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P27

GRAPH SIGNAL PROCESSING ON EEG TO PREDICT THE SURGICAL OUTCOME IN EPILEPSY

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BACKGROUND

Epilepsy is a neurological disorder characterised by altered brain network properties. In **temporal lobe epilepsy (TLE)**, it has been shown that the proportion of global integration increases during **interictal epileptic discharges (IEDs)** (Rigoni et al. 2023), and patients with bad surgical outcomes have higher functional integration during IEDs than good outcome patients (Carboni et al. 2019).

AIMS

Using graph signal processing (GSP) and structural network harmonics with high-density EEG to study **structure-function (SF) coupling** and **integration-segregation balance** during IEDs in patients with refractory TLE, to predict the surgical outcomes.

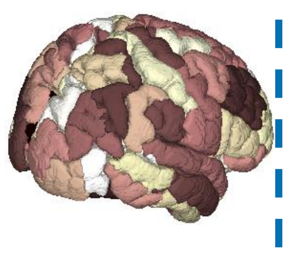
METHODS

- Participants: 33 patients with refractory TLE (15 RTLE vs 18 LTLE, 20 good vs 13 bad outcomes)

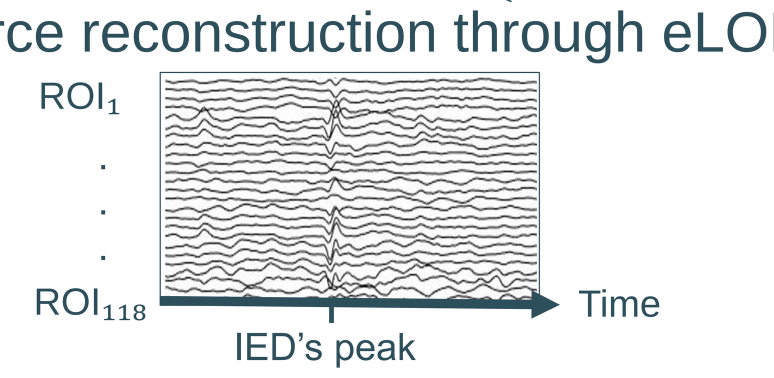
- **Functional data:**

High-density EEG IEDs

T1-weighted MRI: grey matter segmentation and parcellation into 118 regions of interest (ROIs) using the Lausanne atlas

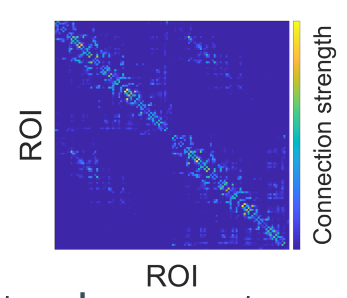


Electrical source reconstruction through eLORETA

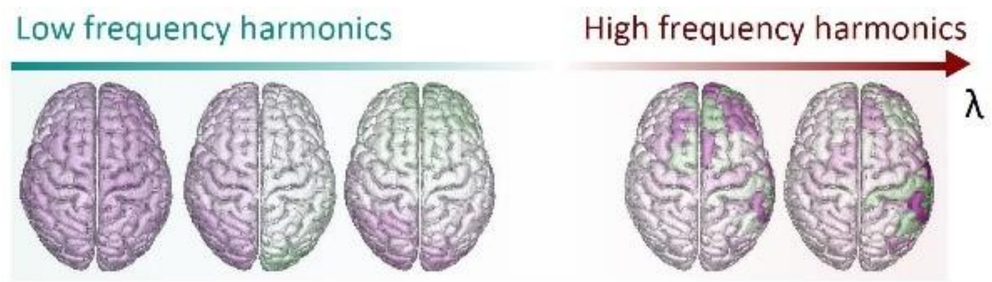


ROI time-series = $x_{ROI}(t)$

- **Structural data:** we extract the network harmonics from a consensus structural connectome (SC) obtained with diffusion MRI scans of 80 healthy participants and tractography. Network harmonics are defined as the eigenvectors of the SC's graph Laplacian and capture structural connectivity patterns. First harmonics correspond to low spatial frequencies (LF, smooth patterns), while later ones correspond to high frequencies (HF, coarse patterns).



Structural connectome (SC)



Network harmonics = U

GSP – projection of the ROI time-series on the network harmonics through the inverse GSP: $x_\lambda(t) = U^T x_{ROI}(t)$

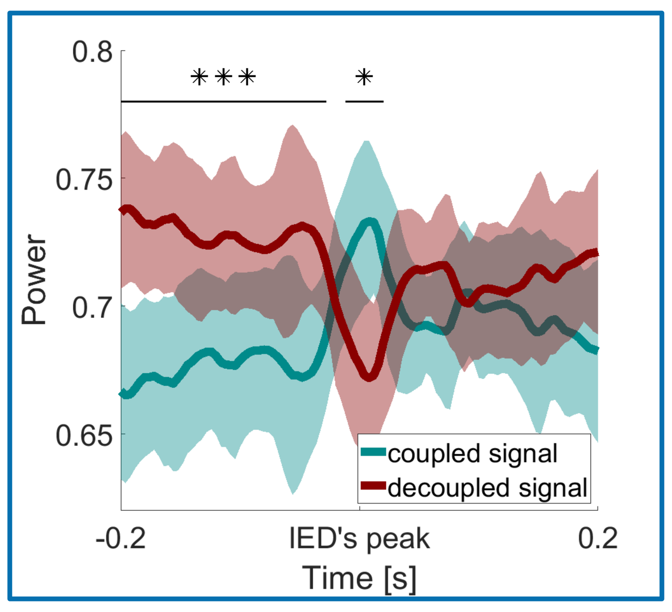
- For each subject, the energy of the transformed signal is divided into LF harmonics (reflecting network integration) and HF one reflecting segregation). The first harmonics are used to reconstruct the part of the ROI traces mostly coupled to the underlying structure, while the latter harmonics the decoupled one:

1) $x_{ROI,coupled}(t) = U^{LOW} * U^T * x_{ROI}(t)$
2) $x_{ROI,decoupled}(t) = U^{HIGH} * U^T * x_{ROI}(t)$

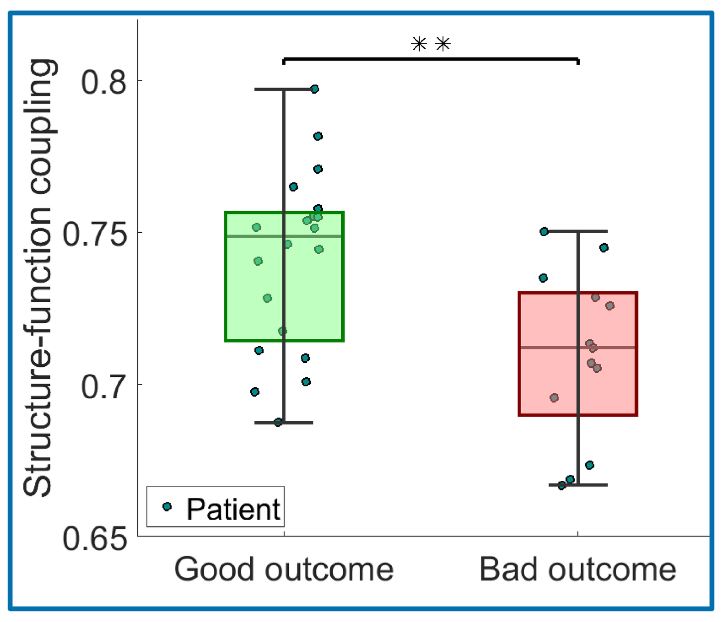
Analyses:

- The norms of $x_{ROI,coupled}(t)$ and $x_{ROI,decoupled}(t)$ are calculated over all brain regions and the dynamics of their energy distribution along the IEDs are compared with a cluster-based permutation test across patients.
- The difference in the norm of $x_{ROI,coupled}(t)$ is computed between seizure-free and non-seizure patients with a rank-sum test.

RESULTS



- Two clusters were identified, reflecting an increase in integration/SF-coupling around the IED peak ($p<0.05$) and an increase of segregation/SF-decoupling preceding it ($p<0.001$).
- At the peak of the IED, patients with poor surgical outcome tend to have lower structure-function coupling/integration level that patients with good surgical outcome ($p<0.01$).



CONCLUSION

- The **dynamic shift between integration and segregation** during IEDs aligns with previous finding and suggests effective IED signal transfer through propagation in the epileptic network.
- Contrary to the findings of this study, previous research reported an increase in functional integration among poor outcome patients.
- **Seizure freedom could be attributable and predicted by how the IEDs rely on the main structural connections in the brain.**

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