

# **Researchers develop a method of deep-brain stimulation during sleep to improve memory consolidation**

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A conceptual illustration of the passage of memories from the hippocampus to

the cerebral cortex during the night. Credit: Osnat Feitelson.

A breakthrough study demonstrated for the first time that long-lasting memories are consolidated in the human brain through communication between the hippocampus and the cerebral cortex during sleep. Moreover, the researchers found that by inducing deep-brain stimulation during sleep they can improve memory consolidation.

The unique study, published today in the leading journal [\*Nature Neuroscience\*](#), involved an international collaboration led by Dr. Maya Geva-Sagiv (today at UC Davis). The study was a collaboration between the laboratories of Prof. Yuval Nir from the Sackler Faculty of Medicine, Department of Biomedical Engineering, and Sagol School of Neuroscience at Tel Aviv University, and Prof. Itzhak Fried from the Department of Neurosurgery at UCLA and the Sackler Faculty of Medicine at Tel Aviv University.

"This study was made possible by a rare group of 18 patients with epilepsy at the UCLA Medical Center," says Prof. Nir. "Prof. Fried implanted electrodes in these patients' brains to try and pinpoint the areas that cause their epileptic seizures, and they volunteered to take part in a study investigating the effects of deep-brain stimulation during sleep. Close work with expert neurologists led by Prof. Dawn Eliashiv at UCLA enabled our team to integrate advanced brain stimulation in the research. Thus, we were able to test, for the first time in humans, the long-held hypothesis—that coordinated activity of the hippocampus and cerebral cortex during sleep is a critical mechanism in consolidating memories. Moreover, we improved memory consolidation through a special stimulation protocol that enhanced synchronization between these two areas in the brain. Intervention during sleep represents a unique approach that can be further developed in the future to provide

hope for people with memory impairments such as dementia."

"We know that a good night's sleep is critical for the consolidation of long-lasting memories, but so far we had little evidence regarding the precise processes that are at work during human sleep," explains Dr. Maya Geva-Sagiv. "In this study we directly examined the role of neural activity and electrical brain waves during sleep. Our goal was to enhance the natural mechanisms at play, to discover exactly how sleep assists in stabilizing memories."

The researchers developed a deep-brain stimulation system that improves electrical communication between the hippocampus—a deep-brain region involved in acquiring new memories, and the frontal cortex—where memories are stored for the long term. By monitoring activity in the hippocampus during sleep, the system enables precisely timed delivery of electrical stimulation to the frontal cortex. The study's participants completed two memory tests, comparing their performance after two different nights—one undisturbed and one with deep-brain stimulation. On both occasions, they were asked in the morning to recognize famous persons whose pictures they had been shown the previous evening. The study found that deep-brain stimulation significantly improved the accuracy of their memory."

"We found that our method had a beneficial effect on both brain activity during sleep and memory performance," says Prof. Fried. "All patients who had received synchronized stimuli to the frontal cortex demonstrated better memory performance, compared to nights of undisturbed sleep. The control group, which received similar yet unsynchronized stimuli, showed no memory improvement. Our deep-brain stimulation method is unique because it is close-looped—stimuli are precisely synchronized with hippocampal activity. In addition, we monitored the stimuli's impact on brain activity at a resolution of individual neurons."

"Our findings support the hypothesis that precise coordination between sleep waves assists communication between the hippocampus that takes in new memories, and the frontal cortex that stores them for the long term," adds Prof. Nir. "To our surprise, we also discovered that the intervention did not significantly increase the number of right answers given by participants, but rather reduced the number of wrong answers. This suggests that sleep sharpens the accuracy of our memory, or in other words, it removes various distractions from the relevant memory trace."

**More information:** Maya Geva-Sagiv et al, Augmenting hippocampal–prefrontal neuronal synchrony during sleep enhances memory consolidation in humans, *Nature Neuroscience* (2023). [DOI: 10.1038/s41593-023-01324-5](https://doi.org/10.1038/s41593-023-01324-5)

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