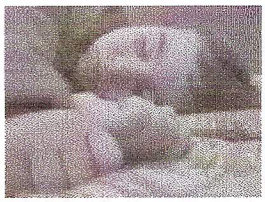
at helping us improve our memory.

Now, what is ¨memory¨? how does the process of memory work?



Dr. Bill Klemm, Professor of Neuroscience at Texas A&M University, explains a very important concept below.

- Alvaro

Getting from Here to There:
Making Memory Consolidation Work

By Bill Klemm, Ph. D.

Until consolidation has occurred, a short-term memory is very vulnerable, as all of us have experienced from looking up a phone number only to have some distraction cause us to lose the number before we can get it dialed.

What is "consolidation"?

Brain researchers use the term "consolidation" for the process whereby short-term memory gets made more permanent.

Here, I would like to discuss some aspects of consolidation that many people may not know about: why sleep is so important, why memory must be practiced, and how testing promotes consolidation.

1. Over-training: You Can Learn Too Much

Experiments have shown that human memory performance unexpectedly deteriorated if learning sessions were increased to four 60-minute sessions at regular intervals on the same day. In other words, the more the subjects were trained, the poorer they performed. However, this interference did not occur if subjects were allowed to nap for 30-60 minutes between the second and third sessions.

It is hard to explain why over-training disrupts performance, but I suspect that as training trials are repeated the information starts to interfere with memory consolidation, perhaps because of boredom or fatigue in the neural circuits that mediate the learning. Napping must have a restorative function that compensates for the negative effects of over-training. What all this suggests is that memory consolidation would be optimized if learning occurred in short sessions that are repeated but only with intervening naps and on different days with regular night-time sleep. In other words, repeating long study periods in the same day on the same task can be counter-productive. This is yet another reason why students should not cram-study for exams. Learning should be optimized by rehearsing the same learning material on separate days where normal sleep occurred each night.

Sources:

- Maquet, P. et al. 2002. Be caught napping: you're doing more than resting your eyes.Nature Neuroscience. 5 (7); 618-619.

- Mednick, Sara, et al. 2002. The restorative effect of naps on perceptual deterioration.Nature Neuroscience. 5 (7): 677-681.

2. Losing Your Past

Do you remember the names of your elementary-school teachers? How about the name of the bully in middle school? Or names of your friends when you were a kid? These are all things you remembered well at one time and remembered for a long time. But you may well have forgotten by now.

A recent study on rats suggests what it takes to sustain longer term memories. Rats in the study learned a "bait shyness" task. Rats were given a drink of saccharin-flavored water, and then shortly afterwards injected with lithium, which made them nauseated. This was a typical conditioned learning situation, as with Pavlov's dogs. In this case, rats typically remembered to avoid such water for many weeks. This is the basis for "bait shyness." If rats survive a poisoning episode, they will avoid that bait in the future. In this experiment, one group of rats received an injection directly into the part of the brain that holds taste memories. This injection contained a drug that blocks a certain enzyme, a protein kinase. These rats lost their learned taste aversion. The bad memory was lost irrespective of when the injection was made during the 25 days after learning occurred. Giving the enzyme blocker before learning had no effect on learning to avoid the flavored water. The protein kinase thus seems to be necessary for sustaining a long-term memory. It is possible that other long-term memories the rats may have had were also wiped out by the enzyme-blocking drug.

So what is the practical importance? I suggest that even "long-term" memories have to get rehearsed or they may eventually forgotten. Or if you do remember, there is a good chance that the memory is corrupted, that is, not totally correct. The consequence is that things that happened long ago may be either forgotten, or misremembered.

What sustains the enzyme necessary for long-term memory? I suspect it is rehearsal and periodic reactivation of the memory. Some scientists are excited about the possibility of developing a drug to manipulate levels of the enzyme. The problem with that, however, is that the drug could abolish old memories that you might not want to forget (like your name) or may cause you to remember too much that is now irrelevant.

Source: Shema, R., Sacktor, T. C., and Dudai, Y. 2007. Rapid erasure of long-term memory associations in the cortex by an inhibitor of PKM. Science. 317:951-953.

3. Testing Promotes Consolidation

Tests do more than just measure learning. Tests are learning events. That is, testing forces retrieval of incompletely learned material and that very act of retrieval is a rehearsal process that helps to make the learning more permanent. Testing, and not actual studying, is the key factor on whether or not learning is consolidated into longer term memory.

A recent report from Washington University in St. Louis, examined the role that retrieval had on the ability to recall that same material after a delay of a week. In the experiment, college students were to

learn a list of 40 foreign language vocabulary word pairs that were manipulated so that the pairs either remained in the list (were repeatedly studied) or were dropped from the list once they were recalled. It was like studying flash cards: one way is to keep studying all the cards over and over again; the other way is to drop out a card from the stack every time you correctly recalled what was on the other side of the card. After a fixed study period, students were tested over either the entire list or a partial list of only the pairs that had not been dropped during study. Four study and test periods alternated back-to-back. Students were also asked to predict how many pairs they would be able to remember a week later, and their predictions were compared with actual results on a final test a week later.

The initial learning took about 3-4 trials to master the list, and was not significantly affected by the strategy used (rehearsing the entire list or dropping items out as they were recalled). On average, the students predicted that they would be able to remember about half of the list on a test that was to be given a week later. However, actual recall a week later varied considerably depending on learning conditions. On the final test, students remembered about 80% of the word pairs if they had been tested on all the word pairs, no matter whether they had been studied multiple times with all of them in the list or if they dropped correctly recalled words from the list in later study trials. However, recall was only about 30% correct when correctly identified words were dropped from subsequent tests, even though all words were studied repeatedly. In other words, it was the repeated testing, not the studying, that was the key factor in successful longer-term memory.

So, what is the practical application? When using flash cards, for example, you need to follow each study session (whether or not you drop cards from the stack because you know them), with a formal test over all the cards. Then, repeat the process several times, with study and test epochs back-to-back. Can we extend this principle of frequent testing to other kinds of learning strategies? I would guess so.

Why does forced recall, as during testing, promote consolidation? It probably relates to other recent discoveries showing that each time something is recalled the memory is re-consolidated. If the same information is consolidated again and again, the memory is presumably reinforced.

This study also showed that the subjects could not predict how well they would remember, which is consistent with my 45 years experience as a professor. Students are frequently surprised to discover after an examination that they did not know the material as well as they thought they did. Tests not only reveal what they know and don't know, but serve to increase how much they eventually learn. If I were still teaching, I would give more tests. And I would encourage students to use self-testing as a routine learning strategy, something that one study revealed to be a seldom-used strategy. The repeated self-tests should include all the study material and not drop out the material that the student thinks is already mastered.

Source: Karpicke, Jeffrey D., and Roedinger, Henry L. III. 2008. The critical importance of retrieval for learning. Science. 319: 966-968.

--- W. R. (Bill) Klemm, D.V.M., Ph.D. Scientist, professor, author, speaker As a professor of Neuroscience at Texas A&M University, Bill has taught about the brain and behavior at all levels, from freshmen, to seniors, to graduate students to post-docs. His recent books include *Thank You Brain For All You Remember* and *Core Ideas in Neuroscience*.