Beyond the edge of chaos: Amplification and temporal integration by recurrent networks in the chaotic regime

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Randomly connected networks of neurons exhibit a transition from fixed-point to chaotic activity as the variance of their synaptic connection strengths is increased. In this study, we analytically evaluate how well a small external input can be reconstructed from a sparse linear readout of network activity. At the transition point, known as the edge of chaos, networks display a number of desirable features, including large gains and integration times. Away from this edge, in the nonchaotic regime that has been the focus of most models and studies, gains and integration times fall off dramatically, which implies that parameters must be fine tuned with considerable precision if high performance is required. Here we show that, near the edge, decoding performance is characterized by a critical exponent that takes a different value on the two sides. As a result, when the network units have an odd saturating nonlinear response function, the falloff in gains and integration times is much slower on the chaotic side of the transition. This means that, under appropriate conditions, good performance can be achieved with less fine tuning beyond the edge, within the chaotic regime.