Inhibitory plasticity balances excitation and inhibition in sensory pathways and memory networks

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A number of recent studies suggest that the excitatory synaptic input received by individual cortical neurons is balanced by concurrent inhibition, possibly down to the level of individual synaptic events.

This balance is thought essential for maintaining stability of cortical networks, it may explain the highly irregular activity patterns that are observed in cortical neurons and probably has a strong influence on how information propagates in the brain. Despite the recent interest in this phenomenon, no mechanism has been suggested that allows the establishment of such balanced networks and its maintenance in the presence of plasticity.

I will show analytically and in simulations that such a balance can be established and maintained in a self-organized manner by a simple plasticity rule in inhibitory synapses (ISP). For networks with feedforward inhibition, ISP leads to a detailed balance: inhibitory synapses adapt such that excitatory and inhibitory currents develop the same stimulus tuning. In recurrent networks, ISP establishes a balance that stabilizes the asynchonous irregular state, which most resembles cortical activity patterns in vivo. When synaptic memories are introduced into the network in the form of Hebbian assemblies, ISP causes a rebalancing of the network until a global and homogeneous asynchronous irregular state is reached, so that network activity no longer reveals the memories. The memory can be recalled, however, by reactivating a subset of the neurons in a given assembly.

If time permits it, I will also present some preliminary results on the influence of a dynamically rebalancing feedforward inhibition on excitatory plasticity.