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# Interplay between spike-timing-dependent plasticity and neuronal correlations gives rise to network structure

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## Introduction

Spike-Timing-Dependent Plasticity (STDP) describes the change in the strength (or weight) of neuronal connections depending on the pre- and post-synaptic firing activity [1-3], which in turn changes the spiking properties of the post-synaptic neurons on a slower time scale. The interplay between the parameters of the neurons, the plasticity rule and the input stimulation results in changes to the network structure by strengthening or weakening pathways. This leads to functional changes of the neuronal information processing that takes place in the network. In addition to learning spiking-rate-based information, STDP captures the effect of spike-time correlations on short time scales, down to milliseconds, which are neglected by rate-based learning. STDP has been demonstrated to capture, for example, interaural time differences [1] and the presence of narrowly distributed correlations among input spike trains [2].

## Methods

Extending a previously developed framework [3], we consider the effect of STDP in recurrent neuronal networks stimulated by pools of external inputs, where either the input or recurrent connections (or both) are plastic. We use a theoretical framework based on the Poisson neuron model to analytically describe the network dynamics (firing rates and spike-time correlations) and thus the evolution of the synaptic weights. This framework incorporates the time course of the post-synaptic potentials and synaptic delays. Our analysis focuses on the asymptotic states of a network stimulated by two homogeneous pools of "steady" inputs, namely Poisson spike trains which have fixed firing rates and spike-time correlations.

## Results and discussion

We show that, in all cases, STDP can generate two simultaneous effects on the weight dynamics: a homeostatic equilibrium that stabilizes neuronal activity (firing rates) and a diverging behavior according to the pairwise spike-time correlation structure. Our analysis suggests that weight-dependent STDP may be necessary in order to obtain stability when both the input and recurrent weights are plastic. At the scale of a neuronal network, inhomogeneities in the connectivity and in the input structure results in an interesting behavior where feed-forward synaptic pathways and areas with reinforced feedback emerge in the initially homogeneous recurrent network. This robust weight competition gives rise to neuronal specialization, which can be linked to self-organization [4] that takes place in the primary visual cortex during the first weeks of new-born mammals [5]. Our results support the idea that spike-time correlations play a major role in the functional organization resulting from synaptic learning in networks.

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