

Reward improves visual perceptual learning—but only after people sleep

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Past studies have found that rewarding participants during a visual perceptual task leads to performance gains. However, new research suggests that these performance gains occur only if participants follow

up the task with sleep.

The new findings may have particular implications for students tempted to sacrifice [sleep](#) in favor of late-night study sessions, said study corresponding author Yuka Sasaki, a professor of cognitive, linguistic and psychological sciences at Brown University.

"College students work very hard, and they sometimes shorten their sleep," Sasaki said. "But they need sleep in order to retain their learning."

In the study, published this month in the *Proceedings of the National Academy of Sciences*, young adults were asked to identify a letter and the orientation of a set of lines on a busy background. Some participants were told to refrain from eating or drinking in the hours leading up to the [task](#) and were then given drops of water as a reward for correct responses. In contrast to groups that were not rewarded during training, rewarded participants exhibited significant performance gains—but only if they slept after the training session. This finding suggests that reward doesn't improve visual perceptual learning until people sleep.

The researchers believe that reward (or anticipation of reward) reinforces [neural circuits](#) between reward and visual areas of the brain, and these circuits are then more likely to reactivate during sleep to facilitate task learning. Indeed, during post-training sleep in rewarded participants, electroencephalogram (EEG) recordings found increased activation in the prefrontal, reward-processing area of the brain and decreased activation in the untrained visual areas of the brain.

That pattern of activation can likely be explained by past studies, which suggest that the prefrontal, reward-processing area of the brain sends signals to inhibit some of the neurons in the visual processing area. As a result, irrelevant connections are trimmed and the most efficient

connections are preserved, and task performance improves.

The study also examined when the patterns of activation occurred. Untrained visual areas of the brain exhibited reduced activation during both REM and non-REM sleep, but prefrontal, reward-processing areas became active only during REM sleep. REM sleep appears to be particularly important for task learning—likely because connections are reorganized and optimized during this sleep stage—and it may be linked to the activation of reward-processing areas of the brain. Consistent with this theory, the rewarded study participants exhibited longer periods of REM sleep compared to those who did not receive a reward during training.

Sasaki added that physical-based rewards, like food and water, may have a stronger impact on neural circuits compared to rewards such as money.

"Water deprivation may be fundamental," she said. "When you're really thirsty and you get water as a reward, the impact of that reward may be more prevailing to the [brain](#)."

Future research could examine whether other types of learning, such as motor and associative learning, also benefit from the interaction between reward and sleep.

Going forward, Sasaki hopes the study will encourage collaboration between sleep researchers and scientists studying [reinforcement learning](#).

"Reinforcement learning is a hot topic in neuroscience, but it hasn't interacted much with sleep research," she said. "So this could lead to more interdisciplinary work."

More information: Masako Tamaki et al, Reward does not facilitate visual perceptual learning until sleep occurs, *Proceedings of the National*

Academy of Sciences (2019). [DOI: 10.1073/pnas.1913079117](https://doi.org/10.1073/pnas.1913079117)

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