Multimodal Oscillation-based Connectivity Theory

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Editor

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Preface

The system-level neuronal mechanisms that coordinate temporally, anatomically, and functionally distributed neuronal activity into coherent cognitive functions in the human brain have remained poorly understood. Synchronized neuronal activity coordinates and regulates neuronal processing in local neuronal circuits and could hence be a system-level biological mechanism governing the coordination of anatomically distributed processing in perception, action, and cognitive processes.

In humans, neuronal oscillations and synchronization can be recorded non-invasively with electro- and magnetoencephalography (EEG and MEG) that have excellent temporal and good spatial resolution when combined with source-reconstruction methods. Although EEG and MEG recordings have revealed that local oscillations characterize task-dependent neuronal activity and predict behavior, less is known of the role of large-scale neuronal synchronization in the coordination of neuronal processing in support of cognitive processes as the analysis of large-scale synchrony from noninvasive MEG recording has been slowed down by several technical challenges. Estimating the role of large-scale synchrony in cognitive processes has been hindered by several technical difficulties, and only in recent years has it been shown that large-scale inter-areal synchronization may have a critical role in cognitive processing. In this book, the leading authors in the field describe how recent technical advances have paved the way for several major breakthroughs in the analyses and observations of human noninvasive MEG data.

In the first chapter, the research of groups of J. Matias Palva and myself describes the technical challenges in the analyses of large-scale synchronization from MEG data and approaches to overcome them. In the fourth chapter, we then discuss empirical data using these novel approaches for MEG data analyses and what they reveal about the roles of local and large-scale synchronization in visual attention, working memory, and conscious perception.

The same theme is carried on in the second and third chapters, in which the dynamical network states and synchronization are discussed as predictors of conscious sensory perception by the groups of Nathan Weisz and Lawrence Ward. The chapter written by Peter Uhlhaas and Frederic Roux takes an additional view of the topic by discussing the observations of thalamo-cortical oscillations and

synchronization in MEG data. A different theme is covered by Fernando Maestu and colleagues who discuss the role of oscillations and synchronization in neuroaesthetics.

As discussed in these chapters, neuronal oscillations and large-scale synchronization are hence crucial in normal cognitive functioning. However, in several neuropsychiatric diseases, development of the nervous system, including neuronal oscillations and synchronization, is abnormal and thought at least partially to explain the deficits in the cognitive functions. This aspect is discussed in the chapters "Development of Human Neurophysiological Activity and Network Dynamics" and "The Role of Functional Networks in Neuropsychiatric Disorders" by Sam Doesburg, Fernando Maestu, and Leonides Canuet together with their colleagues.

I would like to warmly thank all the authors for their contributions to this book. This book covers extensively the functional significance of neuronal oscillations and synchronization in healthy and diseased human brain.

I wish you a good and instructive time in reading this book.

Helsinki, Finland Satu Palva
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