Individually optimized and MEG-targeted multi-channel tDCS stimulation reduced seizure frequency in a focal epilepsy patient

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Introduction

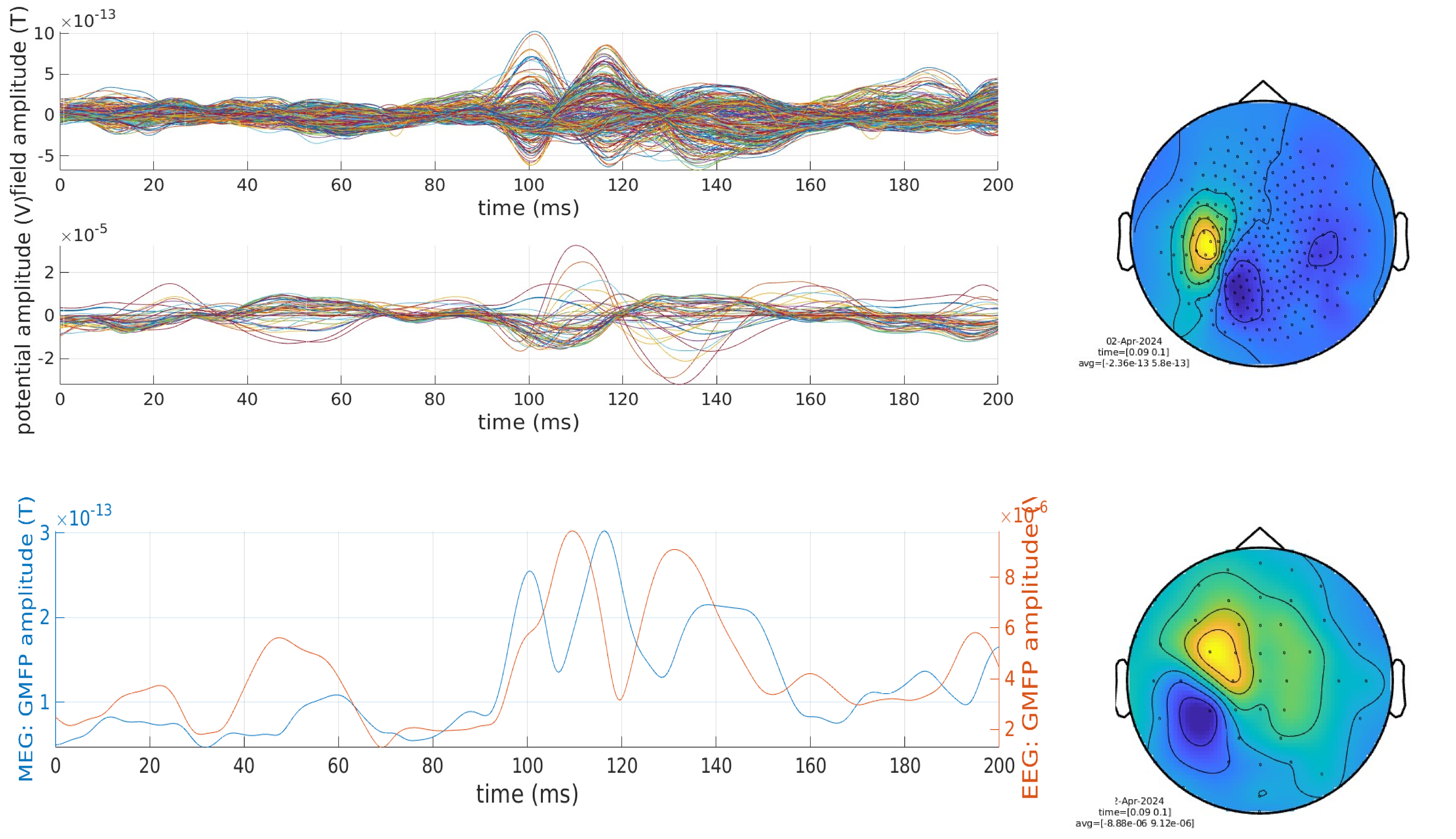
Transcranial direct current stimulation (tDCS) has shown promise in non-invasively reducing epileptic activity in focal epilepsy.

In this patient case study we demonstrate a workflow to determine a suitable tDCS target based for the first time on ictal activity, measured by magnetoencephalography (MEG) and marked by an epileptologist. Further, we quantify the impact of subsequent optimized tDCS stimulation on ictal and interictal discharge quantity.

Methods: A multi-compartment head model that includes cortical/cranial defects from prior surgery was created based on magnetic resonance imaging and computer tomography data. 1 hour of MEG data was measured, during which the patient suffered a mild seizure. The seizure onset was reconstructed using finite element forward modeling and inverse dipole scan analysis.

Based on the reconstructed ictal target, a personalized multi-channel tDCS cap was created and the patient was stimulated for two weeks, one optimized and one Active-sham in a double-blind experimental setup. Electroencephalography data was measured before and after each stimulation.

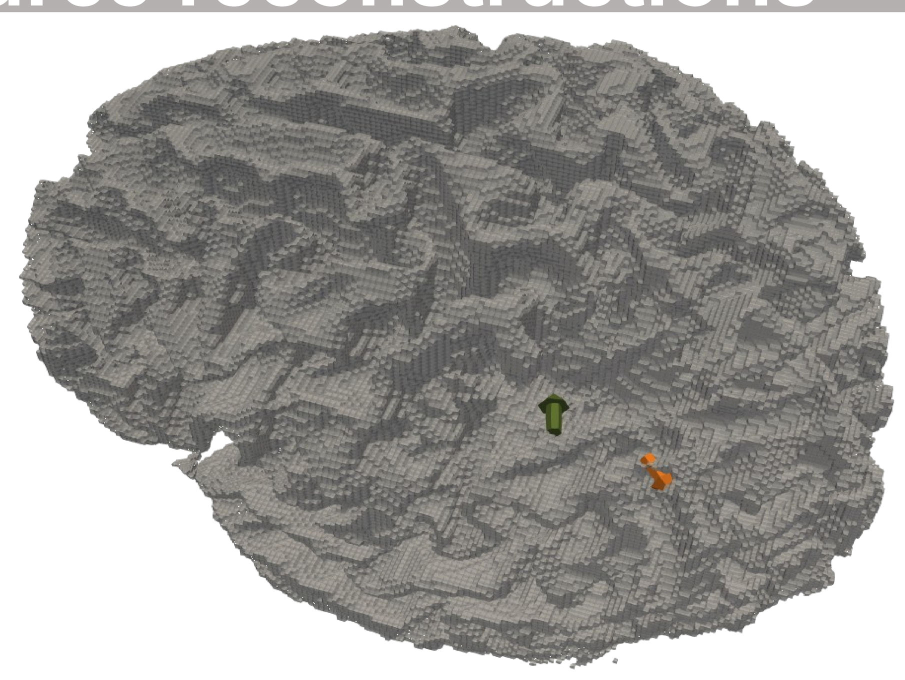
Seizure data



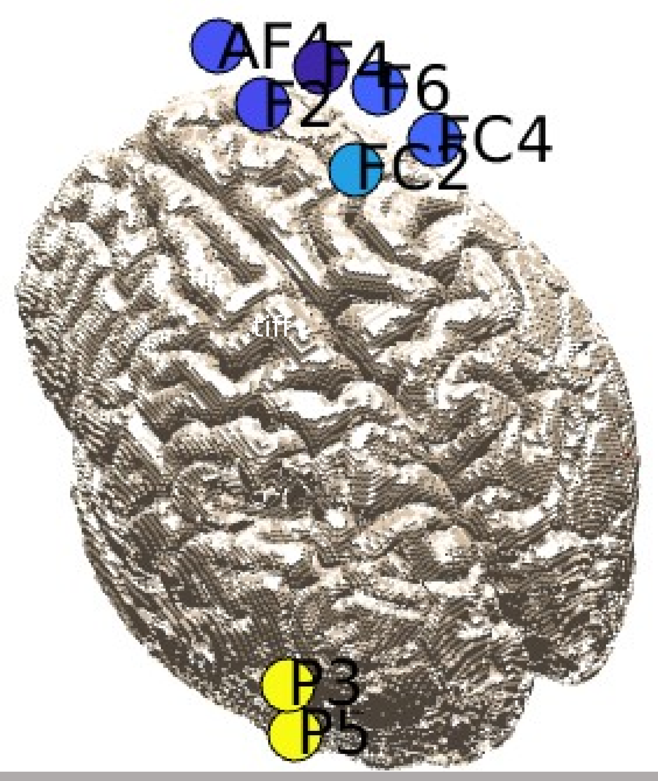
- first peak is tangential, clearer in MEG than EEG
- EEG less reliable due to cranial holes

→ use MEG for tDCS optimization

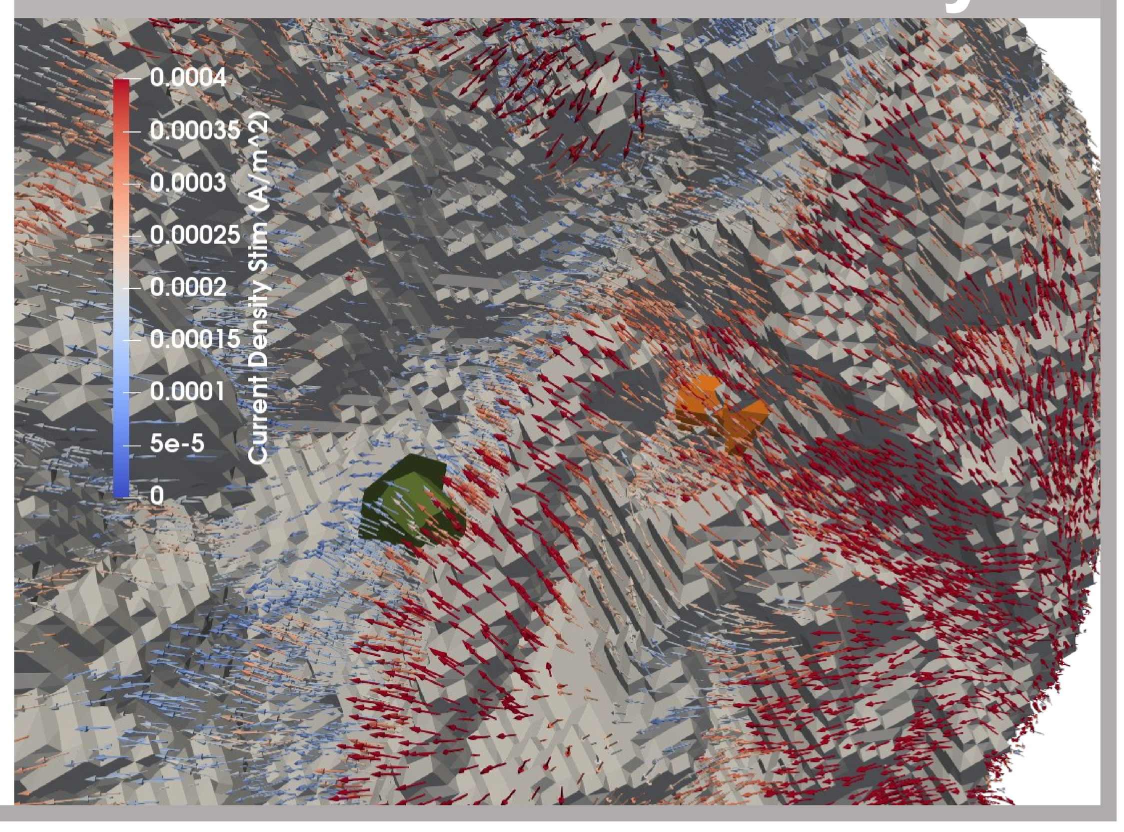
Ictal (orange) & Interictal (green) source reconstructions



D-CMI[1] optimization



Cortical current density



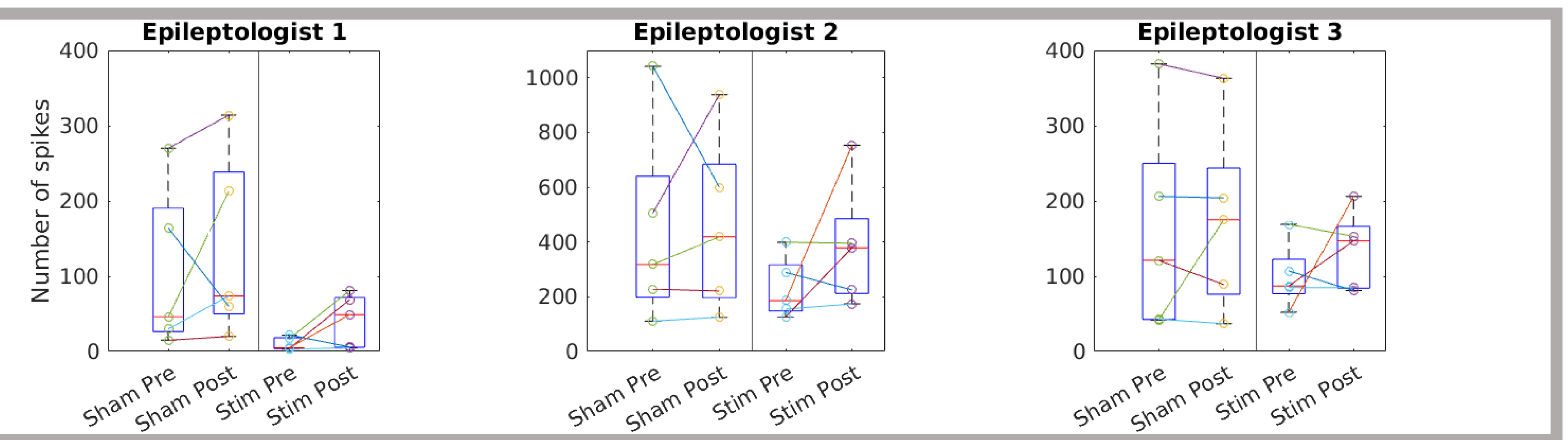
Stimulation protocol[2]

2 weeks, Mo.-Fr.
- 1 week tDCS Active-sham
- 6 weeks washout
- 1 week tDCS stimulation

Each day, 10 a.m. :
- 1 hr EEG pre stim/sham,
- 2x20 min 4mA tDCS stim/sham
- 1 hr EEG post stim/sham

Evaluation:
- 3 separate markings by blinded Epileptologists
- quantify spikes and seizures

Seizure count	Sham Pre	Sham Post	Stim Pre	Stim Post
Epil. 1	6	4	10	5
Epil. 2	6	4	10	5
Epil. 3	7	4	9	5



Results & Conclusion

Optimized stimulation could reduce seizure activity by 50% (33% reduction in Active-Sham). Slight increases in quantity of interictal activity were observed. Matches expectation as seizure and spike have opposite orientations.

Conclusion: We showcased a workflow to create optimized tDCS caps based on MEG data in a patient with severe cranial/cortical defects. TDCS stimulation showed a promising inhibitory effect. A larger group studies will quantify the effects more clearly.

Acknowledgements

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References

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[2]Antonakakis et al. *"Targeted and optimized multi-channel transcranial direct current stimulation for focal epilepsy: An N-of-1 trial" Brain stimulation, 2024*