To understand the big picture, give it time -- and sleep

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Memorizing a series of facts is one thing, understanding the big picture is quite another. Now a new study demonstrates that relational memory -- the ability to make logical "big picture" inferences from disparate pieces of information – is dependent on taking a break from studies and learning, and even more important, getting a good night's sleep.

Led by researchers at Beth Israel Deaconess Medical Center (BIDMC) and Brigham and Women's Hospital (BWH), the findings appear on-line in today's Early Edition of the *Proceedings of the National Academy of Sciences*.

"Relational memory is a bit like solving a jigsaw puzzle," explains senior author Matthew Walker, PhD, Director of the Sleep and Neuroimaging Laboratory at BIDMC and Assistant Professor of Psychology at Harvard Medical School (HMS). "It's not enough to have all the puzzle pieces – you also have to understand how they fit together."

Adds lead author Jeffrey Ellenbogen, MD, a postdoctoral fellow at HMS and sleep neurologist at BWH, "People often assume that we know all of what we know because we learned it directly. In fact, that's only partly true. We actually learn individual bits of information and then apply them in novel, flexible ways."

For instance, if a person learns that A is greater than B and B is greater than C, then he or she knows those two facts. But embedded within those is a third fact – A is greater than C – which can be deduced by a process

called transitive inference, the type of relational memory that the researchers examined in this study.

Earlier research by Walker and colleagues had shown that sleep actively improves task-oriented "procedural memory" – for example, learning to talk, to coordinate limbs, musicianship, or to play sports. Because relational memory is fundamental to knowledge and learning, Walker and Ellenbogen decided to explore how and when this "inferential" knowledge emerges, hypothesizing that it develops during "off-line" periods and that, like procedural memory, would be enhanced following a period of sleep.

So, the researchers tested 56 healthy college students, each of whom was shown five pairs of unfamiliar abstract patterns – colorful oval shapes resembling Faberge' eggs. The students were then told that some of the patterns were "correct" while others were "incorrect," for example, Shape A wins over Shape B, Shape B wins over Shape C, and so on. All of the students learned the individual pairs but were not told that there was a hidden "hierarchy" linking all five of the pairs together.

After a 30-minute study period, the students were separated into three groups to test their understanding of the larger "big picture" relationship between the individual patterns: Group One was tested after a period of 20 minutes; Group Two was tested after a 12-hour period; and Group Three was tested after a 24-hour time span. In addition, approximately half of the students in Group Two slept during the 12-hour period, while the other half remained awake. All of the students in Group Three had a full night's sleep.

The test results showed striking differences among the three groups, especially between the students who had a period of sleep and those who remained awake.

"Group One, the students who were tested soon after their initial learning period, performed the worst," says Walker. "While they were able to learn and recall the component pieces [for example, Shape A is greater than Shape B, Shape B is greater than Shape C] they could not discern the hierarchical relationships between the pieces [Shape A is greater than Shape C] – they couldn't yet see 'the big picture.'"

Groups Two and Three, on the other hand, demonstrated a clear understanding of the interrelationship between the pairs of shapes.

"These individuals were able to make leaps of inferential judgment just by letting the brain have time to unconsciously mull things over," he says. But, perhaps most notable, he adds, when the inferences were particularly difficult, the students who had had periods of sleep in between learning and testing significantly outperformed the other groups.

"This strongly implies that sleep is actively engaged in the cognitive processing of our memories," notes Ellenbogen. "Knowledge appears to expand both over time and with sleep."

Concludes Walker, "These findings point to an important benefit [of sleep] that we had not previously considered. Sleep not only strengthens a person's individual memories, it appears to actually knit them together and help realize how they are associated with one another. And this may, in fact, turn out to be the primary goal of sleep: You go to bed with pieces of the memory puzzle, and awaken with the jigsaw completed."

Source: Beth Israel Deaconess Medical Center