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(G) Emergence of Structure in Brain Dynamics and Adventures in Phase Space

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Biological systems need to react to stimuli over a broad spectrum of timescales. If and how this ability can emerge without external fine-tuning is a puzzle. This problem has been considered in discrete Markovian systems where results from random matrix theory could be leveraged. Here, a generic model for Markovian dynamics with parameters controlling the dynamic range of matrix elements via uniformity and correlation of state transitions. Analytic predictions of critical values where transitions between random and non-random dynamics were found before having the model applied to real data. The model was applied to electrocorticography data of monkeys at wakeful rest undergoing an anesthetic injection to induce sleep, an antagonist injection was then administered in order to bring the monkey back to wakefulness. This data was processed into discrete Markov models at regular time intervals throughout the task. The Markov models were then analyzed with respect to the uniformity and correlation for transition rates, as well as resultant entropy and entropy rate measurements. The results were quantitatively understood in terms of the random model and the brain activity was found to cross over a predicted critical regime. Moreover, interplay between the uniformity and correlation parameters coincided with predictions of maintaining criticality across a task. Results are robust enough that the states of consciousness for the monkey were identifiable through parameter values, with sudden changes correlating with transitions between wakefulness and rest.

Keyword-1

Criticality

Keyword-2

Neuroscience

Keyword-3

Entropy

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