Changes in Phase Slip Patterns due to Cortical Phase Transitions During Epileptic Events and Visual Cognition Tasks

Ceon Ramon
Department of Electrical and Computer Engineering and Regional Epilepsy Center
University of Washington, Campus Box 352500, Seattle, WA 98195, U.S.A.
ceon@uw.edu Phone: +1 206 778 0942

Presenter Name: Ceon Ramon, Ph.D., University of Washington

Abstract (250-600) words

The coordinated activity of cortical neurons is generally in a metastable state at or near the state of criticality. Any slight input, internal, e.g., a mental thought, or external, e.g., visual stimuli, could cause a phase state transition which produces a small perturbation in the measured EEG or ECoG data. These give rise to sharp phase slips in the phase of EEG data which can be used as a biomarker to study the behavior of the brain. In this talk I will present a brief theory of cortical phase transitions, Hilbert transform techniques to extract spatiotemporal patterns of phase slips and phase cones from the EEG data, and their applications to human cognition and epilepsy localizations.

The phase slip rates (PSRs) were studied from the high-density (256 channel) EEG data of five adult subjects during covert visual object naming tasks [Ramon et al., 2023]. The spatiotemporal profiles of EEG and PSRs during the stimulus and the first second of the poststimulus period were examined in detail to study the visual evoked potentials and different stages of visual object recognition in the visual, language, and memory areas. It was found that the activity areas of PSRs were different compared to EEG activity areas during the stimulus and poststimulus periods. Different stages of the insight moments during the covert object naming tasks were examined from PSRs and it was found to be about 512±21 ms for the 'Eureka' moment. Similarly, the phase cone activities in the low gamma band (30–50 Hz) and in the ripple band (80–150 Hz) were extracted from the 256-channel high-density data of adult patients. Stable phase cone patterns were selected based on the criteria that the sign of the spatial gradient did not change for at least three consecutive time samples and the frame velocity was within the range of propagation velocities of cortical axons. The spatiotemporal plots exhibited dynamical formation of phase cones which were higher in the seizure area as compared with the nearby surrounding brain areas. Overall, these results indicate that information about the cortical phase transitions can be derived from the measured EEG data and can be used as a biomarker to study the cognitive behavior and epileptogenic activity of the brain.

Ramon et al., Comput Math Methods Med. 2018:9034543. doi: 10.1155/2018/9034543. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6343174/

Ramon et al., Front Integr Neurosci. 2023, 17:1087976. doi: 10.3389/fnint.2023.1087976. https://pubmed.ncbi.nlm.nih.gov/37384237/

Biography of Presenter about 100 words

Ceon Ramon obtained his B.E.(Hons.) in Electrical Engineering from the Indian Institute of Science, Bangalore in 1966, and his Ph.D. in 1973 from the University of Utah with specializations in lasers and quantum optics. After graduation, his research interest shifted to biomedical engineering. Since the 1990s his work has been in modeling the electrical activity of the brain and EEG data analysis with applications to epilepsy and visual cognition. He has about 45 years of research and teaching experience and about 250 research publications. He has held faculty positions at SUNY/Stony Brook, the University of Washington, and Reykjavik University in Iceland. He retired in 2018 as an emeritus professor but is still very active in research. Currently, he is an affiliate professor in the Department of Electrical and Computer Engineering and is also associated with the Regional Epilepsy Center at the University of Washington.

Details of presenting author to be mentioned in certificate:

Name: Ceon Ramon
Affiliation: University of Washington
Country: U.S.A.

Photograph of the presenting author.