Enhancing Human Memory: From Single Neurons to Neuromodulation

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ABSTRACT

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Loss of memory is one of the most dreaded afflictions of the human condition. With the increase in population age and subsequent striking increase in number of patients with memory impairments, we are facing a social calamity
of alarming dimensions.

The medial temporal lobe (MTL) is central to the transformation of percepts into lasting memories that can be consciously recollected in the future. Yet the neuronal code underlying this transformation in humans remains unclear. Recordings from neurons within the brain and focal brain stimulation in patients implanted with electrodes for clinical reasons provide a rare opportunity to bridge physiology with cognition.

During sleep these recordings provide insight into the orchestration of several brain rhythms- slow waves, spindles and ripples- that are thought to be critical to the consolidation of memories during non-REM sleep. These recordings point to the local nature of slow waves and spindles, and to the propagation of slow waves through the human cortical- hippocampal circuitry. Still demonstration of neuronal replay related to human episodic memory and the study of hippocampal-neocortical dialogue remains a formidable challenge.

Electrical stimulation provides an exciting tool to study causal mechanisms of memory encoding and consolidation. During encoding, of new information, electrical stimulation

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applied at the entorhinal region appear to enhance

subsequent performance on memory retrieval of that information. During slow wave sleep electrical stimulation locked to hippocampal slow waves applied at frontal lobe sites, results in enhancement of slow wave power as well as improvement in memory performance. These results may lead to development of closed loop neuro-prosthetic devices- memory aids- providing stimulation based on sensing of local brain activity in order to enhance memory encoding during waking periods and memory consolidation during sleep.

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