Information processing in neural networks with dynamic synapses

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We review here our recent work over the effect of activity-dependent synaptic processes, such as short-time depression and facilitation, on the emergent behaviour of different neural net-

works. We have studied, for instance, how synaptic depression affects the dynamic properties of Hopfield-type recurrent networks. We demonstrated that synaptic depression induces a novel phase in which the neural activity jumps among the memory attractors [1], which can be related with the appearance of oscillations between up and down states in the brain [2]. If one also considers the possibility of facilitation, and depending on the balance of depression, facilitation, and the underlying noise, the network displays different behaviors, including associative memory and switching of activity between different attractors. We concluded that synaptic facilitation enhances the attractor instability in a way that (1) enhances the system adaptability to external stimuli, and (2) favors the retrieval of information with less error during short time intervals [3].

We have also studied the influence of facilitation and depression on the storage capacity in a neural network. Our study shows that synaptic depression drastically reduces the capacity of the network to store an retrieve memory patterns. Instead, facilitation enhances the memory capacity in different contexts. In particular, we found optimal values of the relevant synaptic parameters (such as the neurotransmitter release probability or the characteristic facilitation time constant) for which the storage capacity can be maximal and similar to the one obtained with "static" synapses, that is, without activity-dependent processes [4]. We conclude that a recurrent neural network with dynamic synapses with a proper level of depression and facilitation respond better to external stimuli than static synapses, while maintaining the same storage capacity.

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