COMBINED EEG/MEG AND OPTIMIZED TRANSCRANIAL DIRECT CURRENT STIMULATION FOR NON-INVASIVE DIAGNOSIS AND THERAPY OF FOCAL EPILEPSY

Fabian Kaiser*, Marios Antonakakis, Stefan Rampp, Christoph Kellinghaus, Stjepana Kovac, Joachim Gross, Gabriel Möddel and Carsten H. Wolters

Introduction

In **focal epilepsy**, seizures can often not adequately be controlled with anticonvulsant drug treatment, necessitating new forms of diagnosis and therapy. **Combined** Electroencephalography (**EEG**) and Magnetoencephalography (**MEG**) **source analysis** has the potential to improve the localization of the **epileptogenic zone** [1]. Its results may open the way to **new treatment** options, including **targeted non-invasive tDCS** [1,2]. As shown in standard 2-patch tDCS [3,4], significant reductions of epileptic activity can be expected. In this work, we will for this purpose use for the **first time** our recently developed **Distributed Constrained Maximum Intensity (D-CMI) mc-tDCS technique** [2].

Methods

Our **patient** is a 20-year-old female with epilepsy since the age of 14. **Seizure semiology** was described as distributed thinking and inability to speak or follow a conversation, without any motor symptoms and without impairment of awareness. The patient did not become seizure free despite treatment with multiple anticonvulsant drugs.

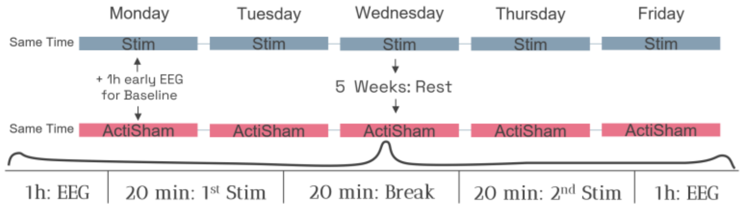
From **T1- and T2**-weighted magnetic resonance image (**MRI**) data we first constructed a realistic finite element method (**FEM**) volume conductor **head model** of the patient, including **skull defects**, **calibrated skull conductivity** and **white matter conductivity anisotropy**. We then used this head model in combined EEG/MEG source analysis for **localizing the irritative zone** from sub-averaged interictal epileptiform discharges (**IEDs**) [1].

Current Density in A/m^2	dCMI $\lambda = 80$	ActiSham
In Target Area	0.2986	0.0405
In Non-Target Area	0.0874	0.0121
Directionality	0.2124	0.0318

Table 1: Calculated Current Density and Current Directionality of STIM (dCMI) and ActiSham Montage.

D-CMI [2] was then used for the **optimization** of a **mc-tDCS montage**. A total amplitude of 4 mA was applied twice for 20 minutes, with a pause of 20 minutes in between, for five consecutive days. An **Acti-Sham montage** (adjacent leads have opposite polarities) was applied with the same regimen as treatment. There was a washout of 5 weeks between the two stimulation weeks.

Figure 1: Study Design.



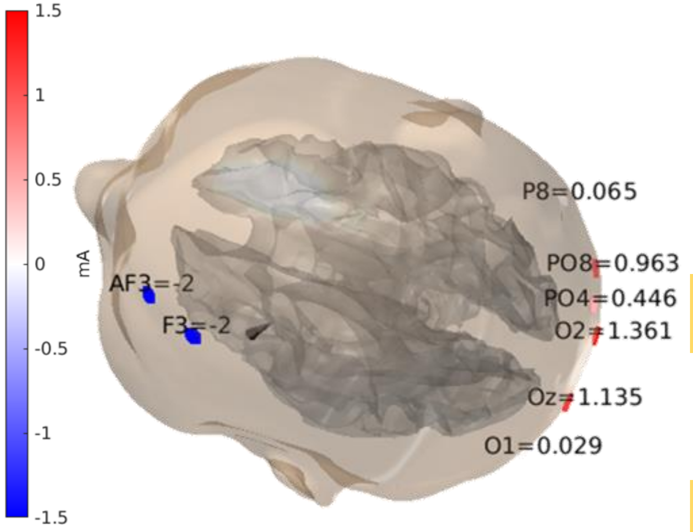


Figure 2: Shows the dCMI optimized montage with current in A. The ActiSham montage is the same as the dCMI optimized montage when it comes to electrode positions. The difference lies in the applied current: AF3: -2 mA, F3: 2 mA, O2: 2 mA, Oz: -2 mA and the rest: 0 mA.

Results

Targeted D-CMI mc-tDCS led to a **highly significant reduction in IED frequency** after treatment with median **66%** (55.8% ± 11.2%, $p < 0.00001$), while **Acti-Sham did not** ($p > 0.05$). The **IED source amplitude** was **decreased** by **76%** after treatment with D-CMI mc-tDCS while it was only reduced by 29% after treatment with Acti-Sham. Side effects were exclusively transient sensations. The only detected **seizure** had **decreased severity** and occurred during the stimulation week.

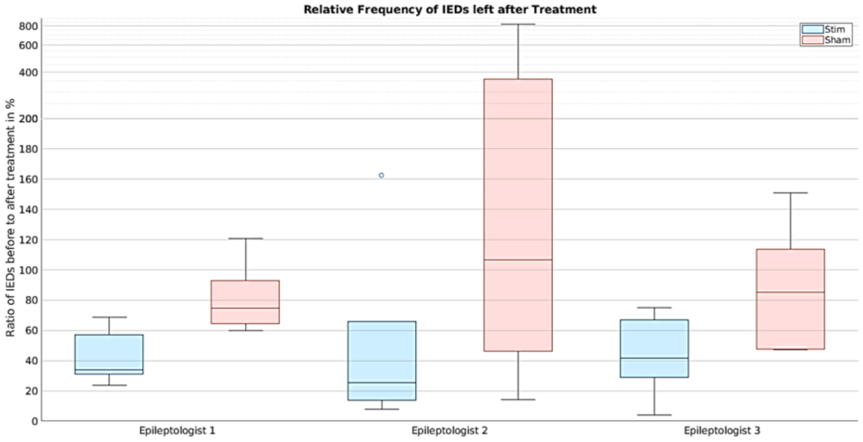


Figure 3: The relative frequency of IEDs left after treatment is the amount of IEDs per hour EEG after treatment divided by the amount of IEDs per hour EEG before treatment.

Conclusion

This **proof of principle** shows **high therapeutic potential** for **combined EEG/MEG-targeted and D-CMI optimized mc-tDCS** and paves the way for a group study in focal epilepsy.

References

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Questions, comments and inquiries welcome!

E-Mail: FKaiser@Neuroscan.com