Gating in Cerebral Networks

The correct functioning of the mammalian brain depends on the integrated activity of myriad neuronal and non-neuronal cells. Throughout, neuronal networks are under the control of neuromodulatory systems. One goal of current neuroscientific research is to elucidate how these systems operate, especially during normal conscious behaviours and processes. Mircea Steriade and Denis Paré describe the neuronal properties and networks that exist within and between the cortex and two important subcortical structures: the thalamus and the amygdala. The authors explore the changes in these properties, covering topics including morphology, electrophysiology, architecture and gating, and comparing regions and systems in both normal and diseased states. This book is aimed at graduates and postdoctoral researchers in neuroscience.

Mircea Steriade held the position of Professor and Head of the Laboratory of Neurophysiology at Laval University, Quebec, from 1968 to 2006.

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Mircea Steriade
Denis Paré
MS dedicates this book to Donca, Claude and Jacqueline.
DP dedicates this book to Noemi, Julian and Martha.
Sadly, when this book was in the final stages of production, Dr. Mircea Steriade passed away at the age of 81, after a long fight with cancer. Dr. Steriade began writing this book while undergoing chemotherapy, knowing that his was a terminal condition. Mircea Steriade was an extremely energetic man, passionate, uncompromising, forever driven by scientific discovery. He published more than 400 scientific papers during his career and was respected by supporters and competitors alike. I refer the reader to earlier obituaries [1,2] for biographical information.

I met Mircea Steriade in 1985 when I started as a PhD student in his laboratory. To a young graduate student, he was a formidable man who commanded respect. He had an unrivaled knowledge of the scientific literature and knew by heart the references of many classical papers. His culture was not limited to science however as he was an accomplished pianist, a student of history, and an avid reader of French literature. After my post-doctoral training in 1992, I returned to Steriade’s Department at University Laval (Quebec City, Canada) as an Assistant Professor. We had adjacent offices and had lunch together every day. Thus, we grew very close and stayed in touch after I left Laval for Rutgers University in 2001. I am deeply indebted to him for he patiently taught me everything he knew about the science trade. More than a mentor however, he was a friend whose support and advice had a decisive influence in my life. Even after 50 years of research in neuroscience, he was still consumed by his work. He would often call me to share his excitement about the latest finding to come out of his laboratory. This is the image of Mircea I cherish most: passionate, enthusiastic, inquisitive, and forever young.

In correcting the proofs of this book, I was reminded of all the knowledge lost with the passing of Mircea Steriade. In writing this, I am reminded of the mentor who taught me so much and of the friend I miss.

Denis Paré


Contents

Preface page ix
Acknowledgements x

Chapter 1 Morphology and electroresponsive properties of thalamic neurons 1
1.1 Nuclear systematization, morphology and immunoreactivity of thalamic cells 1
1.2 Intrathalamic and thalamocortical neuronal networks 9
1.3 Intrinsic neuronal properties and their modulation by synaptic activity 17

Chapter 2 Morphology and electroresponsive properties of neocortical cells 27
2.1 Varieties, immunoreactivity and connectivity of neocortical neuronal classes 27
2.2 Intracortical, corticothalamic and other long-axon projections 35
2.3 Intrinsic properties of cortical cells and their changes by synaptic activity 40

Chapter 3 The amygdala 54
3.1 Is the amygdala a valid anatomical concept? 54
3.2 Cell types and physiological properties 58
3.3 Intrinsic and extrinsic connections 69

Chapter 4 Rhinal and medial prefrontal cortices 75
4.1 Cytoarchitectural organization and cell types 75
4.2 Connections 82
4.3 Interactions between the rhinal and medial prefrontal cortices and amygdala 86

Chapter 5 Neuromodulation and state-dependent activities in forebrain neuronal circuits 99
5.1 Multiple modulatory systems in the brainstem core, hypothalamus and basal forebrain: connectivity and properties 100
5.2 The effects of different neuromodulatory systems on thalamic and cortical cells: state-dependent changes in thalamocortical systems 113
5.3 Neuromodulation of amygdala, perirhinal and medial prefrontal neurons 123
In neuroscience, the term gating can assume various meanings depending on the level of analysis. At the level of ionic channels, gating refers to the transition between two or more conformational states of channel proteins. At the neuronal or networks level, gating refers to changes in responsiveness and in inhibitory processes during different behavioral states. In both instances, the causative events and their functional consequences can vary widely. This book focuses on gating in the thalamocortical and amygdalocortical systems.

In the thalamocortical system, gating was often used to describe the blockade of signal transmission from the external world to the cerebral cortex during disconnected states, such as slow-wave sleep. In this monograph, we also discuss evidence that, despite absence of information from the external world, the behavioral state of slow-wave sleep is associated with the processing of internally generated signals and with synaptic plasticity. We also argue that these events may lead to the consolidation of memory traces acquired during the waking state as well as to a form of consciousness expressed by dreaming mentation. The opening of thalamic gates during brain-active states of waking and REM sleep changes the excitability of cortical neurons and leads to different forms of mentation.

In the amygdalocortical system, gating refers to how the transmission of sensory inputs is modulated according to their emotional significance. This process leads to alterations not only in behavioral responsiveness, but also in memory consolidation. In this system, gating can also be used to describe the facilitating effect of emotions on memory. We will therefore present evidence that, via the amygdala, emotional arousal can facilitate memory.

Besides these topics, this book compares the anatomical and physiological organization of two different brain networks: the thalamocortical and amygdalocortical systems. Whereas the thalamocortical system is the gateway for sensory inputs into consciousness, the amygdalocortical system receives highly processed sensory information from the neocortex and uses it to generate affects and modulate memory. Although both systems display unique properties, they are also similar in many ways. In particular, both systems illustrate how neuronal computations arise from complex interactions between the intrinsic properties of constitutive elements and the architecture of the network in which they are inserted. We will show how intrinsic neuronal properties are modulated, and sometimes overwhelmed, by background synaptic activities, which would explain some dissimilarities between data obtained in the intact brain and in some simplified preparations.
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