Abstract

The subiculum is a structure that forms a bridge between the hippocampus and the entorhinal cortex (EC) in the brain, and plays a major role in the memory consolidation process. It consists of different types of pyramidal neurons. Based on their firing behavior, these excitatory neurons are classified into strong burst firing (SBF), weak burst firing (WBF) and regular firing (RF) neurons. In the first part of the work, morphological differences in the different neuronal subtypes was explored by biocytin staining after classifying the neurons based on the differences in electrophysiological properties. Detailed morphological properties of these three neuronal subtypes were analyzed using Neurolucida neuron reconstruction method. Unlike the differences in their electrophysiological properties, no difference was found in the morphometric properties of these neuronal subtypes.

In the second part of the thesis, experimental results on spike- timing- dependent plasticity (STDP) at the proximal excitatory inputs on the subicular pyramidal neurons of the juvenile (P15-P19) rat are described. The STDP was studied in the WBF and RF neurons. Causal pairing of a single EPSP with a single back propagating action potential (bAP) at a time interval of 10 ms failed to induce plasticity. However, increasing the number of bAPs in such EPSP-bAP pair to three at 50 Hz (bAP burst) induced LTD in both, the RF, as well as the WBF neurons. Increasing the frequency of action potentials to 150 Hz in the bAP burst during causal pairing also induced LTD in both the neuronal subtypes. However, all other STDP related experiments were performed only with the bAP bursts consisting of 3 bAPs evoked at 50 Hz. Amplitude of the causal pairing induced LTD decreased with increasing time interval between EPSP and the bAP burst. Reversing the order of the EPSP and the bAP burst in the pair induced LTP only with a short time interval of 10 ms. This finding is in contrast to most of the reports on excitatory synapses, wherein the pre-before post (causal) pairing induced LTP and vice-versa. The results of causal and anti-causal pairing were used to plot the STDP curve for the WBF neurons. In the STDP curve observed in these synapses, LTD was observed upto a causal time interval of 30 ms, while LTP was limited to 10 ms time interval. Hence, the STDP curve was biased towards LTD. These results reaffirm the earlier observations that the relative timing of the pre- and

postsynaptic activities can lead to multiple types of STDP curves. Next, the mechanism of non-Hebbian LTD was studied in both, the RF and WBF neurons. The involvement of calcium in the postsynaptic neuron in plasticity induction was studied by chelating intracellular calcium with BAPTA. The results indicate that the LTD induction in WBF neurons required postsynaptic calcium, while LTD induction in the RF neurons was independent of postsynaptic calcium. Paired pulse ratio (PPR) experiments suggested the involvement of a presynaptic mechanism in the induction of LTD in the RF neurons, and not in the WBF neurons since the PPR was unaffected by the induction protocol only in the WBF neurons. LTD induction in the WBF neurons required activity of the NMDA receptors since LTD was not observed in the presence of the NMDA receptor blocker in the WBF neurons, while it was unaffected in the RF neurons. However, the RF neurons required the activity of L-type calcium channels for plasticity induction, since LTD was affected in the presence of the L-type calcium channel blockers, although the WBF neurons did not require the L-type calcium channel activity for plasticity induction. Hence, in addition to a non-Hebbian STDP curve, a novel mechanism of LTD induction has been reported, where L-type calcium channels are involved in a synaptic plasticity that is expressed via change in the release probability. The findings on the STDP in subicular pyramidal neurons may have strong implications in the memory consolidation process owing to the central role of the subiculum and LTD in it.