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Editors

Coherent Behavior in Neuronal Networks

Springer

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Preface

New developments in experimental methods are leading to an increasingly detailed description of how networks of interacting neurons process information. These findings strongly suggest that dynamic network behaviors underlie information processing, and that these activity patterns cannot be fully explained by simple concepts such as synchrony and phase locking. These new results raise significant challenges, and at the same time offer exciting opportunities, for experimental and theoretical neuroscientists. Moreover, advances in understanding in this area will require interdisciplinary efforts aimed at developing improved quantitative models that provide new insight into the emergence and function of experimentally observed behaviors and lead to predictions that can guide future experimental investigations.

We have undertaken two major projects to promote the translation of these new developments into scientific progress. First, we organized the workshop *Coherent behavior in neuronal networks*, which took place on October 17–20, 2007, in Mallorca, Spain, funded by the US National Science Foundation, the Spanish Ministerio de Educación y Ciencia, Govern de les Illes Balears, the Office of Naval Research Global, Universitat de les Illes Balears, the Consejo Superior de Investigaciones Científicas, the University of Houston, the University of Pittsburgh, and the Ajuntament de Palma de Mallorca. This unique workshop brought together a highly interdisciplinary and international mixture of 95 researchers with interests in the functional relevance of, and the mechanisms underlying, coherent behavior in neuronal networks. Reflecting the belief that understanding coherent behavior in neuronal networks requires interdisciplinary approaches, a key component of the meeting was the inclusion of linked back-to-back talks by experimental and theoretical collaborators, on their joint research endeavors. Scientifically, the meeting was structured around multiple themes, including the possible roles of globally coherent rhythms in the coordination of distributed processing, the possible roles of coherence in stimulus encoding and decoding, the interplay of coherence of neuronal network activity with Hebbian plasticity, and the mechanisms and functional implications of repeated spiking sequences. Participants responded quite positively to the workshop, expressing a strong desire for further activities to encourage the exchange of ideas and establishment of collaborative efforts in this field.

To address this need, and to reach a wider audience with interests in the broad area of coherent behavior in neuronal networks, our second project has been editing

this volume. The chapters collected here include work from some workshop participants as well as some nonparticipants. The goal of the book is not to provide a summary of workshop activities but rather to provide a representative sampling of the diverse recent research activities and perspectives on coherent behavior in neuronal networks, and to serve as a resource to the research community. Nonetheless, we have made sure that the interdisciplinary flavor of the workshop has extended to this volume. Indeed, many of the chapters are coauthored by collaborating theorists and experimentalists. We hope that these chapters will provide useful examples of how theoretical abstractions can be derived from experimental data and used to attain general, mechanistic insights, and how theoretical insights can guide experiments in turn. Several chapters also include reviews or examples of novel methodologies, some experimental and some theoretical, that may be useful in analyzing coherent behavior in neuronal networks.

Scientifically, the book starts with a focus on ongoing or persistent cortical activity, as a baseline upon which sensory processing and faster oscillations must occur. In particular, the first chapters consider spatiotemporal patterning of synaptic inputs during such states, as well as the more abstract question of identifying repeating motifs within these inputs. From there, the book moves to small networks and small-scale interactions, including input-dominated cultured networks, which are particularly well suited for the study of how network dynamics interact with plasticity in an ongoing feedback cycle. Next, we return to larger scale but abstract issues, but with a shift in focus to the spatiotemporal relationships observed in the activity patterns of different cells, such as synchrony or causality. Subsequent chapters offer a broad survey of coherence in encoding and decoding, such as in stimulus discrimination and perception across systems such as motor, olfactory, and visual, with a particular emphasis on the role of noise.

We believe this book is suitable for special topics courses for graduate students, particularly in interdisciplinary neuroscience training programs, and for interdisciplinary journal club discussions. More broadly, we hope this volume will be a valuable resource for the many researchers, across a wide variety of disciplines, who are working on problems relating to neuronal activity patterns. We look forward to following and participating in future developments in the field, as interdisciplinary collaborations become increasingly widespread and continue to generate exciting advances in our understanding of coherent behavior in neuronal networks.

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