Synaptic Plasticity, Stability and Memory

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In this tutorial talk we introduce synaptic plasticity as a candidate mechanism for memory and the concepts from statistical physics that have been used to analyze single neurons and networks with synaptic plasticity.

After a short overview of the various memory systems and the relation between memory and synaptic plasticity, we start with an introduction to the hippocampus which has been the preferred system to measure synaptic plasticity. Next we will go into some detail into the biophysics of synaptic plasticity. In particular, we will address biophysical changes and stages that correlate with the induction, expression, and maintenance of synaptic plasticity, changes in the receptor composition and changes in the spine volume. We emphasize stability issues of the receptors in the synapse. Next, we show how plasticity can be analyzed in the diffusion approximation. In particular this allows us to calculate the information capacity of the synapse in a single neuron recognition task.

Next we will look at spike timing dependent plasticity rules. We show how the observed weight dependence of spike timing dependent plasticity rules leads to so called soft bound plasticity. We show how Fokker-Planck equations can be used to calculate the distribution of synaptic weights under random stimulation of the inputs. Finally, we show the effect of such soft-bound plasticity on receptive field development. The receptive fields are much less stable using soft-bound plasticity compared to hard-bound plasticity. However, some stability can be regained by lateral inhibition, thus providing biology with the flexibility to regulate plasticity.