Learning to generalize seizure forecasts

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Rationale

Epilepsy, one of the most common neurological disorders, is characterized by spontaneous seizures that seem to occur randomly. Yet, studies using chronic electroencephalography (cEEG) have revealed multi-day (multidien) cycles of recorded brain epileptic activity that correlate with patient-reported seizures. In our earlier work[1], we found that these multidien periodicities center around four peaks that are shared across patients: 7, 15, 20, and 30 days. However, independent of these individual “seizure chronotypes”, seizures consistently occur during the rising phase of multidien cycles, when epileptic brain activity increases over days. This shared phenomenon may bear information for forecasting seizures, even in the absence of any knowledge about patterns of seizure timing in a given patient. To test this rigorously, we trained algorithms on the data taken from a subset of patients, and forecasted seizures in other, previously unseen patients.

Methods

We used retrospectively available long-term cEEG data from participants in the RNS System clinical trials (N=160), and extracted information about the phase of their multidien cycles to forecast seizures solely on this basis. We applied (1) mixed-effects generalized linear models (GLM) and (2) recurrent neural networks (RNN) to model the occurrences of seizures across patients and derived the area under the Receiver operating characteristic (ROC) curve to assess their relative performance, which we also compared to results obtained from models (GLM) that were individually trained.

Results

Using either GLM or RNN, we generated models that forecasted seizures above chance in 55 and 63% of new, previously unseen subjects with a median predictive power of AUC=0.65 or 0.68, respectively. Moreover, the average AUCs were only slightly below that of models that were individually trained (AUC = 0.70)[2].

Conclusion

We demonstrate that the high prevalence and robustness of shared patterns of seizure cycles at the multidien timescale[1] can support generalizable forecasting model. This makes it possible to forecast seizures above chance in patients unknown to an algorithm. These findings suggest that seizure forecasting based on multidien cycles of epileptic brain activity may has broad applicability including in subjects who just started collecting chronic EEG data.

References

1 MG Leguia, et al.,'*Seizure cycles in focal epilepsy*', JAMA Neurology, 2021 **78** (4), 454-463
2 T Proix et al., 'Forecasting seizure risk in adults with focal epilepsy: a development and validation study', Lancet Neurology, 2021, 4422, (20), 6-9