

Reliable and unreliable dynamics in driven oscillator networks

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This is joint work with Kevin Lin and Lai-Sang Young. For a coupled cell system, the question of reliability can be formulated as follows: if an external stimulus is applied multiple times, will it elicit essentially the same response each time, *independent of the state of the network when the input is received*? The answer is fundamental to the ability of the network to encode stimuli, such as incoming sensory signals, in a repeatable way. It also determines whether an ensemble of such systems would synchronize if they receive the signal as a common input.

The reliability of isolated oscillators has been explored extensively in both experiment and theory. For example, single neurons respond reliably to fixed current signals in laboratory experiments (e.g., Bryant and Segundo 1976, Mainen and Sejnowski 1995). Theoretical studies have shown that reliability is typical for phase oscillator models, *i.e.* ODEs on the circle.

The reliability of *networks* of coupled oscillators is far less well understood. Here, we take a first step toward understanding how input stimulus and network architecture interact to determine reliability. We initially focus on a 2-oscillator pulse-coupled network, adopting the standard ‘theta neuron’ model that characterizes spiking neurons near saddle-node bifurcations.

Our main findings are: **1.** Single oscillators that are reliable in isolation can become highly unreliable when coupled, depending on input amplitude and coupling strengths. **2.** Chaotic dynamics with random SRB measures are a signature of unreliability. Such measures are typically supported on lower-dimensional strange attractors, so that phase relationships in unreliable networks are highly structured. **3.** Parameters at which the two-cell network is especially susceptible to producing unreliable dynamics coincide with the onset of 1:1 phase locking for the system with zero input. A geometric explanation is proposed.

We conclude by noting implications of our results for larger networks.

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