

Information better retained with reinforcing stimuli delivered during sleep, research finds

January 15 2013, by Miles O'brien

When you're studying for an exam, is there something you can do while you sleep to retain the information better?

"The question is, 'What determines which information is going to be kept and which information is lost?'" says neuroscientist Ken Paller.

With support from the National Science Foundation (NSF), Paller and his team at Northwestern University are studying the connection between memory and sleep, and the possibilities of boosting [memory storage](#) while you snooze.

"We think many stages of sleep are important for memory. However, a lot of the evidence has shown that slow-wave sleep is particularly important for some types of memory," explains Paller.

Slow-wave sleep is often referred to as "deep sleep," and consists of stages 3 and 4 of non-rapid-eye-movement sleep.

Paller's lab group members demonstrated for Science Nation two of the tests they run on [study participants](#). In the first experiment, the subjects learned two pieces of music in a format similar to the game Guitar Hero. During a short nap following learning, just one of the learned tunes was played softly several times, to selectively reinforce the memory for playing that tune without any reinforcement for the other tune. Paller wanted to know whether the [test subjects](#) could more accurately produce the tune played during sleep.

In the second exercise, the subjects were asked to memorize the location of 50 objects on a computer screen. The presentation of each object was coupled with a unique sound. During the post-learning nap, memory for the location of 25 objects was reinforced by the play-back of only 25 of the sounds. In this case, Paller wanted to know whether the subjects could remember object locations better if the associated sounds were played during sleep.

Researchers recorded [electrical activity](#) generated in the brain using [EEG electrodes](#) attached to the scalp. They thus determined whether the subjects entered "deep sleep," and only those who did participated in the reinforcement experiments. In both experiments, participants did a better job remembering what was reinforced while they slept, compared to what was not reinforced.

"We think that memory processing happens during sleep every night," says Paller. "We're at the beginning of finding out what types of memory can be reinforced, how large reinforcement effects can be, and what sorts of stimuli can be used to reactivate memories so that they can be better consolidated."

Paller's goal is to better understand the fundamental brain mechanisms responsible for memory. And that, in turn, may help people with memory problems, including those who find themselves more forgetful as they age.

"We experience progressively less slow-wave sleep as we age. Of course, many brain mechanisms come into play to allow us to remember, including some processing that transpires during [sleep](#). So, there's a lot to figure out about how memory works, but I think it's fair to say that the person you are when you're awake is partly a function of what your brain does when you're asleep," explains Paller. He says these reactivation techniques could turn out to be valuable for enhancing what people have

learned.

"What is beautiful about this set of experiments is that Dr. Paller identified '[deep sleep](#)' as a critical time window during which memory for specific experiences can be selectively enhanced by the method of reactivation without conscious effort," says Akaysha Tang, director of the cognitive neuroscience program in the NSF Directorate for Social, Behavioral and Economic Sciences.

"Normally, conscious rehearsal of memorized material is needed if one wants to remember something better or retain it for longer, and one has to find time to review or rehearse," continues Tang. "Dr. Paller and the members of his lab group showed that such selective enhancement could be achieved without conscious effort and without demanding more of one's waking hours. So, instead of pulling that all-nighter to memorize the material, in the future, it may be possible to consolidate the [memory](#) by sleeping with a scientifically programmed lullaby!"

Provided by National Science Foundation

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