

The effect of transcranial Direct Current Stimulation on Dynamic Effective Connectivity EEG Patterns of a Focal Epilepsy Case

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Purpose: In refractory focal epilepsy, transcranial Direct Current Stimulation (tDCS) has been suggested as a promising new therapeutic approach. The purpose of this proof-of-principle N-of-1 trial study is to investigate the effects of a multi-channel (mc-) tDCS application on a patient with refractory focal epilepsy by evaluating EEG connectivity patterns using time-varying generalized Partial Directed Coherence (tv-gPDC) before and after stimulation.

Methods and Materials: The present study is part of a long-stage analysis on imaging data of an epilepsy case where the epileptogenic zone (i.e., target area) was defined very close to Broca's area through combined electro- and magneto-encephalography (MEG) source analysis with calibrated and realistic head modeling. This region was further confirmed by invasive EEG. A double-blind, sham-controlled stimulation experiment was performed in a two-week stimulation trial. Distributed constrained maximum intensity (D-CMI)-based mc-tDCS and sham stimulation with 4 mA overall injection current amplitude were applied twice every week-day for 20 min each. EEG data was recorded 1 h before and after stimulation. For D-CMI, a highly significant reduction in interictal spike frequency ($p < 0.0001$) was marked by three experts over the five days of stimulation, while this was not the case for sham. In this study, we go one step further and investigate tv-gPDC patterns of the EEG data before and after stimulation. After preprocessing the raw EEG data, we segment them into 3-second sub-signals and apply gPDC.

Results: We found that the strength of the connections around the target area was different before and after the stimulation. Before stimulation, a high outflow tv-gPDC connectivity pattern was observed on the channels around the target area. After stimulation, however, the connectivity diminished, showing a less intense, smoother information flow. Finally, before and after the sham stimulation, no clear information flow was observed.