Bounds in the variability of brain coordinated activity in health and disease

J.L. Perez Velazquez, Adam Teitelbaum, Vera Nenadovic
Neuroscience and Mental Health Programme, Brain and Behaviour Centre, Division of Neurology, Hospital for Sick Children, Department of Paediatrics and Institute of Medical Science, University of Toronto.

Rhythms pervade physiology, however these oscillations are never strictly periodic, but show variability. Lack of variability has been associated with disease, most clearly in the abundant work on heart rate variability, where a decrease in the fluctuations in heart rate has been found in a variety of pathological situations from cardiac disease to post-traumatic stress disorder. Our work focuses on brain dynamics. The foundation of information processing by the nervous system lies in the interactions amongst its constituents. There is evidence that transient synchronization is needed for efficient sensory processing, while extended periods of widespread synchrony are associated with disease like epilepsy. Current theories of brain function propose that the coordinated integration of *transient* activity patterns in distinct brain regions is the essence of brain information processing, giving rise to consciousness. Hence, fluctuations in the synchronous activity should be present when brains are processing information, perhaps not so much when they are sleeping. But, if the flexible formation of neural activity patterns requires transient coordination which will be manifested in a certain variability in the measurement of synchronization, is there any upper (or lower) bound to it? When is too much or too little synchronization unhealthy? To assess the coordinated patterns of activity, we use phase synchrony analysis derived from electrophysiological signals (EEG, MEG or intracerebral recordings in patients). In our ongoing investigations, we have obtained preliminary evidence that less variability in brain recordings is detected after traumatic brain injury, as well as in cases of coma and cardiac arrest, compared with those recordings from healthy subjects, and that this measure can even have potential for a better prognosis after brain injury.

The general question can be formulated as "Is the magnitude of physiological fluctuations bounded for systems to function properly? Our particular aspect we wish to address is whether there are upper or lower bounds on the brain coordinated activity (measured as phase synchronization), for the individual to be considered "healthy".

The basic general question that the proposers have is whether they should attempt to solve their question more empirically than theoretically. They have tried using experimental values of synchrony (using some typical values of some index of synchrony), but they would really like to obtain something more global (abstract perhaps), so that the framework can be applied to other types of fluctuations or variability that medical/clinical researchers record.