
BRAIN THEORY

SPATIO-TEMPORAL ASPECTS
OF BRAIN FUNCTION
A. AERTSEN / EDITOR



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OF BRAIN FUNCTION

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PREFACE

Modern theories of brain function are increasingly concerned with dynamics. The task of organizing perception and behaviour in a meaningful interaction with the external world prompts the brain to recruit its various resources in a properly coordinated manner. Vis-a-vis the complexity and the multitude of the dynamics involved, a careful orchestration of the various processing components, distributed over space and time, is essential. Hence, it should come as no surprise that a number of recent developments in brain science have emphasized the aspect of spatio-temporal coordination. This holds for experimental and theoretical investigations alike. Experimental studies of the brain at different levels of resolution have established a multitude of distributed physiological mechanisms, ranging from interactions at the level of individual ionic channels, via the integrative processes governing the behaviour of single neurons, all the way up to the dynamics within and across populations of neurons or even entire regions of the brain. Similarly, theoretical investigations of the behaviour of model neurons and computational networks of neuron-like elements have revealed a number of intriguing dynamical phenomena which acquire their meaning only if the entire spatio-temporal complexity is considered. Thus, much of recent theoretical work in brain science is, in fact, concerned with the development of an adequate conceptual framework for the space-time dynamics exhibited by natural as well as by artificial brains.

The present collection of papers intends to capture these various developments in the brain sciences. It brings together new insights and concepts from various branches of experimental and theoretical neuroscience, partly in the form of review chapters, partly in short, focussed contributions, or critical essays. Starting point of this enterprise were the presentations and discussions at the Fourth International Meeting on Brain Theory held at the Istituto per la Ricerca Scientifica e Tecnologica (IRST) in Trento (Italy) on April 11-13, 1992. This meeting, organized by Valentino Braitenberg, Werner von Seelen, Luigi Stringa and Ad Aertsen, set out to explore "the problems of the processing of the temporal dimension of sensory input and of the generation of space-time patterns in the motor output, as well as the intervening storage and transformation of temporal patterns in nerve nets". The meeting was the fourth in a series, starting in 1984 at the International Center for Theoretical Physics in

Trieste [1], and continuing in 1986 in Bad Homburg [2] and in 1990 at Schloss Ringberg [3].

The meeting lasted three full days, providing a natural segmentation into three subheadings. On the first day, spatio-temporal aspects of brain function were discussed in the context of processing of sensory input and perception. Similarly, the third day focussed on spatio-temporal aspects of brain function at the output end: planning and control of movement. These two sessions flanked the middle one, which was dedicated to the intervening level of neuronal activity in the working brain, and the various dynamics observed at different levels of resolution in space and time. We adopted essentially the same tripartition to organize the present book. A fourth part combines contributions that transcend this scheme. A declared goal of these various meetings was "to raise an interest in theoretical models that actively seek confrontation with experimental data from the functioning brain, and by a didactic effort aimed at experimentalists to present their data in a format that makes them more amenable to theory". The same goal was pursued in the composition of the present book. The proof of the pudding is left as an exercise to the reader. The Fourth International Meeting on Brain Theory was jointly sponsored by the European Commission, the Gertrud Reemtsma Stiftung, the Istituto per la Ricerca Scientifica e Tecnologica (Trento), the Accademia degli Agiati, as well as by contributions from the various institutions who financed the participation of their delegates. Splendid hospitality, together with most efficient organization was provided by IRST, Trento. The last afternoon was hosted by the Accademia degli Agiati in the neighbouring town of Rovereto. The generous support by all these institutions is most gratefully acknowledged.

Ad Aertsen

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