Quantitative Biology > Neurons and Cognition

Nonnormal amplification in random balanced neuronal networks

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In dynamical models of cortical networks, the recurrent connectivity can amplify the input given to the network in two distinct ways. One is induced by the presence of near-critical eigenvalues in the connectivity matrix W, producing large but slow activity fluctuations along the corresponding eigenvectors (dynamical slowing). The other relies on W being nonnormal, which allows the network activity to make large but fast excursions along specific directions. Here we investigate the tradeoff between nonnormal amplification and dynamical slowing in the spontaneous activity of large random neuronal networks composed of excitatory and inhibitory neurons. We use a Schur decomposition of W to separate the two amplification mechanisms. Assuming linear stochastic dynamics, we derive an exact expression for the expected amount of purely nonnormal amplification. We find that amplification is very limited if dynamical slowing must be kept weak. We conclude that, to achieve strong transient amplification with little slowing, the connectivity must be structured. We show that unidirectional connections between neurons of the same type together with reciprocal connections between neurons of different types, allow for amplification already in the fast dynamical regime. Finally, our results also shed light on the differences between balanced networks in which inhibition exactly cancels excitation, and those where inhibition dominates.

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