Embedding memories in a network with excitatory and inhibitory plasticity leaves a spiking regularity trace

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Cortical synapses are plastic, allowing sensory experience to be stored in the network connectivity. Theoretical studies have shown that neuronal assemblies can form upon stimulation in networks with multiple forms of plasticity [1, 2, 3, 4]. In some of these studies [3,4], the resulting network activity reflects previous experiences, with assemblies transitioning between periods of high and low activity. In the others [1, 2], inhibitory plasticity counteracts the effect of excitatory potentiation, leading to the formation of cell assemblies in which excitatory neurons receive increased excitatory and inhibitory currents (EI assemblies). Such EI assemblies could implement inhibitory engrams [5], which allow memories to be stored in a quiescent state, from where they can be recalled for example through disinhibition [6]. Here we show that, also in EI assemblies, the previous experience may be reflected on spontaneous activity, and information about the assembly may be encoded on the regularity of spike trains. We perform simulations of recurrent networks of excitatory and inhibitory leaky integrate-and-fire neurons, in which excitatory-to-excitatory connections follow the triplets STDP rule [7], and inhibitory-to-excitatory connections are subject to iSTDP [1]. We show that, after stimulation, excitatory neurons belonging to the EI assembly can be distinguished from the other excitatory neurons in the network based on the coefficient of variation of their inter-spike-intervals. We also show how information about irregularity of spike trains can be readout with the support of short-term plasticity, and how this irregularity leads to a slower decay of excitatory weights within the EI assembly.

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