Abstract

The hippocampus is one of the most widely studied brain parts, and it is of interest to most of the neuroscientists, from those who study its structure and function to those who study its malfunction in various diseases and pathological conditions. The hippocampus plays a key role, among other things, in the acquisition and consolidation of episodic memory, as well as on spatial orientation. Perhaps the most attractive property of the synapses in the hippocampus is its ability to reply to specific activation patterns with long-term increases or decreases in synaptic efficiency.

The main objective of this thesis, result of a close colaboration between Centro de Biomateriales e Ingeniería Tisular at Universitat Politècnica de València and Laboratorio de Plasticidad de las Redes Neuronales at Instituto de Neurociencias (Consejo Superior de Investigaciones Científicas – Universidad Miguel Hernández) at San Juan (Alicante), is to provide new insights about the mechanisms of transfer of information between different areas of the hippocampus and thus contribute to a better understanding of neurophysiological mechanisms underlying learning and memory by analysis of signals acquired by high density electrophysiological recordings, corresponding to different parts of the hippocampus and associative parietal cortex, acquired at different time points before and after long term synaptic potentiation. To this end, we have developed a methodology that allowed us to study the system ipsilaterally and bilaterally, and we observed the spatial and temporal dependence of the standard deviation of the estimates of coherence and correlation. Furthermore, we have worked with the Local Field Potencial channels and their independent components, and we made a comparative between the correlation and coherence results obtained for each case, using fragments from different stages, before, during and after the Long Term Potentiation, to learn about changes that occur in this structure after synaptic potentiation. With coherence, we have observed the changes that occur due to

synaptic potentiation in different frequency bands. All these calculations were made ipsilaterally, comparing signals from the same cerebral hemisphere, and bilaterally, comparing signals from different cerebral hemispheres.

Lastly, from the experience in handling these electrophysiological recordings and their independent components, we have identified interregional correlation patterns that occur through time as singular entities and we have called "ministates" for his duration of less than a second. These patterns, which appear repeatedly in the records, are associated with electrophysiological events identifiable in the signal, and are modulated by sinaptic plasticity processes.

Thus, we have developed an adequate methodology for the analysis of signals acquired by high density electrophysiological recordings, by calculating the correlation and coherence of these electrophysiological signals and their independent components, and has been programmed in MATLAB environment.

Using the developed tools, we have verified the temporal and spatial dependence of the dispersion of the values of correlation and coherence and we have analyzed the resting functional structure of the hippocampal formation circuits, obtaining evidence for the existence of two parallel and independent processing pathways. Furthermore, we have found communication patterns, which we have called "ministates" that occur through time in sequences controlled by synaptic plasticity processes, appearing repeatedly in different studied stages of our learning experimental model.

We are still far from being able to describe how learning changes the brain 'internal state'. Among the difficulties encountered worth mentioning the huge variability in the electrophysiological signals recorded in the various states through which, spontaneously, the brain activity runs. Thus the footprint of the learning or memory is masked by large activity fluctuations. However, thanks to the tools developed, we were able to provide new data about how communication occurs in the hippocampal formation and find that synaptic plasticity modulates that communication.