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Circuit polarity effect of cortical connectivity, activity and memory

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Experimental constraints have traditionally implied separate studies of different cortical functions, such as memory and sensory-motor control. Yet, certain cortical modalities, while repeatedly observed and reported, have not been clearly identified with one cortical function or another. Specifically, while neuronal membrane and synapse polarities with respect to a certain potential value have been attracting considerable interest in recent years, the purposes of such polarities have largely remained a subject for speculation and debate. Formally identifying these polarities as on/off neuronal polarity gates, it is analytically shown that cortical circuit structure, behavior and memory are all governed by the combined potent effect of these gates, which is collectively termed as circuit polarity. Employing widely accepted, biologically validated, firing rate and plasticity paradigms, it is shown that circuit polarity is mathematically embedded in the corresponding models. Moreover, it is shown that the firing rate dynamics implied by these models are driven by on-going circuit polarity gating dynamics. Furthermore, circuit polarity is shown to segregate cortical circuits into internally-synchronous, externally-asynchronous sub circuits, defining their firing rate modes in accordance with different cortical tasks. In contrast to the Hebbian paradigm, which is shown to be susceptible to mutual neuronal interference in the face of asynchrony, circuit polarity is shown to block such interference. Noting convergence of synaptic weights, it is shown that circuit polarity holds the key to cortical memory, having a segregated capacity linear in the number of neurons. While memory concealment is implied by complete neuronal silencing, memory is restored by reactivating the original circuit polarity. Finally, it is shown that incomplete deterioration or restoration of circuit polarity result in memory modification, which may be associated with partial or false recall, or, yet, novel innovation.

Biography

Yoram Baram has pursued his BSc degree in Aeronautical Engineering from the Technion and has completed his MSc degree in Aeronautics and Astronautics from MIT. He has pursued his PhD degree in Electrical Engineering and Computer Science from MIT.

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