How and why do we sleep?

Introduction

This paper will provide a comprehensive investigation into the function and characteristics of sleep for human beings. Several relevant processes, such as REM, dreaming, and immune system homeostasis will be discussed. Sleep is an essential part of every animal's life, and humans especially need it to regulate their emotions, fine motor skills, neurotransmitter and hormone levels, and more. The long list of benefits from getting adequate sleep—and conversely, the negative effects from not getting enough—can be divided into two main categories: mind and body. During the state of being asleep, consciousness of the individual is altered, and many of the biological systems within the body work differently. While scientists are still researching the mysteries of *how* and *why* this physiological phenomenon occurs, sleep can be defined as a resting period where an organism, usually with its eyes closed, interacts significantly less with the stimulus in its environment and unconsciously performs multiple important tasks within its body to improve its health and efficiency. As important to survival as food or water, we spend around a third of our lifetimes sleeping—yet many people experience negative health conditions related to not getting enough sleep or to the circumstances in which they sleep. By exploring the mechanics of sleep and relevant empirical studies, we can build a repertoire of broadly applicable strategies with which to achieve better rest. While it may seem straightforward to climb into bed and doze off once the sun has set, sleep is anything but a simple activity. Sleep is an essential human need, one which we should prioritize and learn more about so as to maximize our potential while awake.

Mind — REM, Memories, & Dreams

De Gennaro and Ferrara claim that “the sleep effect refers to the fact that performance is superior when sleep occurs during the interval between learning and recall than when there is no sleep during this retention interval.” This generalized effect supports evidence that sleep is extremely important to the mental processes of memory recall, among others like decision making, empathy, and creativity. During sleep, the brain moves information and memories from short-term to long-term storage. Biophysical mechanisms of alternating slow and fast waves in the neural pathways of the cortex during sleep coincides with growing evidence that memories are stored by way of iterating information into molecules in the brain. During rapid eye movement (REM) sleep, the electrophysiological signatures measured by an electroencephalogram (EEG) are equivalent to those measured from an awake person, which suggests that brain activity while a person is asleep is by no means suppressed in comparison to when they are awake. Researchers theorize that this heightened metabolic activity is used for recalling and storing information gathered while awake, like memories or reactions to stimulus. In REM sleep, however, motor function is very limited, and the probability of dreaming increases. Slower waves are emitted by the brain when not in a REM cycle; this non-rapid eye movement (NREM) period is described as a truly restful part of sleep where blood flow regulates processes throughout the body below the neck.

Dreams are vivid experiences that occur while we are asleep, wherein the brain creates fictional environments and interactions drawing from a mixture of memories and other perceptions. There is a lack of conclusive research surrounding dreams, since they are so specific to the individual, are difficult to remember, and cannot be measured with many quantifiable means such as EEG scans. Dreams generally center around emotional themes, and can involve real memories and people familiar to the dreamer. Freud suggested in his novel *The*

Interpretation of Dreams (1900) that all dreams are a form of psychological wish fulfillment. The French term *déjà vu* describes a feeling that one has experienced a present situation before, with exactly similar details and context. Its occurrence is positively correlated to remembering dreams, and so could be explained by the relationship between perception of the present, memories, and how those are used to construct dreams.

Nightmares are broadly defined as bad dreams in which the fears, negative emotions, or trauma of the dreamer are brought to life in seemingly real and often disturbing scenes. These cause distress which is more easily identifiable: faster heart rate, shortness of breath, sweating, and heightened brain activity in areas like the amygdala, which activates in response to fear. Night terrors are episodes of distressed arousal from unconsciousness wherein a person enters a state of panic; they can open their eyes, scream, and flail their body about in addition to the aforementioned physiological responses to nightmares. Nightmares and night terrors are distinguished most prominently by their location in the sleep cycle—nightmares take place during REM sleep and are therefore easier to remember, whereas night terrors are an unusual phenomenon that happen during NREM sleep and are rarely remembered the next morning. It is advised to not wake someone suffering from a night terror, as the attempted physical arousal could extend the length of the episode or cause them to injure themselves or others.

Body — Energy, Growth, & Healing

Many consider the primary function of sleep to be restoring energy to the brain and body, for the purpose of thinking and accomplishing goals while awake. This is achieved by the rerouting of blood flow from the brain to other body parts during NREM, or deep sleep. The brain cools down and the pituitary gland releases growth hormone into the bloodstream, which

gets to work repairing muscle tissue and stimulates the immune system. At this time two of the core chemicals responsible for the feeling of energy are synthesized and balanced: adenosine and glycogen. The adenosine theory states that during wakefulness, adenosine accumulates in the cortex and basal forebrain to reduce the activity of 'wake-active neurons' and make a person feel tired; glycogen is replenished overnight to restore the brain's energy (Porkka-Heiskanen p. 802). If we didn't have to sleep, we would have about 1.5x more time to spend. But what would that look like? Energy is certainly not the only reason we sleep.

Take, for example, Randy Gardner, who holds the world record for longest time spent without sleep—11 days. His experiment to stay awake indefinitely won him and his friends first prize in the Annual Greater San Diego Science Fair in 1964, but in an interview years later he recalls those 11 days as quite challenging: "I mean, it was crazy, where you couldn't remember things, it was almost like an early Alzheimer's thing brought on by lack of sleep." As an adult, he suffers from insomnia and testifies that sleeping every night is important. His interviewer brings up the point that when daylight savings time subtracts an hour of sleep from the more than 1 billion people who live in cultures using it, heart attacks increase by 24%. Supplementarily, a lack of sleep decreases the levels of leptin, the hormone that creates the feeling of being full, while increasing the levels of the hunger hormone ghrelin.

Sleeping is imperative to the growth and development of young people, and conversely a lack of adequate sleep can lead to dangerous medical consequences for newborns and infants in particular. "The studies of acute partial sleep loss [...] are quite consistent in indicating that [partial sleep deprivation] negatively affects sleepiness and performance, as well as some metabolic, hormonal and immunological variables," Tarja Porkka-Heiskanen found in her studies. Sleep plays an even larger role in child development and growth, for a number of

reasons. Children spend more time asleep than awake for the first few years of life, issues with sleep are one of the main reasons parents must seek professional help for young children, and sleep is linked to many other facets of life: academic performance, body mass index, puberty, brain maturation, and more. To analyze and define sleep, several qualities are identified by researchers Sadeh and El-Sheikh: sleep duration, quality, schedule, whether the child takes naps, and when the child wakes up. It is reasonable to assume that, aside from aiding in the processes of puberty and early development, these findings can be generalized to adults, as well. Sadeh and El-Sheikh also outline several levels of context which affect sleep, ranging from the child's genetics and maturation to familial bedtime rules and routines to conscious cultural beliefs about sleep. REM sleep dramatically drops off as we grow out of infancy; newborns experience about 8 hours of REM every night, whereas most adults experience significantly less (Sadeh and El-Sheikh).

While asleep, a person's body also repairs injuries, fights diseases, and regulates chemical and physiological systems through a process called homeostasis. Homeostasis is the process of regulating the immune system, body temperature, and levels of chemicals in the blood and brain. Performed most intensely while we are asleep, homeostasis is the body's natural inclination towards equilibrium. Tarja Porkka-Heiskanen conducted a study into how the brain determines how long to sleep, and what to spend that time doing, based on the intensity of the preceding waking period. She describes a model of 'sleep pressure,' a term indicating the necessary amount of sleep after an intense waking period, which can be calculated by looking at how quickly someone falls asleep, how long they are asleep, and the levels of their slow wave brain waves picked up by an EEG.

Lack of sleep is associated with many diseases, including infection, and with increased mortality. Dr. Freda Ganz outlines a "sleep architecture" framework for the stages of NREM sleep in chronological order: stage 1 is the transition from wakefulness to deep sleep; stage 2 is a somewhat deeper sleep state where the sleeper becomes less aware of their surroundings; stage 3 begins deep or slow-wave sleep (SWS), wherein both fast and slow brain waves are emitted as the sleeper becomes much harder to wake; stage 4 is when mostly slow waves are being emitted. SWS is an anabolic state where immune function and physiological repairs are prioritized. Generally, NREM and REM comprise 90-minute cycles that repeat 5 to 6 times throughout the average night of sleep (Ganz). The sleep-wake cycle lasts 24 hours, and is associated with the biological rhythm of bodily functions such as sleeping, body temperature, and metabolism. The biological clock, according to Ganz, is mostly influenced by the relationship between light perceived by the retinas and the suprachiasmatic nucleus, located in the hypothalamus of the brain. Because of this, night shift workers with disrupted releases of melatonin, a neurotransmitter responsible for the feeling of sleepiness, are shown to be at an increased risk for cancer. The longer we sleep, the more time our brain and body have to complete their self-maintenance.

The Challenge of Sleep

Sleeping is not always easy, but with a foundation established for what we can and cannot control about sleep, several strategies exist for maximizing the benefits of our time in bed. 1 in 3 adults worldwide have some level of insomnia, which is a condition characterized by the inability to fall asleep, stay asleep, or receive the benefits of quality sleep. "About 25% of adults are dissatisfied with their sleep, 10–15% report symptoms of insomnia associated with daytime

consequences, and 6–10% meet criteria for an insomnia disorder," sleep scientists Morin and Benca found. Insomnia can be treated with a combination of cognitive-behavioral therapy (CBT) and clinically prescribed medications. Since sleep is both a cognitive and physiological process, so too are the problems associated with a lack of sleep straddling the lines between being chemically and mentally based. Additionally, since psychological traumas and too much stimuli can lead to insomnia (which itself is a broad term), it is almost never treated in a one-size-fits-all approach. Anesthesia is generally accepted as a practice that increases the safety of a given patient's condition, mostly during surgical procedures. Since sleep is a state where external stimulus has a lesser effect on the brain and body, it is medically necessary to put patients asleep to administer some treatments. Sleep disordered breathing or other physiological difficulties while asleep have a positive correlation with exacerbating factors such as aging, obesity, discomfort while asleep, and sickness. These negative effects are fittingly called comorbidities, as they predicate one another. The isolation of variables due to decreased movement and suppressed brain activity allows for sleep to yield valuable information about the medical condition(s) from which a person suffers.

A good sleeping posture is one that supports the alignment of your spine from your hips to your head, but what works for you depends on your health condition and comfort preferences. Nonetheless, some positions are generally regarded as more advantageous than others. Sleeping on your side or back is believed to be better than sleeping on your stomach since these positions facilitate spine support and balance, easing the strain on your spinal tissues and allowing your muscles to unwind and heal.

It is difficult for scientists to reach an agreement on the amount of sleep that everyone needs. Studies involving sleeplessness have shown that getting less than six hours of sleep can

indeed impair motor, emotional, immunological, metabolic, and hormonal functions, but unique individuals of course have unique needs. De Gennaro and Ferrara outline how sleeplessness has increased in recent decades: “in the past century we have reduced our average time asleep by 20%.” They discuss how the demand of modern occupational work and schoolwork have led to a decade-by-decade decrease in the number of hours of sleep. These authors also remark how important it is to factor in napping when discussing or measuring sleep—many populations report wishing for more sleep, and this usually results in a greater tendency to sleep during the day. Naps, of course, create their own problems and solutions. It is disputed whether a shorter, say, 20- to 45-minute nap is more advantageous for the sleep-wake cycle than longer, multiple hour siestas, but overall it is accepted that napping for too long will deceive the body into entering REM sleep, which is unhealthy to interrupt. Similar to drinking caffeinated beverages too late in the day, napping too close to bedtime throws off the body’s production of melatonin and can contribute to a harmful sleep schedule. Blue light from electronic devices such as smartphones, video games, televisions, and tablets has a similarly jarring effect on melatonin production, and should be avoided in the two hours preceding bedtime.

Here are some suggestions for a healthier sleep routine, according to the Society of Behavioral Medicine:

- Limit bright lights before bed.
- Turning off all bright lights at least an hour before bed can help promote melatonin production.
    - Dim lights, however, do not have an adverse effect on melatonin levels.

- Avoid screens before bed. If possible, stop using electronic devices at least 30 minutes before bed, as the blue light emitted from these devices can also disrupt melatonin production
- Wind down before bed. If possible, create a 30-60 minute routine before bed that involves relaxing activities such as reading, stretching, or nighttime hygiene. It's best to do these outside the bedroom so your brain associates your bed with sleep only.
- Block out distractions. Keep your sleep area quiet and dark. Tools like blackout curtains, sleep masks, or white noise generators can be helpful.
- Maintain a consistent wake time. This helps regulate your circadian rhythm and solidifies sleep triggers for your body.
- Get bright light during the day. Exposure to bright light during the day, particularly from spending time outdoors, can promote wakefulness during the day and sleepiness at night.

Conclusion

Sleep is a process we will never outgrow. It is a necessary part of our day-and-night cycles that allows us to grow, feel better, and have the energy to work and play. Being such a delicate state of consciousness, disruptions to sleep and a lack of sleep are shown to have detrimental health effects such as increased risk of disease, lethargy, and mental impairment. Many aspects of modern society damage our ability to reap all the benefits of sleep—we stay up late, throw off our chemical balances with drugs, caffeine, and alcohol, and spend much of our time looking at screens displaying artificial blue light. If we can individually improve the consistency and quality of our sleep schedules, everyone will notice that they have more patience, more energy, a clearer mind, and a longer lifespan.

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