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Dimensionality and entropy of spontaneous and evoked rate activity[1] RAINER ENGELKEN, FRED WOLF, Max Planck Institute for Dynamics and Self-Organization — Cortical circuits exhibit complex activity patterns both spontaneously and evoked by external stimuli. Finding low-dimensional structure in population activity is a challenge. What is the diversity of the collective neural activity and how is it affected by an external stimulus?
Using concepts from ergodic theory, we calculate the attractor dimensionality and dynamical entropy production of these networks. We obtain these two canonical measures of the collective network dynamics from the full set of Lyapunov exponents.
We consider a randomly-wired firing-rate network that exhibits chaotic rate fluctuations for sufficiently strong synaptic weights. We show that dynamical entropy scales logarithmically with synaptic coupling strength, while the attractor dimensionality saturates. Thus, despite the increasing uncertainty, the diversity of collective activity saturates for strong coupling. We find that a time-varying external stimulus drastically reduces both entropy and dimensionality. Finally, we analytically approximate the full Lyapunov spectrum in several limiting cases by random matrix theory.
Our study opens a novel avenue to characterize the complex dynamics of rate networks and the geometric structure of the corresponding high-dimensional chaotic attractor.

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