frontiers FOR YOUNG MINDS

Neuroscience
Published: 13 November 2013
doi:10.3389/frym.2013.00003

Why sleep?

Dara S. Manoach[1], Robert Stickgold[2]

1 MGH Psychiatric Neuroimaging Prog. Athinoula A. Martinos Center, Charlestown, USA
2 Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, USA

Reviewed by:

Eleanor
8 years old

We human beings spend about a third of our lives sleeping. That means that if you live to 90, you'll sleep for about 30 years – probably more time than you'll spend doing anything else. Sleep is really important since we cannot live without it and spend so much time doing it. Yet unlike the other basic biological drives such as eating and reproducing, we still don't understand exactly why we need to sleep. It used to be thought that sleep was mainly to rest and restore the body and the mind, and to keep us safe from predators that hunted at night. But over the last 15 years, this view has radically changed. We now know that sleep plays an essential role in learning, memory and emotional well-being. In this review, we'll first discuss the structure of a good night's sleep, and then the role of sleep in learning and memory.

A GOOD NIGHT'S SLEEP

Just as a good meal is made up of different kinds of food, a good night requires different kinds of sleep. A night of sleep can be divided into rapid eye movement (REM) and non-REM sleep, and non-REM sleep can be further broken down into four different stages based on the type of activity in the brain (See Figure 1). This activity can be measured using a technique called electroencephalography (EEG), which involves placing sensors on the scalp that detect the brain's electrical activity. During the night, you pass through the different stages, from lighter to deeper sleep and back again over and over again, every 90 minutes. In the wee hours of the morning, sleep becomes lighter and you spend more time in REM sleep, which means more dreaming.

In addition, the different patterns of brain activity seen in these sleep stages serve different functions, and as a result each stage helps with specific kinds of learning and memory.

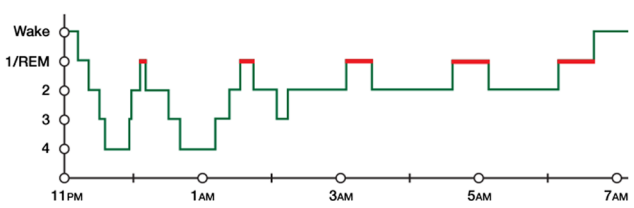

FIGURE 1 - A good night's sleep.
The normal progression of sleep stages across a night of uninterrupted sleep. REM sleep is highlighted in red. On the y-axis are wake, REM sleep, and the four sleep stages. On the x-axis is time. The green line shows how much time is spent in each sleep stage.

SLEEP, LEARNING AND MEMORY

Scientists once thought that all of our learning occurred during the day, while we are awake. Now we know that the brain continues to work on new information for days and even years, and that much of this continued learning happens while we're asleep. Sleep is involved in strengthening new memories and fitting them in with what we already know, and changing and updating our older memories based on what we just learned. But we do not remember everything we learn during the day. Somehow, the sleeping brain knows what new information is important enough to keep and what can be allowed to fade away [1]. Here are some examples of the many kinds of learning and memory that we need to sleep on.

PROCEDURAL LEARNING

Procedural learning means learning how to do something. When you're learning a new skill, like skiing or playing the piano, you may have the experience of reaching a point during practice where you just can't get any better. But when you try again the next day, right away your performance is much, much better. For most types of procedural learning, this improvement happens while you're asleep, and not just after some amount of time. For example, if you spend 10 minutes typing a sequence of keys on a computer keyboard over and over, as fast as you can, after the first 5 minutes you just don't get any faster. But the next morning you'll not only be faster, but you'll be typing more smoothly. On the other hand, if you train in the morning and test that evening with no sleep in between? Nada, zip, zero. You won't be any better [2]. Interestingly, not all sleep helps. The overnight improvement is greater if you spend more time in Stage 2 sleep (See Figure 1) and have more sleep spindles, which are brief, powerful bursts of brain activity that occur during Stage 2 sleep.

INSIGHT

Most everyone has heard of "sleeping on a problem," but does it really work? A group of German researchers taught students how to do a special kind of mathematical problem [3]. Unknown to the students, there was a much easier way to do it, but almost none of them figured it out. Twelve hours later, they were tested again. Some students were trained in the morning and tested 12 hours later (with no napping) that evening, but they weren't much better. Only about 22% figured out the shortcut. In contrast, when students were trained in the evening, and tested 12 hours later after a good night of sleep, 60% of them – two and a half times as many – discovered the shortcut. So sleep can lead to insights!

EMOTION

It is common knowledge that you're likely to be more emotional after a poor night's sleep. So it is not surprising to find evidence that disrupting sleep makes it harder to manage your feelings. For example, after not getting enough sleep, people who are shown either pleasant or upsetting pictures have more activity in the amygdala, a part of the brain involved in emotions. In one study, the amygdala did not communicate as well with another part of the brain that normally helps to control emotional reactions, the prefrontal cortex (See Figure 2). Unfortunately, the

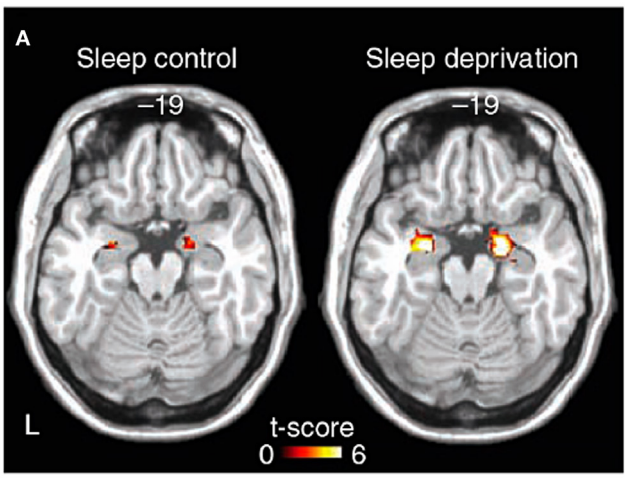

FIGURE 2 - The effects of not enough sleep on a part of the brain involved in emotion, the amygdala.
These horizontal MRI slices show structures deep in the brain. The colors show brain activity in the amygdala while research participants viewed unpleasant pictures compared to neutral pictures. Comparing the right to the left brain slice shows that participants who were deprived of a good night's sleep (right) had more activity in the amygdala than those who slept well (left).

sleeping brain remembers unpleasant memories better than neutral ones. While these memories may be more important to our survival, remembering mostly the bad things that happen can color your outlook and the decisions you make.

SOLVING MAZES DURING DREAMS

When students play an arcade style video game where they have to find their way through a complex maze, they can actually get better at it by simply taking a nap after practicing. Does dreaming have anything to do with this improvement in their memory of the layout of the maze? It's starting to look like the answer is, Yes. When researchers woke the students up during their naps and asked them what they had been dreaming about, it turned out that those who reported that they were dreaming about something related to the maze later showed ten times more improvement than those who didn't! (See Figure 3).

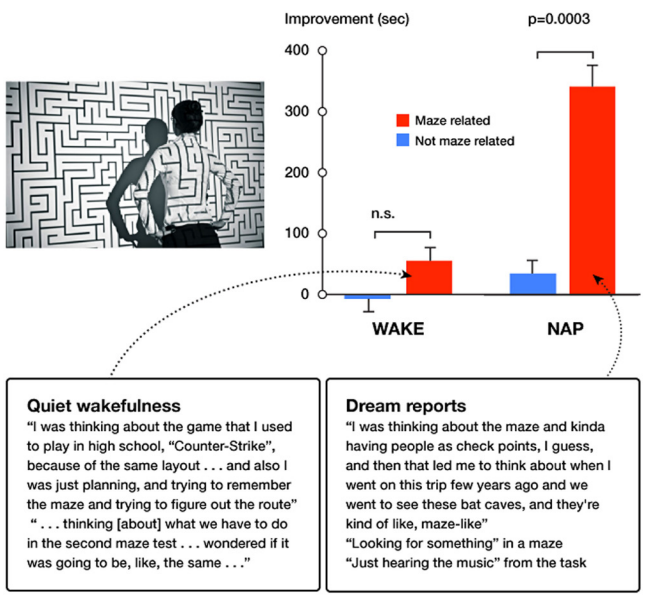

FIGURE 3 - Dreaming about the maze helps you get through it faster. Top left: A person looking at a maze. Top right: Improved speed for students who did not (WAKE) and did (NAP) take a nap between training and testing, and who did not (blue bars) or did (red bars) report thinking or dreaming about the maze. Only students who napped and reported dreaming about the maze got significantly better (n.s. means that the difference between the bars was not statistically significant). Bottom: Samples of reports given by students.

WHAT HAPPENS IF YOU DON'T SLEEP ENOUGH?

When you don't sleep enough, well, you become tired. And aside from the bad health effects of not enough sleep (people who don't sleep enough tend to eat more and unhealthier foods, gain weight, and get sick!), you also don't learn as well the next day and have trouble paying attention. Its almost as if your brain is too full to absorb any more information. For some information learned the day before, its like you've missed the opportunity to press the 'save' button – its gone forever. For other learning, you just don't show the normal sleep-dependent improvement (like for that piano piece you practiced). You are also more emotionally reactive to both pleasant and unpleasant events, which can lead you to feel stressed out, yell at friends and make bad decisions, based more on emotion than reason.

SO WHAT'S THE BOTTOM LINE?

Get enough sleep, and don't sleep with your cell phone by your side. Sleep is too important to miss. A good night's sleep is like a symphony of brain rhythms with each movement serving a different function. Cut it short, or let it be interrupted by a text or a tweet, and you may miss the chance to have a breakthrough on that thorny problem you were sleeping on, or to perfect that piano piece just in time for the recital. And its not like you can make up for it the next night – you'll probably have to start from scratch. Keep in mind that most teenagers need at least 9 hours of sleep per night! So here's wishing you many good nights of sleep and sweet dreams.

REFERENCES AND FURTHER READING

1. Stickgold, R., and Walker, M. P. 2013. Sleep-dependent memory triage: evolving generalization through selective processing. *Nat Neurosci.* 16:139–45. doi:10.1038/nn.3303

2. Walker, M. P., Brakefield, T., Morgan, A., Hobson, J. A., and Stickgold, R. 2002. Practice with sleep makes perfect: sleep-dependent motor skill learning. *Neuron.* 35:205–11.

3. Wagner, U., Gais, S., Haider, H., Verleger, R., and Born, J. 2004. Sleep inspires insight. *Nature* 427:352–5. doi:10.1038/nature02223

Gujar, N., Yoo, S. S., Hu, P., Walker, M. P. 2011. Sleep deprivation amplifies reactivity of brain reward networks, biasing the appraisal of positive emotional experiences. *J. Neurosci.* 31:4466–74. doi:10.1523/JNEUROSCI.3220-10.2011

Yoo, S.S., Gujar, N., Hu, P., Jolesz, F. A., and Walker, M. P. 2007. The human emotional brain without sleep-a prefrontal amygdala disconnect. *Curr. Biol.* 17:877-8. doi:10.1016/j.cub.2007.08.007

Wamsley, E.J., Tucker, M., Payne, J. D., Benavides, J. A., and Stickgold, R. 2010. Dreaming of a learning task is associated with enhanced sleep-dependent memory consolidation. *Curr. Biol.* 20:850-5. doi:10.1016/j.cub.2010.03.027

Submitted: 13 October 2013; Accepted: 30 October 2013; Published online: 13 November 2013.
Citation: Manoach, D. S., and Stickgold, R. (2013). Why sleep? Front. Young Minds. 1:3. doi: 10.3389/frym.2013.00003

REVIEWED BY:

Eleanor, 8 years old

I like reading and drawing. My favorite colors are blue, silver, pink, and purple. My favorite food is creamed spinach. I like to go shopping with my Mom.

AUTHORS

Dara S. Manoach

She is a scientist who uses brain imaging tools to reveal how different parts of the human brain work together when we think, learn, and solve problems. This information helps us to understand and treat brain disorders in which thinking is disturbed such as schizophrenia and autism.

Robert Stickgold

He studies how sleep and dreaming make our memories stronger and last longer, while also trying to figure out what they really mean, and whether they are even worth keeping. His work suggests that sleeping is a big part of learning, and sometimes as important as studying!