

Losing sleep undoes the rejuvenating effects new learning has on the brain

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As the pace of life quickens and it becomes harder to balance home and work, many people meet their obligations by getting less sleep.

But sleep deprivation impairs spatial learning -- including remembering how to get to a new destination. And now scientists are beginning to understand how that happens: Learning spatial tasks increases the production of new cells in an area of the brain involved with spatial memory called the hippocampus. Sleep plays a part in helping those new brain cells survive.

A team of researchers from the University of California and Stanford University found that sleep-restricted rats had a harder time remembering a path through a maze compared to their rested counterparts. And unlike the rats that got enough sleep, the sleep-restricted rats showed reduced survival rate of new hippocampus cells.

The researchers used sleep-restricted rats rather than sleep-deprived rats to more closely mimic the common human experience of inadequate sleep during the work week, said lead investigator Ilana Hairston of both the University of California, Berkeley, and Stanford University. The paper, "Sleep restriction suppresses neurogenesis induced by hippocampus-dependent learning," appears in the *Journal of Neurophysiology* published by the American Physiological Society.

Learning appears to rejuvenate the brain

Scientists already know – and most of us can confirm from firsthand experience -- that lack of sleep impairs cognitive function. Sleep-restricted individuals have a shorter attention span, impaired memory, and a longer reaction time. "Sleep is necessary for general health, but it now appears that the brain needs sleep more than any other part of the body," Hairston said.

Previous studies have shown that the hippocampus is important for spatial learning. "The hippocampus also has the unique ability to generate new brain cells throughout life, a process called 'neurogenesis,'" Hairston noted. "When animals learn a task that requires the hippocampus, the rate of neurogenesis increases. This suggests that learning itself rejuvenates the brain."

Knowing that spatial learning triggers production of new brain cells in the hippocampus, Hairston and her team wanted to find out whether restricting sleep during a spatial learning task would affect new cell production in the hippocampus.

The experiment: swimming to the exit platform

The researchers trained rats on one of two tasks using a water maze -- a plastic pool about six feet in circumference and two feet deep. Rats were placed in the water and had to swim to the exit platform.

One group could not see the platform, which was placed underwater, and had to form a "mental map" of the maze -- a spatial memory task that is hippocampus-dependent -- to quickly reach the exit.

The second group could see and smell the exit platform, which had a citrus odor. The researchers moved the platform every fourth trial, requiring the animal to rely on its senses, not on memory, to find it. This task did not engage the hippocampus because the rat did not need a

mental map of the pool to reach the platform, Hairston explained.

Fewer brain cells for the weary

At the end of each training session, half the animals in each group were kept awake for six hours by being presented novel stimuli that kept them interested and awake. The other half were returned to their cages and allowed to sleep. After six hours, the sleep-restricted rats were allowed to sleep for the remainder of the day until the next session, 18 hours later.

Rested animals that had to rely on memory to find the goal showed increased neurogenesis in the hippocampus compared with animals that could use sight and smell. That made sense, because the task that relied on memory involved the hippocampus, while the other did not.

However, the sleep-restricted rats that had to rely on memory to find the goal showed no increased neurogenesis, unlike their rested counterparts. This means that lack of sleep undoes the cell rejuvenation benefit that would normally come from the task, the researchers noted.

Sleep restriction prompts use of a secondary strategy

On the other hand, the sleep-restricted rats that were required to locate the platform using visual and odor cues did better on the task than their rested counterparts. This was an unexpected finding.

Hairston et al. believe it is because the rested group tried to rely on memory to find the platform, generally a better strategy to reach a goal you have reached before. But in this case, where the researchers moved the goal every fourth trial, using the visual and odor cues was a better strategy. It appears that the sleep-restricted rats changed their strategy to

compensate for their lack of sleep – and it worked.

"The sleep-restricted rats in this group actually did better because the lack of sleep interfered with their ability to memorize the maze -- forcing them to rely on easily accessible cues," Hairston said.

Researchers point to practical implications for the overtired Overall, the study underlined that learning depends upon two things: exposure to novel material and getting a good night's sleep, Hairston said.

Learning new things, at least in the case of spatial memory, quite literally keeps your brain young by ensuring a better survival rate for new brain cells in the hippocampus. However, not getting enough sleep eliminates the potential benefit of new learning on the hippocampus by suppressing neurogenesis. "Mild, chronic sleep restriction may have long-term deleterious effects on neural functioning," according to the paper.

On the other hand, that sleep-deprived rats did better on a task requiring use of visual and odor cues compared to their better rested counterparts "implies that some kinds of cognitive function are resistant to sleep loss," Hairston said. "This may be significant in human learning as well, and implies that it may be possible to optimize the way information is presented to rested versus fatigued individuals to take advantage of the specific neural substrates that are unaffected by sleep loss," the researchers concluded.

"This finding could be used to design training regimens for chronically sleep-deprived people, including members of the military and medical students," Hairston said. "That said, while the cognitive impairment may be overcome, our findings indicate that mild, chronic sleep restriction may have long-term deleterious effects on neural function," according to the paper.

Further studies could clarify learning strategies the brain employs

One implication of these findings is that sleep restriction disrupts the hierarchy of cognitive processes. That is, spatial learning seemed to be the primary cognitive strategy, and only when it was disrupted by lack of sleep, did a secondary strategy emerge. "It would be interesting to expand our findings to see if other competing processes are similarly affected by sleep restriction," Hairston said.

For example, scientists know that people who have suffered certain types of brain lesions may be unable to screen out irrelevant stimuli such as random noises in a room, something healthy individuals do easily. A flip side is that people with these lesions tend to associate familiar stimuli with new information more rapidly than healthy counterparts, a phenomenon called attention switching.

This suggests that learning to ignore stimuli and rapid attention switching are competing processes, with healthy individuals ignoring familiar stimuli as their primary strategy. It would be interesting to assess whether sleep restriction causes people to lose the ability to screen out extraneous stimuli and preferentially apply attention switching, she said.

Stanford researchers Milton T.M. Little, Michael D. Scanlon, Monique T. Barakat, Theo D. Palmer, Robert M. Sapolsky, and H. Craig Heller co-authored the paper.

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