Dynamic effective connectivity of combined EEG/MEG sources in pharmacoresistant epilepsy

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***Abstract*— Epilepsy has been characterized as a network disease in which several brain regions might be involved. The primary goal is the identification of the hub region which could correspond to the so-called *epileptogenic zone (EZ)*. Taking into account all available information, epilepsy surgery can then be carried out to resect EZ. Here, we evaluate effective connectivity using combined electro- (EEG) and magneto- (MEG) source analysis of interictal activity in a calibrated head model with the goal to better identify the EZ.**

I. Introduction

Epilepsy is widely characterized as a network disease [1]. EEG/MEG have been used for connectivity analysis to identify networks of neuronal activities [2]. Non-invasive source analysis is a promising tool for the identification of underlying sources in presurgical epilepsy diagnosis [3]. MEEG source reconstruction in calibrated head models can outperform single modality EEG or MEG source analysis epilepsy [3]. Here, we analyze the epileptic activity of a pharmacoresistant epilepsy patient using MEEG and then investigate network connectivity.

II. Methods

All procedures were approved by the ethics committee of the University of Erlangen (Ref No 4453 B). The patient is a 29-year-old female with pharmacoresistant epilepsy. The seizure semiology included somatosensory aura of left arm followed by tonic-clonic movements of left arm and hand.

MEEG measurements were acquired followed by 3T Magnetic Resonance Imaging. Spike detection was performed by a trained epileptologist (SR) and spikes of similar topography were averaging to increase SNR. Our proposed pipeline [4], named here as *DispNeuro,* was used to construct an individual six-compartment skull conductivity calibrated (16.7 mS/m) head model with white matter anisotropy. We then performed FEM forward computations and sLORETA current density inverse estimations to indicate the FCD accurately as in [3]. The closer source localization was at -80 ms. A threshold procedure was used to reduce weak source waveforms. Finally, we estimated connectivity maps with integrated generalized orthogonalized partial directed coherence (GOPDC) but we convert it to time-varying (tv-GOPDC) and we then estimated the outflow and inflow of the nodes to determine the hub node [5].

III. Results and conclusion

We observe (Fig. 1a) that the EEG/MEG scalp topographies show a dipolar pattern over right temporal sensors at -100 ms. The MEEG source reconstruction revealed the most activated region at the right postcentral gyrus (Fig. 1b). From our analysis, this specific brain region seems to be of specific (hub node) importance due to the highest outflow and simultaneously the second lowest inflow value that it contains (Fig 1c). This effective connectivity result is not only consistent with the symptomatology, but also with MR imaging, as an FCD could be detected within the postcentral gyrus. As outlook, the surgical outcome will be needed to confirm the accuracy of our diagnostic result. We conclude that MEEG with calibrated head modeling and dynamic effective connectivity can indicate epilepsy lesions very accurately.

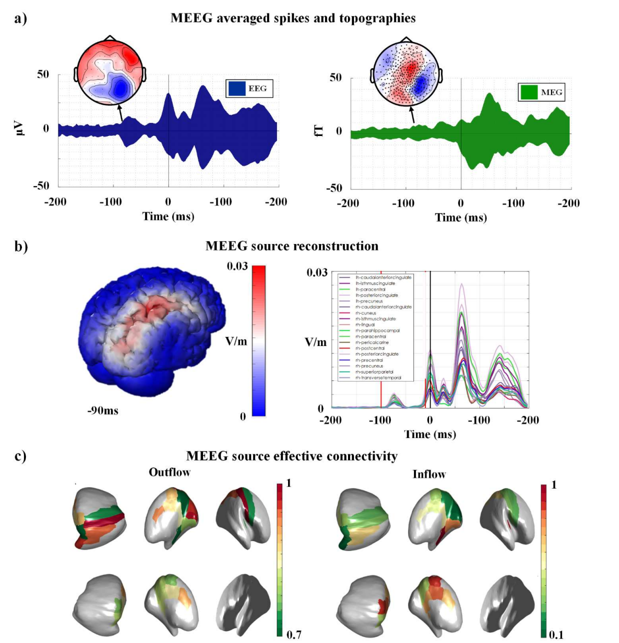

Figure 1. MEEG source reconstruction and effective connectivity. **a.** The average value across all marked spikes for EEG (blue) and MEG (green) and the scalp topographies at -90 ms. **b.** The current density of MEEG source reconstruction at -90 ms (left column) and the threshold source waveforms. **c.** The outflow (left column) and inflow of GOPDC at -90 ms for the selected source waveforms.

References

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