

Background EEG networks capture the time-course of epileptogenesis and ictogenic mechanisms

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Purpose: Largescale, ictogenic brain networks are increasingly recognised as important for the generation of seizures in epilepsy [1, 2]. However, it remains unclear how best to quantify such networks and how they evolve from healthy brain networks through the process of epileptogenesis. Here, we use network analyses and mathematical modelling to investigate the interplay between focal and network mechanisms in epileptogenesis.

Method: We study longitudinal high-density epicranial EEG recordings (30 electrodes) of a rodent model of mesial temporal lobe epilepsy; kainic acid injected unilaterally into the hippocampus. We analyse functional connectivity networks derived from background EEG (i.e. EEG without any epileptiform activity) of awake head-fixed mice. We use noisy theta neurone model to simulate ictogenesis and predict which nodes in the network are likely to be drivers of the remote epileptiform activity. To this end, we conceptually follow the procedure presented in [3] and analyse to what extent the activity of a single node can induce activity in the rest of the network.

Results: We show that the functional networks capture the time-course of epileptogenesis. The functional networks progress from an initially symmetric arrangement at day 0 (before the injection) to asymmetric networks post-injection (days 7 and 28). Furthermore, when combined with mathematical models, these networks reveal specific drivers of the remote epileptiform activity within the network. Interestingly, the drivers do not always align to what is traditionally thought of as the ‘focus’. Crucially, results of the analyses are experimentally validated.

Conclusion: We demonstrate that relevant ictogenic mechanisms are reflected in the background EEG, which can be used to track and understand the unfolding of epileptogenesis. Additionally, we showcase mathematical neuroscience as a practical tool that can be used to guide interventions.

References

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