Spontaneous neuronal activity as a self-organized critical phenomenon

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Neuronal avalanches are a novel mode of activity in neuronal networks, experimentally found *in vitro* and *in vivo*, and exhibit a robust critical behaviour. Avalanche activity can be modelled within the self-organized criticality framework, including threshold firing, refractory period and activity-dependent synaptic plasticity. The size and duration distributions confirm that the system acts in a critical state, whose scaling behaviour is very robust.
Next, we address the classical enigma of how a system with no characteristic response can ever learn in a controlled and reproducible way. Learning in the model occurs via plastic adaptation of synaptic strengths by a non-uniform negative feedback mechanism. Learning is a truly collective process and the learning dynamics exhibits universal features. Even complex rules can be learned provided that the plastic adaptation is sufficiently slow.
Finally, we discuss the temporal organization of neuronal avalanches. This is given by the alternation between states of high and low activity, named up and down states, leading to a balance between excitation and inhibition controlled by a single parameter. During these periods both the single neuron state and the network excitability level, keeping memory of past activity, are tuned by homeostatic mechanisms.