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Athenian Symposia: Cerebral Instantiation of Memory, Under the auspices of the Hellenic Clinical Neurophysiology Society, Athens, March 30-31, 2018

Guest Editors: Andrew C. Papanicolaou, Ioannis Evdokimidis, Theodoros S Constantinidis

Lecture

Concurrent Physiological Multisite-Recordings & Brain Imaging: Study of Dynamic Connectivity Related to System and Synaptic Memory Consolidation

Nikos K. Logothetis

Abstract

Experimental work in animals and humans suggests that various short-lasting patterns of neural activity, including single- or multiple-cycle oscillatory episodes, may reflect state changes of self-organizing large- scale networks. Such state-marking events, including K complexes, spindles, hippocampal sharp wave ripples (SPW-R), and ponto-geniculo-occipital (PGO) waves, are in fact thought to regulate cognitive capacities, such as learning, memory encoding and consolidation, as well as memory-guided decision making.

Although the neural events themselves have long been studied in great detail with neurophysiological methods, the actual brain-states related to them remain elusive, primarily due to a dearth of methodologies permitting concurrent recordings in various structures and mapping of whole-brain activity. The use of multishank-multichannel (MS-MC) electrical recordings of activity in different structures per se permits both the detection and the contextual identification of structure-specific neural events, for that matter also of their interrelationships. Combining in real-time the MS-MC recordings with spatiotemporally resolved functional magnetic resonance imaging (fMRI) evidently offers a unique opportunity to study the cooperative patterns of a large number of brain structures either leading or responding to recorded events. In an effort to map and study such patterns, we have recently developed so-called neural event triggered fMRI (NET-fMRI) and used it to understand the dynamics of the networks related to SPW-R and PGO events, both considered to be critical for the sequential states of system and synaptic memory consolidation during sleep.

The observed neurophysiological interactions of hippocampus, thalamus, cortex and pontine nuclei, together with the maps of robust up/down modulation of the brainwide metabolic activity revealed both synergistic and strong antagonistic interactions between memory systems, as well as between the activities of sensory thalamic and neuromodulatory nuclei and the hippocampal formation during epochs potentially related to memory consolidation. On-going work is currently examining the event-triggered neurophysiological responses in a number of structures, mapped with imaging, as well as the extent to which fMRI-measured multistructure activity patterns at any given time may themselves predict the occurrence of various neural events.

Nikos K. Logothetis is director of the department "Physiology of Cognitive Processes" at the Max Planck Institute for Biological Cybernetics (MPIBC), in Tübingen, Germany. He is also a faculty member at the Victoria University of Manchester (VUM) in England, and Honorary Professor in the Department of Biology at the University of Tübingen. He received a B.S. in mathematics from the University of Athens, a B.S. in biology from the University of Thessaloniki, and his Ph.D. in human neurobiology from the Ludwig-Maximilians University in Munich. In 1985 he moved to the Brain and Cognitive Sciences Department of M.I.T., where he initially worked as a post-

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doctoral fellow and later as Research Scientist. In 1990 he joined the faculty of the Division of Neuroscience at the Baylor College of Medicine. Seven years later he moved to the Max Planck Institute for Biological Cybernetics to continue his work on the physiological mechanisms underlying visual perception and object recognition. In addition to his primary affiliations in Germany and UK, Nikos K. Logothetis has long been Adjunct Professor of Neurobiology at the Salk Institute in San Diego, Adjunct Professor of Ophthalmology at the Baylor College of Medicine, Houston, Associate of the Neurosciences Institute, San Diego, Senior Visiting Fellow in University College, London, Adjunct Professor in the Department of Cognitive and Neural Systems and of Cognitive and Neural Systems and of Cognitive and Neural Systems in the College of Arts and Sciences, both at the Boston University, Massachusetts. Nikos K. Logothetis is member of the German Academy of Natural Scientists Leopoldina, and the Rodin Remediation Academy, a honorary member of the American Academy of Arts and Sciences, and a foreign associate of the National Academy of Sciences of the United States. He is recipient of the DeBakey Award for Excellence in Science, the Golden Brain Award of the Minerva Foundation, the 2003 Louis-Jeantet Prize of Medicine, the 2004 Zülch-Prize for Neuroscience, the 2007 IPSEN Prize for Neuronal Plasticity, the 2008 Alden Spencer Award of Columbia University, New York, and the Aristeion-Award of the Academy of Athens 2016.