Dynamic Neural Interactions Revealed by the State-Space Ising Model

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Abstract Stimulus information and cognitive states of an animal are represented by correlated population activity of neurons. The maximum entropy method provides a principled way to describe the correlated population activity using much less parameters than the number of possible activity patterns. This method successfully explained stationary spiking activity of neural populations such as in vitro retinal ganglion cells. Modeling activity of cortical circuitries in vivo, however, has been challenging because both the spike rates and interactions among neurons can change according to sensory stimulation, behavior, or an internal state of the brain. To capture the non-stationary interactions among neurons, we augmented the maximum entropy model (Ising model) using a state-space modeling framework, which we call the state-space Ising model. We will demonstrate that applications of the state-space Ising model to activity of cortical neurons reveal dynamic neural interactions, and how they contribute to sparseness and fluctuation of the population activity as well as stimulus coding.

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A. Lintas et al. (eds.), *Advances in Cognitive Neurodynamics (VII)*, Advances in Cognitive Neurodynamics,
https://doi.org/10.1007/978-981-16-0317-4_27