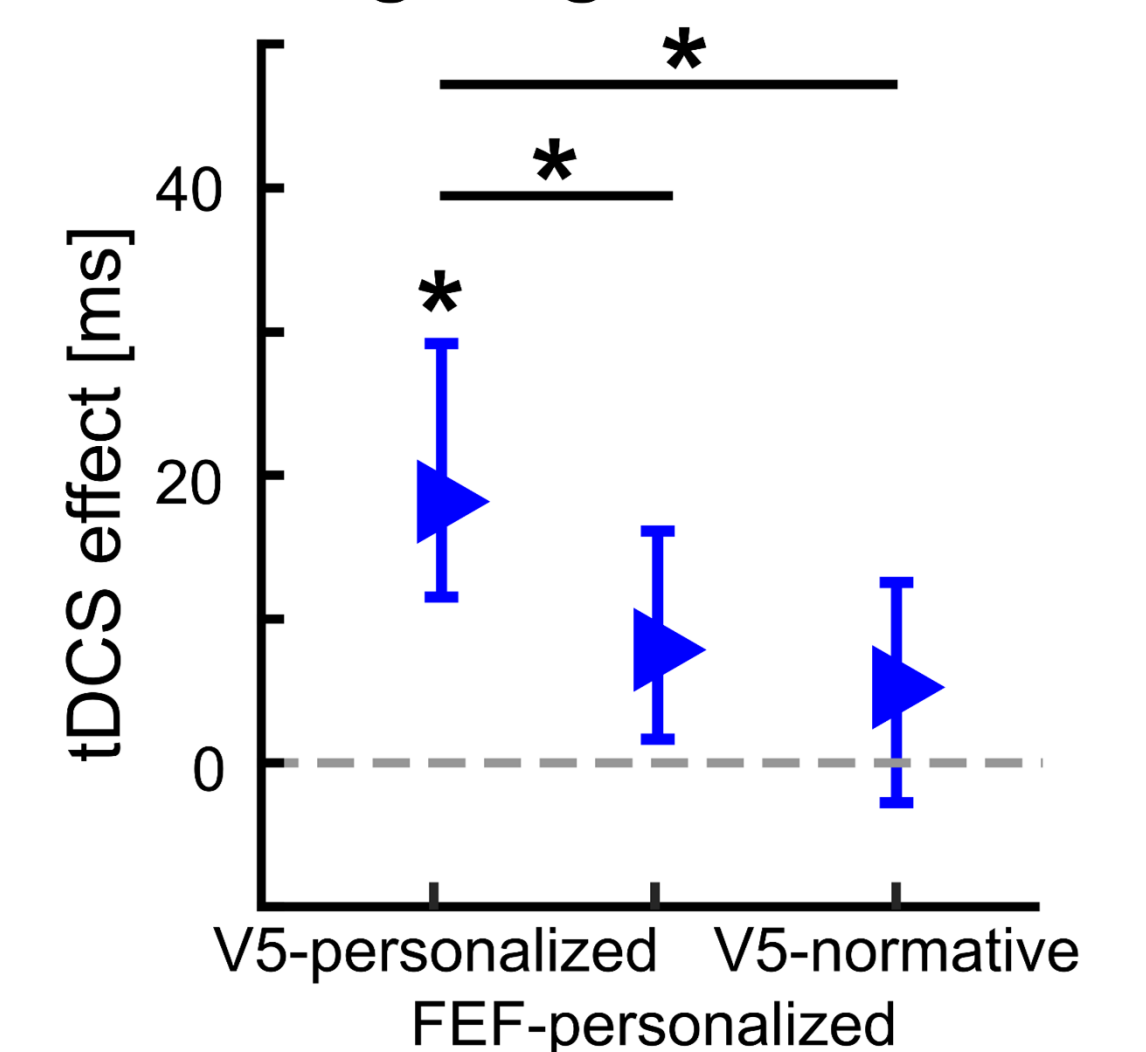

Outlook

Going beyond the modulation of pursuit latencies by personalized tDCS, personalized tACS might affect - presumably oscillatory - mechanisms during sensorimotor maintenance of pursuit.

Current follow-up studies focus on

- … oscillatory brain activity (EEG) during pursuit in healthy participants

- ... EEG activity during pursuit maintenance deficits associated with psychosis

- … the application of personalized tACS to modulate pursuit deficits in psychosis patients

Personalized tACS targeting V5
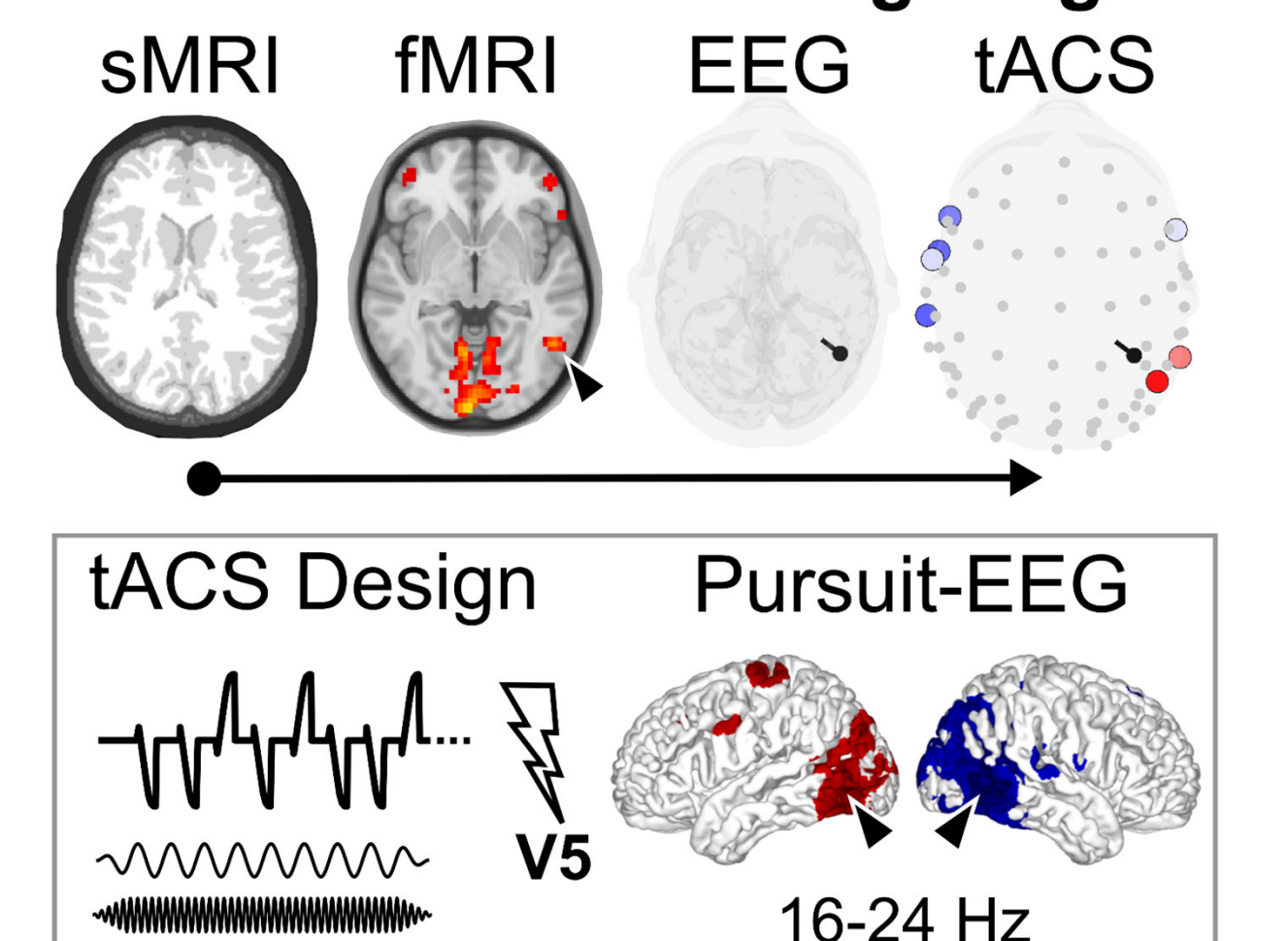
References

[1] Radecke, JO, Sprenger, A, Stöckler, H, Espeter, L, Reichhardt, MJ, Thomann, L, …, Lencer, R. (2023). Normative tDCS over V5 and FEF reveals practice-induced modulation of extraretinal smooth pursuit mechanisms, but no specific effects. Scientific Reports 13, 21380.
[2] Lencer, R., Trillenberg, P., Trillenberg-Krecker, K., Junghanns, K., Kordon, A., Broocks, A., Hohagen, F., Heide, W., & Arolt, V. (2004). Smooth pursuit deficits in schizophrenia, affective disorder and obsessive–compulsive disorder. Psychological Medicine, 34(3), 451–460.
[3] Lencer, R., Nagel, M., Sprenger, A., Heide, W., & Binkofski, F. (2005). Reduced neuronal activity in the V5 complex underlies smooth-pursuit deficit in schizophrenia: Evidence from an fMRI study. NeuroImage, 24(4), 1256–1259.
[4] Heide, W, Kurzidim, K, Kömpf, D, (1996). Deficits of smooth pursuit eye movements after frontal and parietal lesions. Brain 119, 1951–1969.
[5] Newsome, W. & Wurtz, R, (1988). Probing visual cortical function with discrete chemical lesions. Trends Neurosci 11, 394–400.