Preface

Toward new theories of brain function and brain dynamics

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‘During the ‘decade of the brain’ brain science is coming to terms with its ultimate problem: understanding the mechanisms by which the immense number of neurons in the human brain interact to produce the higher cognitive functions’ (Freeman, 1998). As one of the candidate mechanisms, oscillatory neuroelectric activity has recently attracted much interest.

Since the pioneering work by Lord Adrian on brain oscillatory phenomena in the 1940s, intensive research on the functions of such oscillations began in the 1990s. The ERP is a compound neuroelectric signal which is ‘rich in functional information’ (Bullock, 1993) and is related to a large spectrum ranging from single percepts to complicated memory processes. Furthermore, in the analysis of integrative brain functions it is indispensable to consider not only one specific ERP in a given brain structure, but that distributed ERPs are interrelated due to the evident strong parallel processing in the whole brain.

In the decade between 1970 and 1980 few laboratories emphasized the importance of oscillatory phenomena in brain function. Since in this short preface only few collection-works (such as special issues of international journals or books) can be mentioned, I would in the first place mention Walter Freeman’s work (1975), which has opened the way to the work by Gray and Singer (1987), Gray et al. (1989) and by Eckhorn et al. (1988). By referring to the collected works or books we intend to establish a chain of ideas to emphasize functional correlates of brain oscillations.

Two other developments in book form were undertaken by (Başar 1976, 1980) These works surveyed the literature and emphasized the importance of distributed oscillatory networks in a larger frequency range between 1 and 1000 Hz.

In 1992 Mountcastle announced a ‘paradigm change’ in the neurosciences by assuming that oscillatory processes would play a key role in the understanding of cognitive processes in the preface of a book based on a workshop in New York as an activity of Neuroscience Research Program conducted by Edelman. Furthermore, Mountcastle (1998) introduced, in a more intensive way, the importance of EEG-oscillations in perception and related processes.

An essential contribution was the special issue of this Journal (edited by Gruzelier, 1996) in which new advances in EEG and Cognition have been published in an extremely useful way, in covering functional correlates of oscillations in various frequency windows. The volume, edited by Gruzelier, was followed by Başar, Hari, Lopes
da Silva, and Schürmann as guest editors in this journal with reports on the origin and functional correlates of alpha activity. In the latter volume, possibly a first general view and renaissance on functions of alpha activities or alphas was established by synthesizing research work of the contributors to this volume. Alpha activity as a sign of brain function has been emphasized in this volume also at the level of single neurons. This functional interpretation of event-related alpha activity has also been discussed at the Taormina conference of the International Organisation of Psychophysiology and at the London meeting of the British Psychophysiology Society, both in 1998.

Two new volumes on Brain function and Oscillations (Başar, 1998, 1999) already created a number of constructive criticisms, extending ideas in this new trend in brain research. Some essential criticism came from Sokolov and from Klimesch (1999).

Since the scope of Sokolov is integrative and contains an important message for general neuroscience, we reproduce his review since the encoding process and memory related oscillations described in reports of this special issue can be better illuminated by the descriptions of encoding processes and functional importance of complex cells efficiently described by Sokolov (personal communication): “...work of Professor E. Başar is devoted to the problem of ‘brain code’ — principles of encoding of external events into subjective phenomena by brain functions. E. Başar approaches the problem in the framework of synergetics studying cooperative processes in physical, biological, psychological and social areas.

Professor E. Başar on the basis of systematic study of brain oscillations using EEG and event-related potentials suggests ‘frequency encoding’. Particular frequencies occurring at particular time intervals constitute ‘letters’ of the code. Combinations of different frequencies build up ‘words’. The distribution of such a ‘frequency code’ in different brain areas is regarded as a basis of cognitive processes. Such an approach is supported by the coincidence of spectra of background EEG and following event-related potentials.

Distributed frequency encoding opposes ‘detector theory’ and ‘gnostic unit concept’. There is a bulk of evidence concerning specificity of cortical neurons in different animals. In humans such a specificity refers to verbal encoding. At the same time neurons generate ‘bursts of spikes’ and regular pacemaker potentials.

I suggest a compromise between ‘frequency code’ and ‘feature detector code’. The compromise is based on unification of these aspects of neuronal activity. Specific feature detectors and gnostic units are tuned according to vector encoding applied to presynaptic inputs and synaptic contacts. From this stand point maximal response of a feature detector is achieved when the presynaptic excitation vector and the synaptic excitation weight vector of a detector coincide in orientation, so that the scalar (inner) product of these vectors reaches maximum. The frequency code makes it possible to extend specificity in the time domain producing ‘frequency and phase selective tuning’ of feature detectors. The EEG result from neuronal oscillations dominated under particular conditions, i.e. frequencies are tools for more precise neuronal tuning, an important role in such tuning and endogenous pacemaker oscillations play result in frequency and phase tuning of the feature detector. Thus the feature detector becomes state-dependently tuned.

The suggested compromise is a working hypothesis that has to be tested by intracellular recording to evaluate the relationship between stimulus specificity of neurons and frequency aspects of presynaptic spikes and postsynaptic pacemaker oscillations. Parallel recorded focal potentials will show intracellular contributions to extracellular phenomena evident as EEG oscillations”.

The review of Sokolov evidently suggests the necessity to develop a hybrid theory of brain functioning in which oscillations of neural populations are not the unique entities required to explain brain functioning. This theory should incorporate functions of neural networks oscillations and specificity of neurons. An essential step in the papers of the present issue is based on superposition of oscillations presenting interactions between the selectively distributed alpha, theta, gamma and delta oscillatory systems of the brain.

In this issue the new emerging memory concepts developed by Goldman-Rakic (1988), and especially Fuster (1997), are mentioned and analyzed by trying to illuminate the functional role of oscillations in memory processes.

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Klimesch, W., 1999. Review of brain function and oscillations,
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bral Cortex. Harvard University Press.
The location in the brain of various capacities matters so much to neuroscientists because it is crucial to understanding the link between the brain and thinking. But the differences also point toward explanations for puzzles that seem far removed from the mind, including the high incidence in left-handed people of migraines, allergies and auto-immune disorders such as rheumatoid arthritis. Left-handers present researchers with a special challenge to sorting out how the brain is organized, particularly in determining what role each hemisphere plays. Left-handers display quite a different 21 subjects took part in a brain-scanning experiment using functional magnetic resonance imaging. Prior to the experiment, they viewed pictures of paintings and listened to musical excerpts, both of which they rated on a scale of 1–9, with 9 being the most beautiful. Citation: Ishizu T, Zeki S (2011) Toward A Brain-Based Theory of Beauty. PLoS ONE 6(7): e21852. https://doi.org/10.1371/journal.pone.0021852. As a counterpart to the evolving and therefore dynamic nature of the musical stimuli, each visual stimulus was made to zoom continuously at the rate of 3° sec⁻¹, using image-editing programs (Adobe® Photoshop CS3®, Premiere Pro CS3®). The visual stimuli were back-projected onto a screen using a LCD projector through an angled mirror. Brain Physics Group, Department of Biomedical Engineering, Tulane University, New Orleans, LA 70118, and Brain Sciences Institute, Swinburne University of Technology, Melbourne, Victoria 3122, Australia pnunez@mailhost.tcs.tulane.edu pnunez@mind.scan.swin.edu.au. DOI: https://doi.org/10.1017/S0140525X00003253. Published online by Cambridge University Press: 10 October 2000. Abstract. A more general â€œmetatheoryâ€ suggests what large-scale quantitative theories of neocortical dynamics may be like when more accurate treatment of local and nonlinear effects is achieved. The theory describes the dynamics of excitatory and inhibitory synaptic action fields.