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Preface

Quiet revolutions in neuroscience

Revolutions and evolutions speed up the developments in science and sometimes establish a wholly new perspective (Einstein and Infeld, 1938). This special issue includes articles of scientists who, in the last few decades, enormously contributed to the conceptual and experimental developments in neuroscience. The present volume amalgamates their models, theories and essays and includes the ingenious ideas that these explanatory formulations are based on. We thought it fit to name this Preface using a phrase from one of Bullock's (1959) papers, one which had a great impact on the neuroscience community.

This special issue contains the "quiet revolutions" in the field of neuroscience (for some of the critical and or representative studies, see Bullock, 1959; Başar et al., 1975; Freeman, 1975; Fuster, 1995; Begleiter and Porjesz, 2006). The authors that were to contribute to this special issue were meticulously chosen. We furthermore held, as guest editors, lengthy discussions with the contributors on their experimental findings and the explanatory formulations that these findings were based on. In this context, we visited T.H. Bullock, R. Galambos, J. Fuster, J. Polich and the group of Begleiter and Porsjez in San Diego, Los Angeles and New York, respectively. We had brainstorming sessions with them. W. Freeman and S. Bressler were invited on May 2004 to İzmir (Türkiye) for a workshop. J. Fuster, H. Begleiter, H. Haken, S. Bressler were the keynote speakers in the Workshop on Brain Dynamics and Cognition that was held again in İzmir on May 2005.

These encounters proved the importance of presenting the contributions of these scientists in a special issue of the International Journal of Psychophysiology. Among the various issues that these models and theories include are the *genetic approach* to brain's electrophysiology, Copernican changes in *memory research*, function of long-ignored *glia cells*, electrophysiology of *cognition*, and the concept of *complexity* in the brain and in cognition. These approaches and fields represent the newly emerging areas that the neuroscience community is gradually getting keenly interested in. The scientists that the present special issue includes, however, have been the pioneers of these areas. They have developed the approaches and have extensively studied the fields to the point of providing explanatory formulations, theories and models, about them.

We believe that the present special issue will guide future research and lead to the development of new models and theories on brain mechanisms in cognitive processing. The amalgamation of these explanatory formulations, backed up with functional magnetic resonance imaging of cognitive processes will surely provide, in the coming decade, a breakthrough in neuroscience.

1. Complexity and integration in neuroscience

Owing to his philosophical view on modeling in specifically neuroscience, the special issue opens with the paper by R. Galambos. In this section, Galambos also shares with the reader his life-long sojourn through the labyrinth of science in his constant search for explanations on brain and cognition. It shares with the reader his musings about his explanatory formulations and the struggles that accompany these endeavors, thus providing implicit advice to the scientific community. Complexity is demonstrated by Galambos in a specific cognitive process; visual perception. According to the "new visual system model", perception is the end result of both a bottom-up process that starts from the retina and top-down effects that originate cortically. One important statement by Galambos was the following: "Unsolvable problems usually await new techniques and new paradigms." This statement is very clearly demonstrated throughout each explanatory formulation that the present special issue consists of.

How do brains evolve complexity? T.H. Bullock concludes from his life-long empirical experiences on different taxa and a wide range of species that the vast difference between clearly simpler and more advanced phyla, classes and orders concerning complexity of brain anatomy and behavior remains largely unknown. Evoked potentials evolved very little and differences in the complexity of electrical activity could not yet be determined. According to this section, complexity may be more complex than is presently understood.

The complexity of brain function is explained by H. Haken from the synergetic viewpoint. Haken uses control parameters, order parameters and slaving principle, demonstrating mathematically and experimentally, that phenomena at the macroscopic level (physically measured global properties and psychological phenomena) are produced by phenomena at the microscopic level (neural).

Integration is treated by J. Fuster in relation specifically to memory. The cognits theory proposes that there is memory for perception, perceptual cognits; and memory for action, executive cognits. In each, possible types of memory range from the phyletic to the conceptual. However, all these are

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organized in a perception–action cycle where levels are connected both within systems and between systems. Accordingly, different types of memory are inextricably connected to each other. Fusterś theory on cognits shows that different types of memory which literature mostly consider as separate entities are integrated; episodic memory is based on previously formed semantic memory, and semantic memory is based on internalized instances of episodic memory.

2. Oscillatory dynamics of the brain

Back in 1992 Vernon Mountcastle stated: "Rather suddenly, however, a paradigm change is upon us, for the proposition that slow wave events are *active* ingredients for signal transmission stands as a testable hypothesis." Such a stage was reached as a result of the studies of many scientists, predominantly of E. Başar, T.H. Bullock, R. Galambos, W. Freeman and H. Petsche. According to Mountcastle, these earlier studies conclusively show that slow wave events, spontaneous or evoked, were not passive electrical phenomena, but were the real responses in the functioning brain. The following period was characterized by newer findings on the slow wave events, i.e. the oscillatory activity, and its relation to function in biological systems. The newer studies led to principles, models and theories on the brain and its mechanisms during its core function, cognitive processing. "Brain processes in cognition" is a newly emerging field that is rapidly infiltrating the literature on neuroscience.

The influential mainstream that involved the study of oscillations are represented in the present special issue by several articles. Two of these belong to the pioneers of this field: W. Freeman and E. Başar; these scientists had developed their formulations on the oscillatory dynamics back in the 1970s (Freeman, 1975; Başar, 1976). Başar's theory on the oscillatory neural assemblies includes principles that govern the mechanisms of oscillatory activity. One of these, the principle of superposition according to which the morphology of complex waveforms are produced by the superposition of oscillations in various frequency ranges, was conclusively demonstrated by Karakaş et al. (2000) on a series of cognitive paradigms. According to the theory of whole-brain-work, oscillatory activities in the various frequency bands are selectively distributed in the brain. The distributed oscillations are however integrated and thus there is "super-binding and super-synergy" in the brain. In such a scheme, the cognitive processes of attention, perception, learning and remembering are not separable entities, but are bound together in an alliance.

What are the mechanisms in integrated systems by which associations get formed and what are the principles of the coordination dynamics? The section by S. Bressler and E. Tognoli provides the operational principles which govern selective structuring of neurocognitive networks and the principle of inter-areal constraint which renders flexibility to such a system.

W. Freeman draws attention to the fact that in cinema there are discrete frames that are however experienced as continuous in consciousness. According to Freeman's cinematographic hypothesis, cortical dynamics is also not a continuous flow but operates in discrete time steps or in frames. They are separated by phase transitions and are basically composed of oscillations.

Genetic approach represents one of the most recent mainstreams in biological sciences. Begleiter and Porjesz are pioneering a highly relevant trend in neuroscience by applying the concepts and tools of genetics to the oscillatory activity. We learn from the section by Begleiter and Porjesz that the brain oscillations are highly heritable and, meeting the criteria for good quantitative biological endophenotypes, can be used as *phenotypes of cognition*. The new window of these authors will most possibly enrich neuroscience with new dimensions and findings that may surprise the neuroscience community.

Any discussion on neuroelectricity has to be based on reliable electrophysiological components that have been demonstrated in at least one species. The oscillatory activity of the brain in the various frequency ranges represents one class of neuroelectric events. Event-related potentials represent another class and P300 is one of the most studied in this class. Close to 40 years of research were devoted for understanding the P300 component, for disentangling its subcomponents and discovering its biological correlates. The section by Polich and Criado presents the theory of P300 and provides the findings that confirm the distinction between P3a and P3b subcomponents on also the basis of neuropharmacology.

3. To close up

All explanatory formulations in the present special issue explained, from various approaches, the operations of the brain in cognitive processing. The present special issue closes with two essays of the guest editors. One of these, that by Karakaş and Başar, discusses the explanatory formulations in the present special issue within the context of established models and theories of behavioral cognitive psychology. The section points to areas where the explanatory formulations of neuroscience and cognitive psychology are in consensus or are complementary. The section also points to specific problem areas in each field for which the explanatory formulations in the other provides cues for their solution.

The second essay, that by Başar and Karakaş, discusses the explanatory formulations from the standpoint of theories in physical sciences and biology and within the context of relevant approaches of philosophy. The models and conceptual thinking that were represented by Renée Descartes and Isaac Newton, Albert Einstein and Werner Heisenberg have been critically influential on contemporary brain research. The models and theories of the authors that contributed to this special issue are the natural successors of these great men of science. This long line of scientific enterprise is characterized by an evolution, and, at points, revolutions. The explanatory formulations in this special issue form the basis of "quiet revolutions" in contemporary neuroscience. The guest editors of this special issue believe that the amalgamation of the theories and models, facilitated through their presentation in one special issue of the

International Journal of Psychophysiology, will form the basis of a new breakthrough in neuroscience.

We cordially thank the authors for contributing to this special issue with their explanatory formulations which they painstakingly developed over the years on the basis of extensive research and through keen intellectual processing. The contributing authors carefully studied the papers of each other and prepared their own in such a way that the discriminating characteristic of theirs stood out best. We extend our thanks to the authors for this extra effort.

A special vote of thanks is due to Prof. Dr. John Andreassi, editor-in-chief of the International Journal of Psychophysiology, for giving us the opportunity to be guest editors of this special issue. We also thank him for his cooperation and guidance throughout all stages of the preparation of this special issue.

We wholeheartedly thank Prof. Dr. Constantine Mangina, the President of the International Organization of Psychology (IOP) associated with the United Nations (New York) for his relentless efforts to ever increase the scientific reputation of IOP and for the advances he helped realize in the field of scientific endeavor (Mangina, 2003). This organization and its official journal, International Journal of Psychophysiology, provide an umbrella under which biological, behavioral and technical sciences cooperate to understand the phenomena of psychophysiology and, ultimately, the perpetual 'mind–body problem'.

And finally, we would like to express our thanks to the young psychophysiologists of the Specialization Area of Experimental Psychology at Hacettepe University. Belma Bekçi, Elvin Dogutepe, Arzu Özkan and Zeynel Baran have worked tediously on the manuscripts and helped with the formatting and proofreading procedures.

We deem it an honor and a privilege to have had the opportunity to prepare a special issue on brain theories and models and to work with the outstanding scientists who have developed these explanatory formulations.

Sirel Karakaş
Erol Başar
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Sirel Karakaş*
Hacettepe University Specialization Area of Experimental Psychology and Cognitive Psychophysiology Research Unit, Beytepe Campus 06532, Ankara, Türkiye
E-mail address: skarakas@hacettepe.edu.tr.
* Corresponding author. Tel.: +90 312 2978335; fax: +90 312 2992100.

Erol Başar
Dokuz Eylül University Brain Dynamics Multidisciplinary Research Center and Faculty of Medicine Department of Biophysics, Balçova 35340, İzmir, Türkiye

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