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Observations of dynamical behavior in a stochastic Wilson-Cowan population with plasticity

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Understanding network connectivity and its role in brain activity is an arduous task. Complicating matters further is the introduction of synaptic plasticity rules. Observations using a mean-field perspective [1] are by their nature incomplete so, here, a stochastic model, which includes fluctuations, has been employed. This analysis shows that two types of network connections, driven by plasticity, exhibit oscillatory behavior signaled by a flipping between Up and Down states. Fluctuations in each state in both setups display power law-like avalanche distributions.

This study, employing a stochastic algorithm [2] used previously in a population-based model [3], introduces plasticity, according to a modified version of [4], into both an E → E and I → E network (Figure 1A). The former network includes plastic excitatory, anti-Hebbian synapses, connecting the populations, while the latter contains plastic inhibitory Hebbian synapses. Both networks incorporate a constant recurrent excitatory synapse. Dynamically, each network undergoes oscillations of relaxation type (Figure 1B) with fluctuations whose avalanche distributions look like power laws (Figure 1C).

Conclusions

Understanding the dynamics of plasticity-driven neural networks is vital. Here, it was shown that a stochastic Wilson-Cowan population connected to an exterior

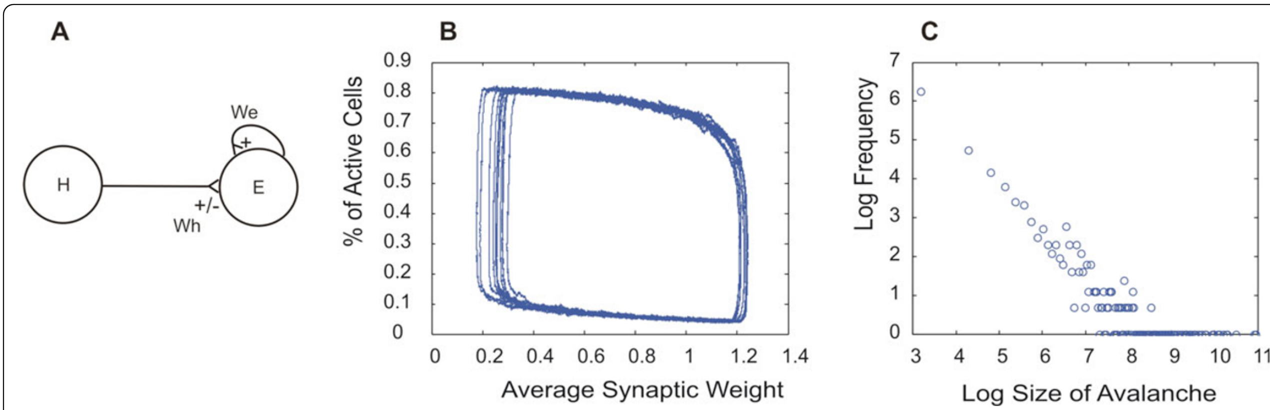

Figure 1 Network configuration with two populations. (A) Diagram of the connection. If H is an excitatory population, synapse Wh has anti-Hebbian plasticity. If H represents an inhibitory population, the synapse has Hebbian plasticity. (B) Phase plot of activity of E versus the strength of Wh in the scenario where H is an inhibitory network. (C) The avalanche distribution of the Up state in panel (B).

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population can naturally exhibit relaxation oscillations. This result with its power law avalanche statistics is a potential sign of self-organized criticality.

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