

# Waking up memories while you sleep

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They were in a deep sleep, yet sounds, such as a teakettle whistle and a cat's meow, somehow penetrated their slumber. The 25 sounds presented during the nap were reminders of earlier spatial learning, though the Northwestern University research participants were unaware of the sounds as they slept.

Yet, upon waking, memory tests showed that [spatial memories](#) had changed. The participants were more accurate in dragging an object to the correct location on a computer screen for the 25 images whose corresponding sounds were presented during [sleep](#) (such as a muffled explosion for a photo of dynamite) than for another 25 matched objects.

"The research strongly suggests that we don't shut down our minds during [deep sleep](#)," said John Rudoy, lead author of the study and a [neuroscience](#) Ph.D. student at Northwestern. "Rather this is an important time for consolidating memories."

Most provocatively, the research showed that sounds can penetrate deep sleep and be used to guide rehearsal of specific information, pushing people's consolidation of memories in one direction over another.

"While asleep, people might process anything that happened during the day -- what they ate for breakfast, television shows they watched, anything," said Ken Paller, senior author of the study and professor of psychology in the Weinberg College of Arts and Sciences at Northwestern. "But we decided which memories our volunteers would activate, guiding them to rehearse some of the locations they had learned

an hour earlier."

The Northwestern study adds a new twist to a growing body of research showing that memories are processed during sleep. It substantiates the literature showing that the brain is very busy during sleep, going over recently acquired information and integrating it with other knowledge in a mysterious consolidation process that sustains our memory abilities when awake.

"Strengthening Individual Memories by Reactivating Them During Sleep" will be published in the journal *Science* Nov. 20. Besides Paller and Rudoy, the paper's co-authors are Northwestern colleagues Joel L. Voss and Carmen E. Westerberg.

Whether or not memories are processed during sleep has been a subject of controversy, with most of the research on the topic focusing on REM, a normal stage of sleep characterized by rapid movement of the eyes. Vividly recalled dreams mostly occur during REM sleep. Recent research, including the new Northwestern study, however, focuses on memory processing during deep sleep, rather than during REM sleep.

"We are beginning to see that deep sleep actually is a key time for memory processing," Paller said.

Prior to their naps, the 12 study participants were taught to associate each of 50 images with a random location on a computer screen. Each object, such as a shattering wine glass, was paired with a corresponding sound, such as that of breaking glass, delivered over a speaker.

Locations were learned by repeating trials until study participants got quite good at placing all the objects in their assigned places. Approximately 45 minutes after learning, each participant reclined in a quiet, darkened room. Electrodes attached to their scalp measured their

brain activity, indicating when they were asleep. Sleep sounds were presented without waking anyone up. When asked later, none of the participants thought sounds had been played during the naps. Yet, memory testing showed that placements of the objects were more accurate for those cued by their associated sounds during sleep than for those not cued.

"Our little experiment opens the door to many questions," Paller said.

Would high-school students do better on SAT tests if daytime studying was supplemented with sleep sounds at night? Would students learning foreign vocabulary words or other facts do better in the morning after listening to related information as they slept? Infants spend an inordinate amount of time sleeping, while their brains work over their recent experiences. Could an infant learn a first language more quickly if stimulation occurred during naps or overnight? What about an actor trying to learn lines or a law student trying to memorize numerous details of case law? Could playing sounds related to such learning improve the recall of relevant facts the next day?

The study opens avenues for discovering boundaries of what can happen to memories during sleep, said co-author Voss. "Can memories be distorted as well as strengthened? Can people be guided to forget unwanted memories?"

Much work remains to determine whether the results of the new research translate to these and other contexts, Paller emphasized. "We don't know the answers at this point," he said, "but more experiments about memory processing during sleep are certain to follow."

Source: Northwestern University ([news](#) : [web](#))

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