Multi-level analysis of continuous physiological dynamics preceding epileptic seizures

N. Medina1, M. Vila-Vidal1, M. Carreño2, P. Roldán3, J. Rumià3, A. Donaire2, A. Tauste Campo1

1Universitat Politècnica de Catalunya, Computational Biology and Complex Systems, Barcelona, Spain
2Hospital Clínic, Epilepsy Program, Barcelona, Spain
3Hospital Clínic, Epilepsy Program, Neurosurgery, Barcelona, Spain

About 50 million people worldwide suffer from epilepsy, making it one of the most common neurological diseases worldwide. The possibility of forecasting the onset of epileptic seizures by recognizing events during the preictal phase would have a positive impact on the quality of life and also on the development of neuromodulation treatments in drug-resistant patients. Currently, the identification of pre-ictal biomarkers using intracranial electroencephalography (iEEG) is an active area of research, as iEEG recordings can detect changes in brain activity that occur prior to an epileptic seizure. In this work we propose a data-analysis pipeline to sequentially characterize the brain activity dynamics during hours/days preceding a seizure at different iEEG analysis scales (power, functional connectivity, network states) together with heart rate monitoring in order to define multi-dimensional biomarkers that have predictive value about the proximity of an epileptic seizure. We apply our pipeline to 13 and 17 hours, respectively, prior to the first recorded seizure in 2 intracranially monitored drug-resistant patients. Our preliminary results indicate that significant pre-ictal changes can be identified in 1-3 hours before the seizure (1) in the iEEG power activations of the seizure-onset zone, (2) in the fluctuations of the heart rate, and (3) in the variability of network states (defined from eigenvector centrality measures) prior to an epileptic seizure, which suggest that the combination of these measurements could provide grounds to define efficacious seizure-forecasting biomarkers.