Added value of connectivity analysis on brain waveforms in EEG source reconstruction to detect the epileptic driver during seizures.

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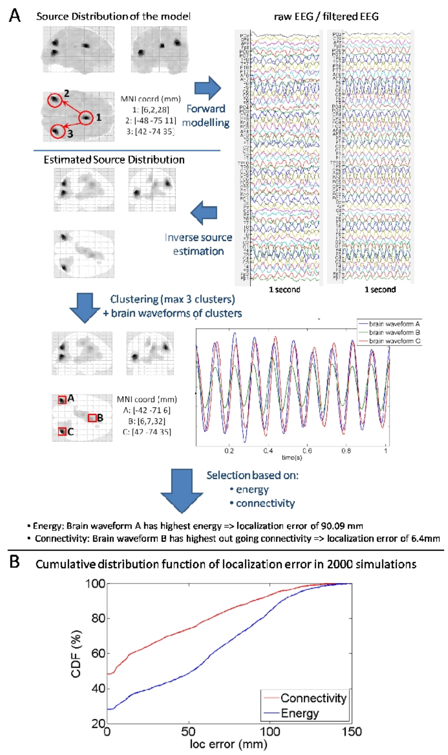
During seizures rhythmic epileptic activity is noticed in the EEG. This activity arises from a functionally connected brain network, in which several brain areas generate epileptic activity. EEG source reconstruction followed by connectivity analysis allows us to analyze the network's dynamics.We simulated 2000, 5s long ictal EEG-epochs of 512Hz using a finite difference method based forward model. The brain tissue in the model was divided into 256 patches. For each simulation, normal brain functioning was modeled as 1/f-noise in all the patches. To mimic the epileptic network, we superimposed 10Hz ictal rhythmic activity with a SNR of 20dB in 3 randomly chosen patches. In 2 patches the rhythmic activity was delayed randomly from 1 up to 10 samples, so one of the patches in the network was the driver. The simulated brain waveforms were reconstructed using the Multiple Sparse Priors algorithm in the Statistical Parametric Mapping toolbox. Each reconstruction led to a high number of active patches. The 20 patches with the highest activity were clustered into 3 groups. Out of each group the patch with the highest activity was selected, leading to 3 patches with their corresponding brain waveforms.

The epileptic driver behind the seizure was selected using (i) energy, the patch with the highest activity and (ii) connectivity, the patch with the highest number of out-going connections based on the full frequency Adaptive Directed Transfer Function. The method is explained in Fig.1A for 1 simulation. The connectivity-based selection clearly outperforms the energy-based selection and can localize the deep brain source as being the driver behind this seizure.

In Fig.1B the results of the 2000 simulations are shown. We prove that the estimation of the driver behind seizures benefits from incorporating connectivity analysis into EEG source localization. This method may improve the localization of the ictal onset zone during the presurgical evaluation in epileptic patients.



Panel A describes the method, panel B shows the resulting cumulative distribution of the localization error of the 2000 simulations. The connectivity-based approach clearly outperforms the energy-based approach.