O-11.4 Short talk

How Criticality shapes structure-function relationships and human brain dynamics

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Healthy brains exhibit a rich dynamical repertoire with flexible and varied spatiotemporal patterns replays on both microscopic and large scales. Neurodegenerative diseases reduce this functional repertoire. We hypothesize that microscopic dynamics must operate in or near a critical regime for the functional repertoire to be explored and for realistic, flexible dynamics to emerge. To test this, we use a modular Spiking Neuronal Network model, where each group of Leaky Integrate and Fire neurons represents a cortical region.A STDP-based rule is used to learn patterns of activations which propagate between modules based on a probabilistic distribution linked to the quantity of white-matter fibers for long-range connections and an exponential decay rule for nearby regions.Consequently, information is encoded both as a precise sequence of neurons and as a trajectory of activated modules. The model's predictions are compared with empirical data from magnetoencephalographic (MEG) recordings in humans. Notably, a high correlation between the functional dynamics in synthetic data and MEG is observed only when the model operates in a critical regime. In conclusion, our research provides a framework for understanding how the brain’s structure supports its diverse cognitive and processing capabilities, emphasizing the importance of critical states in achieving optimal functional repertoire.