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Formation of synchronous activity through STDP in recurrent neural networks with heterogenous delays

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The Spike-Timing Dependent Plasticity (STDP) rule originates from biological evidence [1] showing that an excitatory synapse is potentiated if the EPSP (Excitatory Post-Synaptic Potential) is shortly followed by the emission of an action potential at the soma, and depressed in the opposite case (when the AP is followed by the EPSP). We study the effects of STDP on random recurrent network of spiking neurons of randomly coupled elements, with random axonal transmission delays, and no external input or additional noise. The initial activity is highly irregular (Figure 1, left). After applying Spike-Timing Dependent Plasticity for a long enough time (15–50 s), the activity before periodic and synchronized (Figure 1, right).

Those results confirm the strong regularization effects obtained with STDP. They are coherent with the expected properties of the rule, favoring the conjunctions of pre-post firing, even in the case of heterogenous delays. While the transition to a periodic mode is similar to what is observed in current-based LIF networks, the emergence of synchrony seems to be specific to the case of conductance-based synapses.

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References

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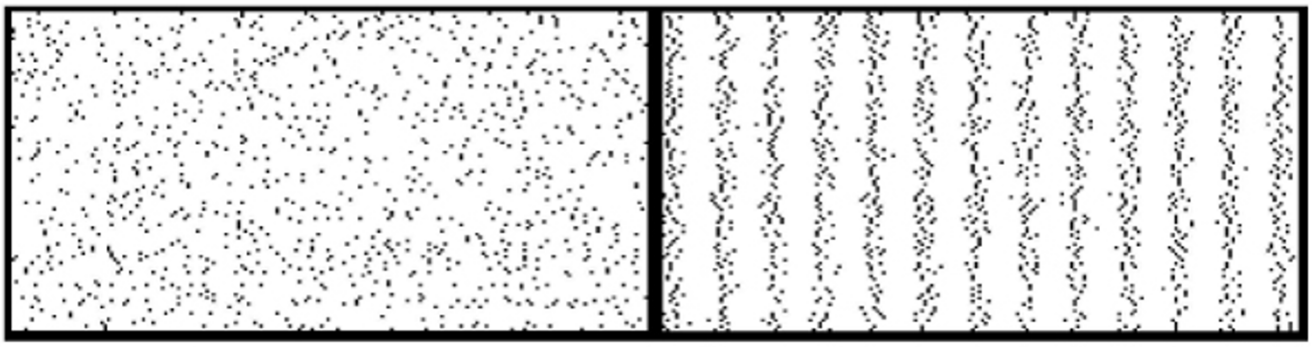

Figure 1
Samples of network activity before STDP (left), and after STDP has been applied for 50 s (right). The figures show the activity of 100 neurons (vertically) on a window of 200 ms (horizontally). A black dot is present when a neuron fires.