Why Do We Need Sleep?

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1 ABSTRACT

People spend eight hours a day sleeping. Getting a proper amount of sleep has been shown to have many health benefits, including lowering stress, increasing longevity, and being able to learn and remember more information. This paper presents two different theories on why humans need sleep and provides a critical evaluation of each theory. The first theory relies on the brain's neural network and argues that REM sleep is a period of "reverse learning." The second theory argues that REM sleep is used for regulating primary-drive-linked behaviors.

2 BACKGROUND

Humans spend about a third of their lives sleeping. After a good night's sleep, most people report that they feel better and are able to focus and remember more than when they are sleep deprived [4]. But what exactly is sleep and what are its characteristics? Sleep is a period of reduced activity that is associated with a typical posture (lying down with closed eyes) in which responsiveness to external stimuli is decreased [4].

There are two types of sleep: NREM and REM. NREM sleep is characterized by a reduction in physiological activity, and as sleep deepens, a person's brain waves slow down and gain amplitude [3]. NREM sleep consists of three stages: N1, N2, and N3. N1 is a time of drowsiness and is the transition stage from being awake to falling asleep. Brain waves and muscle activity begin slowing down in this stage, and people may experience muscle jerks or a falling sensation. N2 is a period of light sleep in which eye movements stop. Brain waves become slower with occasional bursts of rapid waves and spontaneous periods of muscle tone interspersed with periods of muscle relaxation. N3 is characterized by slow brain waves mixed with smaller, faster waves. Sleep is deeper with no eye movement and decreased muscle activity [3]. REM sleep is "an active period of sleep marked by intense brain activity" [3]. Eyes move rapidly in various directions and limb muscles become temporarily paralyzed. Most dreams occur during this type of sleep [3]. During sleep, these stages occur in cycles of approximately ninety minutes until the person wakes up.

Many physiological changes occur during non-REM sleep as opposed to during wakefulness or during REM sleep. Body temperature is reduced by about $1°C$ during sleep. During the usual ten- to thirty-minute periods of REM sleep, there is no thermoregulation, and as a result, body temperature is at its lowest point during this stage. Respiration also changes throughout sleep,

becoming increasingly regular until REM sleep, where breathing increases and is more irregular. Cardiovascular activity changes in a similar manner: heart rate and blood pressure decrease throughout sleep until the REM stage in which both increase and become more irregular. Many other physiological activities like kidney function significantly decrease during sleep while others like digestion, cell repair, and growth increase. These physiological changes show that sleep has many health benefits, including expending less energy to regulate body temperature, giving the heart a chance to rest, and allowing the body to grow and repair [4].

It is no doubt that sleep is a fundamental biological function that everyone needs in order to survive and to stay healthy. Countless devices like Apple Watch and Fitbit as well as applications like Sleep Cycle are currently able to track an individual's sleep. These devices are able to report to the user, with some degree of accuracy, how much they slept, when they were in various stages of sleep, and the quality of their sleep. Next, we focus on some common theories about why humans sleep.

3 PRELIMINARY THEORIES

There are four major theories that attempt to explain why we need sleep: inactivity theory, energy conservation theory, restorative theory, and brain plasticity theory.

Inactivity theory (sometimes referred to as the adaptive or evolutionary theory) is one of the oldest theories of sleep and suggests that inactivity at night is an adaptation that served a survival function by keeping animals out of harm's way during times when they would be especially vulnerable. According to this theory, animals that were able to remain still and quiet had an advantage over other animals that stayed active. However, this theory doesn't explain why sleep must occur during an unconscious state. It would always be safer to remain conscious in order to react to an emergency, so if safety is the main priority, there doesn't seem to be an apparent advantage of being unconscious and asleep [4].

Energy conservation theory suggests that the primary function of sleep is to reduce an individual's energy demand at times when it is least efficient to search for food. Research has shown that body temperature and caloric demand decrease during sleep, and energy metabolism is reduced by as much as ten percent [4].

Restorative theory explains that sleep serves to restore what is lost in the body during wakefulness. This is supported by the fact that major restorative functions like muscle growth, tissue repair, protein synthesis, and growth hormone release occur predominantly during sleep. Many scientists believe that the buildup of adenosine during wakefulness promotes the drive to sleep, and during sleep, the body has a chance to clear adenosine from the system [4].

Brain plasticity theory is one of the most recent and compelling explanations for why humans need sleep. Although brain plasticity is not entirely understood, it deals with the structure and organization of the brain. The importance of sleep has been shown in both infants, who need to spend about fourteen hours a day sleeping for proper brain development, and adults, whose

lack of sleep can hinder their ability to learn and perform a wide range of tasks [4].

4 TWO SLEEP THEORIES

4.1 Theory 1

The first theory is based on the fact that human brains are made up of neural networks. Neural networks are a series of interconnected neurons, such that when they are activated, there is a clearly defined linear pathway. These neural networks are what the brain uses to learn information. Various neurons in the brain are activated, which spread to other neurons, and those neurons spread to more neurons, and so on until a conclusion is made or a solution is figured out from using the strongest neural pathway. Sometimes, there are many weak pathways, and as a result, there is no clear conclusion and many solutions may seem plausible. When the brain is given feedback on the correct answer, the neural connections that lead to that answer are strengthened.

In "The Function of Sleep," Crick and Mitchison argue that the reason humans need REM sleep is to "reverse learn" [1]. This means that the trace of neural connections that led to an incorrect solution are weakened, and thus "unlearned" or "reverse learned." They argue that dreaming during REM sleep occurs unconsciously and the goal is to not remember the dreams because they represent an incorrect way of thinking or an incorrect method of finding the solution [1].

4.2 Evaluation of Theory 1

The first theory presented by Crick and Mitchison seems reasonable at first glance because experimental data about the cortical function and the way the cortex is designed in the brain does not dispute the theory. However, there are several problems with their "reverse learning" hypothesis.

First, the theory does not mention the need for the other stages of sleep (NREM sleep). Why do people undergo N1, N2, and N3 stages of sleep when the ultimate goal is to just get to REM sleep? In addition, there is no mention of how the sleep cycles play a role in the so-called reverse learning. Why do people need to go through cycle after cycle of REM sleep each night in order to reverse learn, rather than simply one continuous block of REM sleep?

Second, the theory does not explain why unborn infants need fourteen hours of sleep, about half of which is REM sleep. Why do unborn babies have to reverse learn so much? What do they even learn in the first place?

Third, the theory is not falsifiable. Using an MRI or another machine capable of looking into brain activity would neither prove nor disprove this theory. Although MRIs have shown that brain activity is significantly increased and brain reorganization does occur during REM sleep, it is highly unlikely that an MRI or any machine would show the physical weakening of neural connections in the brain. There are 100 billion neurons in the brain, so viewing their connections and watching for connections to weaken or fade during REM sleep is infeasible.

4.3 Theory 2

The second theory, known as Vogel's theory, states that REM sleep is used for regulating primary-drive-linked behaviors [2]. Primary-

drive-linked behaviors are innate biological needs and include hunger, thirst, and sex. These are called primary-drive-linked behaviors because they are needed for survival and the continuation of the species. Vogel argues that REM sleep deprivation increases this type of behavior since the body has had no REM sleep and thus, no chance of regulating and inhibiting these behaviors [2].

4.4 Evaluation of Theory 2

In 1975, Siegel monitored food intake and sleep in six cats for about a week. He concluded that "in all but one of the cats, the correlation between REM sleep and food intake was negative. REM sleep was a better predictor of food intake than either waking, slow-wave sleep, or previous food intake" [2].

However, in 1984, Bowersox et al. attempted to replicate Siegel's experiment, but did not obtain similar results. Bowersox et al. found that there was no correlation between food intake and the amount of REM sleep that the animal received.

The experiments performed by Siegel and Bowersox et al. contradict each other and are not conclusive. Both experiments were done with a small number of animals over a short time period that nothing can be definitively concluded from either of their results.

Unlike the first theory, Vogel's theory is certainly falsifiable: it can be proven or disproven if REM sleep deprivation causes primary-drive-linked behaviors to increase. This is exactly what Hicks et al. set out to do in their paper "REM Sleep Deprivation and Drinking in Rats: A Test of Vogel's Theory."

Twenty rats were used to test Vogel's hypothesis. Some rats would undergo REM sleep deprivation, and the others served as the control group. They underwent a twelve-hour water-deprivation period, and then the amount of water they consumed afterwards was recorded [2].

While Hicks et al. did show a very slight increase in water consumption in the REM-sleep-deprived rats, they argue that this difference is not statistically significant and that it does not support Vogel's theory that primary-drive-linked behaviors are not regulated without REM sleep. Hicks et al. concluded that their data "at best, provide weak and ambiguous support for [Vogel's theory]" [2].

5 SUMMARY

This paper first presents a background on sleep, and in particular, REM sleep, describing the characteristics and the importance of sleep. Then, it serves to present two main theories on why people need REM sleep, focusing specifically on the need for unconsciousness as well as the purpose and benefits that REM sleep gives. Each theory is then evaluated based on its argument and its ability to cohesively explain the necessities of the complex nature of sleep. To conclude, both theories provide a clear hypothesis to explain the need for sleep. However, both theories fall short in their explanations since they fail to consider the complexities of sleep (i.e. the need for several stages of sleep as opposed to just simply REM sleep), and the meek data backing up their claims is weak and unsubstantiated.

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