Sleep and the Works

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Abstract

 This essay looks at how the activity of the brain differs from the body being awake and through the different sleep stages. The stages are given in more detail to show what happens to the brain and the body throughout the night. There are several different instruments used to find brain waves, and other waves, like the EEG, EOG, and EMG. The inventor of the K-complex, Alfred Lee Loomis, and Nathaniel Kleitman, also known as the “Father of American sleep research” according to a Stanford University article, and is an inventor of REM sleep. Various sleep disorders are looked at, like hypnagogic and hypnopompic hallucinations, sleepwalking and RBD (REM sleep behavioral disorder), which is closely related to sleepwalking. This is to give a better understanding of the importance of certain changes, and what happens when they go wrong.

Sleep and the Works

Sleeping, maybe one of the few activities shared by everybody in the world. Humans spend approximately one third of their lives asleep, assuming they get the regular eight hours. People go to bed in the hope of getting a good night’s sleep and waking up fully refreshed to start a new day. Today there exist all kinds of gadgets and accessories to aid in sleeping. There are commercials about new mattresses being “new and improved,” thus providing evidence for sleep being a topic that is still under research. It is easy to find tips and ideas to a better and improved sleep on the internet, which provides us with the clue that sleep is still being a conversation today. Nathaniel Kleitman became known in the early 20th century as the “Father of American sleep research” due to his research on sleep, and the studies on characteristics and deprivation (A Brief History of Sleep Research, 1999, para. 1). From rapid eye movement, or REM sleep, being discovered in 1953 by Kleitman himself and one his students, Dr. Eugene Aserinsky, the amount of research around the sleep topic increased abundantly. Everything from normal sleep to disorders (A brief history of sleep research, 1999, para. 1 and 4). Sleep studies can provide the scientists with information about how sleep affects a person, but more specialized equipment will have to be used to determine the activity of the brain, and other aspects of sleep that cannot be learned through sleeping habits alone.

**Purpose of Sleep**

 Sleep is a crucial part of not only human life, but also birds, fish, reptiles, and other mammals. And according to Dijk and Winsky-Sommerer, it was first in the 1950s that scientific research on sleep started for real, and much has been revealed about sleep since then. (2012, para. 32). But what is sleep? And what is its purpose? The term “sleep” is designated for animals with complex nervous systems, but there are states of inactivity in scorpions and insects, for example, that can be considered a state of sleep. Microorganisms do not possess a nervous system, but the discovery of inactivity cycles that are driven by a biological clock might mean that the origins of sleep date back four billion years (Dijk, Winsky-Sommerer, 2012, para. 33-34). According to Dijk and Winsky-Sommerer there are several reasons “ranging from keeping us out of harm's way to saving energy, regulating emotions, processing information and consolidating memory” (2012, para. 36). Seventeen years ago a sleep study was made with more than 10,000 British civil servants participating. Those who slept less than five hours, rather than just seven, increased their chance of dying by 1.78 times from “all causes,” as it was referred to in the study. As an example, the risk of death from cardiovascular disease was increased 2.25 times (Dijk and Winsky-Sommerer, 2012, para. 43).

 Dr. Raphaelle Winsky-Sommerer is the author of several articles published in the recent years. This year Winsky-Sommerer, together with D. J. Dijk, wrote four articles on various topics on sleep. Over the past six years other articles were written, but with various other authors, like “(2006) Sleep deprivation impairs object recognition in mice,” and “(2010) Manipulation of Adenosine Kinase Affects Sleep Regulation in Mice” (Dr Raphaelle Winsky-Sommerer)

**The Stages of Sleep**

Lawrence J. Epstein, M.D, studied sleep under Dr. Philip R. Westbrook at Cedars-Sinai Medical Center in Los Angeles. Dr. Westbrook taught Epstein about different sleep system, various disorders, and available treatments, but sleep deprivation was the most valuable lesson. Epstein were later invited by Dr. Anthony Komaroff at Harvard Health Publications to write a book about sleep, and in 2007 “The Harvard Medical School Guide to A Good Night’s sleep” were published (Epstein, Mardon, 2007, p. xiv).

For a very long time sleep had not been an activity of interest for scientists up until the 1930s. That is when they discovered that electrical current was produced by chemical reactions in the brain. What the scientists had to do next was to place an electroencephalogram, or an EEG, on the scalp of a person. An EEG consists of sensitive electrodes that records electrical activity which occurs in the brain, and is measured in cycles per second (Epstein, Mardon, 2007, p.11-12). Sleep had now been put on the map of research, and an instrument to determine the stages of sleep was now in use. This also provided proof that sleep was not a state of total relaxation, not for the brain at least. Through the EEG, they discovered that the size and frequency of the brain waves differed between activities, from small but fast waves when mentally active, and long and slow waves when at rest or sleeping (Epstein, Mardon, 2007, p. 12). According to this the brain does not rest, but it does slow down when the body is at rest.

It has been determined that there are 5 different stages of sleep. These are divided into two major groups, Non-REM sleep, also known as quiet sleep, and REM sleep, which is also known as dreaming. REM is short for rapid-eye movement. The first group consists of the first four stages of sleep. These stages were discovered through the finding of various activity patterns of the brain, as well as eye movements and muscle tone. The roles these stages play in health, growth and daytime functioning are still to be determined (Epstein, Mardon, 2007, p. 12-13). Even if thinking and most of the physiological activities are slowing down, the body might still make small movements. This explains the shifting of positions which can occur during the first stage of sleep. Several different brain waves have been detected through the sleep stages as well as the moments before falling asleep. Alpha waves show that the person is in a rested state, but not fully asleep yet. It is not until the theta waves appear that the person is falling asleep and entering stage 1 of sleep (Epstein, Mardon, 2007, p. 13-14).

The first stage of sleep is the period between wakefulness and light sleep. This is when the temperature of the body starts to drop, muscles get more relaxed, and the eyes move slowly from side to side. The person’s awareness of his or her surrounding might be lost during this time, but it does not take much to wake the person. This stage only lasts for about five minutes. It might be hard to tell whether a person is asleep or not (Epstein, Mardon, 2007, p. 14). The second stage starts when light sleep establishes. Now the heart rate and breathing slows down, and usually the eyes are still. The brain waves during the second stage are called sleep spindles due to short bursts of fast activity happening in-between medium-sized brain waves. Every other minute there are traces of a pattern, which scientists refer to as a K-complex. The theory about the K-complex is that it is a system that gives a person the ability to wake if necessary, working like a self-defense mechanism. The second stage usually lasts between ten to twenty-five minutes the first time, but normally about half of the night is spent in this stage (Epstein, Mardon, 2007, p.15). If this theory is correct, it can be proof of a survival skill in humans, like with animals that are often light sleepers to protect them from other predators. It is not as crucial for humans to be light sleepers in these modern days, as the chance of getting attacked by an animal while asleep is rather slim. It can be important for other reasons, however, such as if a fire should occur, or for those with young children that need attention during the night.

The third and fourth stages are very similar to each other. Both are regarded as deep sleep, or slow-wave sleep, and the body is repairing and renewing itself during this time. Blood flow to the brain decreases, which cools the brain. According to researchers, the blood levels of interleukin increases to help the body defend against infection. The immune system is activated by the interleukin. The active brain cells that remain active at this point get more coordinated. This is when delta waves start to occur on the EEG recording. Through looking at the EEG, it can be determined whether a person is in the third or fourth stage of sleep. If more than half of the waves are delta waves the person is in the fourth stage. Delta waves appear as large and slow waves on the EEG (Epstein, Mardon, 2007, p. 15-16). This would explain why it is so important for people with a sickness or a disease to get a good night’s sleep. They need the increase in their immune system to ward off and fight against the culprits, bacteria and such, which are either trying to get or are already in the body. These stages take up about twenty percent of the sleep, and last for up to thirty minutes at a time, but the length of this slow-wave sleep starts to decline abruptly once the person reaches the age of sixty-five. Someone that is deprived of sleep will not only enter these stages quicker, but also spend more time in them (Epstein, Mardon, 2007, p.16). This serves as proof to the deep sleep being a more restorative part of sleep, and therefore more important for people that need to catch up on lost sleep.

Rapid eye movement or REM sleep is the final sleep stage; this is the stage where dreaming occurs. In this stage the body is paralyzed while the brain is active. Except for minor twitches, only the muscles controlling breathing and eye-movement are still able to move. As the name suggests, a person’s eyes races back and forth rapidly at this point. The temperature of the body rises again. Blood pressure increases, and the heart rate and breathing picks up to normal daytime levels. The penis or the clitoris becomes erect during this stage (Epstein, Mardon, 2007, p. 17). Awakening with an erection is a sign that the REM stage has been entered, as well as when the temperature is at normal levels for a person in good health.

Having a normal heart rate or breathing is probably not something people think about when waking up, but it is a sign that the person had entered REM sleep. Teachers and professors often warn their students not to stay up all night studying for an exam, and maybe with a good reason. Studies have shown that REM sleep lightens learning and memory, therefore improving new tasks after a good night’s sleep. These improvements, however, were lost when repeatedly woken during REM sleep, but when woken during slow-wave sleep, the third and fourth stages of sleep, the improvements were unaffected (Epstein, Mardon, 2007, p. 18). This strengthens the theory that students should not study all night before an exam, that they should get a good night’s sleep the night before test day. That being awaken from the slow-wave sleep did not interfere with the improvements also strengthens the theory that REM sleep is important for studying. REM sleep is entered three to five times a night, which is about every ninety minutes. The duration of REM varies, starting with a few minutes the first time, and continuously increasing throughout the night up to half an hour the last portion of the night. Normally, twenty-five percent of sleep is in REM, but this might increase if the person has been deprived of REM sleep, which is referred to as REM rebound (Epstein, Mardon, 2007, p.18).

**Brain Activity Instruments**

 William H. Moorcroft wrote the book “Understanding Sleep and Dreaming,” which got published in 2003, to fill the void of sleep research the decade before his book. Moorcroft wrote the book from a sleep researcher’s perspective, with personal experience with sleep disorders, and as a college professor that has taught about sleep for over twenty-five years. The book’s audience is aimed at college students wanting to learn about sleep, but with no prior knowledge (Moorcroft, 2003, p. ix-x). Moorcroft’s book also contains information on sleep instruments.

There are several instruments today that are being used on people to study people’s sleep. According to William H. Moorcroft, Aserinsky and Kleitman developed the sleep lab in 1953, which was also the place where the two reported that there were two kinds of sleep. Over the nearly sixty years that have passed since then, sleep labs can be found all over the world. A sleep lab is a place where the subject, or the sleeper, can sleep without interruption and is attached to sensitive instruments that help study their sleep (Moorcroft, 2003, p. 1-2). One of the instruments being used in the sleep lab is the EEG. (Takahara, Kanayama, Nittono, Hori, 2006, p. 105). The other stages of sleep before the REM sleep also contain alpha, and theta waves, as well as sleep spindles, the K-complex and delta waves as mentioned by Epstein and Mardon (2003, p. 13-14). The alpha waves during the REM sleep, however, are usually slower than the alpha waves occurring during wakefulness (Takahara, Kanayama, Nittono, Hori, 2007, p. 105). This serves as proof that the brain is still active even when people are sleeping.

The EEG can also be used in coordination with other instruments, like the EOG, or electrooculogram. This is an electrode that is placed on the outer corner of the eye, which helps determine eye movements, or something that can be called eye movement waves. This aids the EEG in figuring out the stage of sleep a person is in. Then there is another pair of electrodes placed on either chin, this to see if there is tension in the neck muscle. This instrument is called the EMG, or the electromyogram, which is yet another instrument to help with determining the presence and stage of sleep. This is because the neck muscles are constantly being used to hold up the head. When these muscles are tense or contracted electrical activity is produced, and it is therefore easier to see when the person is asleep as the muscles finally get to relax a little. How relaxed the neck muscles are helps scientists find what sleep stage a person is in (Moorcroft, 2003, p.3-4). These three instruments make tests more reliable as all of them have the potential to come up with the same answer, therefore leaving less room for speculation.

The instruments, or electrodes as they are referred to, are attached to separate computer screens. This is so the scientists or the sleep experts can look at the various brain waves. Sudden abnormalities in the waves can come from the person shifting positions and can point out how restless the patient’s sleep is. Giving the sleep subject different commands, like looking in different directions, or grinning, can have an effect on the EOG and the EMG respectively. The EEG can be tested by having the subject blank his or her mind, and relax (Moorcroft, 2003, p. 6). By doing this, the experts are able to tell whether the electrodes are working properly, and if adjustments are needed. This also reduces the chance of mistakes during the test.

**Sleeping Disorders**

There are several sleeping disorders out there today, hypersomnia being one of the maybe less known, probably due to the challenge of an accurate diagnosis. It is like the world of sleep’s fibromyalgia as there are many other factors that should be taken into account. Sleepiness, sleep deprivation, drug or substance use, disorder of medial or psychiatric origin, or even other sleeping disorders should not be mistaken for hypersomnia (Vernet, Leu-Semenescu, Buzare, Arnulf, 2010, p. 525). Alertness might already start to reduce during daytime, which also might be followed by a desire or need to sleep. Waking up can be harder, confusion can occur, and repeated returns to sleep, which has been named sleep drunkenness. When medical or psychiatric disorders cannot be used to explain hypersomnia, it becomes known as idiopathic hypersomnia, which can be with or without a long sleep time, meaning 10 hours or more of sleep (Vernet, Leu-Semenescu, Buzare, Arnulf, 2010, p. 525-526).

E. J. O. Kompanje reported cases of hypnagogic and hypnopompic hallucinations (2008, p. 464). These happen at the transition from wakefulness, and sleep to wakefulness respectively. The only difference is when they occur. Symptoms are very vivid illusions that are both visual as well as auditory. The hallucinations are often related to sleep paralysis (Kompanje, 2008, p.464). When sleep paralysis occurs in a state of wakefulness, something is wrong. Abnormal sleep paralysis is when people are aware of their surroundings and are able to open their eyes, but still unable to move their bodies. The hallucinations are often of the nightmarish sort, and might be strong enough to induce a fear of dying. They might also be afraid that someone is coming to their bedroom to either kill or rape them, and that it is impossible to escape. The hallucinations and sleep paralysis has played a role behind the “historical ‘old hag attacks’, nocturnal attacks and rapes, space alien abductions and ghostly visitations” (Kompanje, 2008, p. 464).

Sleepwalking is another problem that can happen to people, which is caused due to an arousal which makes the subject involuntarily rise from his or her sleep and perform various actions without a memory of it the morning. The theory behind this phenomenon is that the brain is not able to fully awaken from the slow-wave sleep during the third and fourth stages (Plazzi, Vetrugno, Provini, Montagna, 2005, p.194). Through the use of the EEG, sleepwalking can be spotted. Plazzi, Vetrugno, Provini and Montagna explains that the delta waves during the third and fourth sleep stages are often shown as diffused and rhythmic mixed with theta and alpha ranges at faster frequencies, or raised activity of the alpha and beta waves (2005, p. 194). This means that there are great changes to the EEG when a sleepwalking episode occurs, making it obvious on the EEG that something abnormal is about to happen, or has happened.

Patients suffering from sleepwalking often have their eyes open and therefore appear to be awake, but their motor-skills are typically decreased, causing them to become clumsy and act without purpose. Their speech might be slurred or slow, and have a poor response to stimulation. Reduced reactivity and awareness usually happens as well (Plazzi, Vetrugno, Provini, Montagna, 2005, p. 194). Poor motor-skills can make them appear clumsier than they normally are, and they might not react when they bump their knee on a table due to their reduced stimulation response. There is no evidence to prove that the reticular activating system is to blame for sleepwalking, but that an “incomplete cortical activation in response to an arousing stimulus leads to the symptoms” (Plazzi, Vetrugno, Provini, Montagna, 2005, p. 194).

The reticular activating system, or RAS, is found in the brain, ranging from the lower part of the brain and all the way up to the front. Even if it goes through several parts of the brain, it is not being controlled by any one part, but might play different parts in activating sleep or wakefulness. The RAS maintains the consciousness of a person through the arousal system, which has the objective to cause a continual excitation of nerves. Unconsciousness will occur if there are problems with the arousal system (Izac, 2006, p. 28). Since the RAS goes through several parts of the brain, and it seems like no part has complete control, it is hard to determine whether RAS has anything to do with sleepwalking, as it might be a problem with the normal sleep paralysis during the REM sleep that is malfunctioning (Izac, 2006, p. 28).

Muscle atonia, or REM sleep paralysis, is a normal part of the REM sleep stage. There are, however, situations where there is no muscle atonia, which is referred to as REM sleep behavioral disorder, or RBD. The cause of RBD is due to “disinhibition of normally inhibitory mid-brain projections to spinal motor neurons” (Matwiyoff, Lee-Chiong, 2010, p.334). This means that during normal REM sleep the mid-brain’s messages to the nerves of the spine are blocked, causing muscle atonia, but RBD stops this blocking, thus preventing muscle atonia to occur. When RBD is combined with an active dream state, the RBD patient might start acting out their dreams. This can result in injury to either the patient, or his or her bed partner. For the patient, it is just a vivid dream. Sleep talking or yelling, movement of the limbs, or even complex movements like driving. Patients often recall the contents of their dreams upon awakening (Matwiyoff, Lee-Chiong, 2010, p.334-335).

Between 2005 and 2008, 62 patients diagnosed with idiopathic hypersomnia were chosen for a study on their sleeping disorder. Fifty other control subjects were added to the study, but without any form of sleeping disorders, and thirty of these completed 48 hours of monitoring to ensure good health. They underwent sleep questionnaires, which had questions about their current sleep, when they were 10-years old, the need for naps and their duration, and even the sleep times of their parents. Then three procedures of sleep- and wake-monitoring were to follow. These included sleep with respiratory monitoring starting at 11:00 and ending at 06:30, five standard sleep tests at 8 am and every other hour after that, and a 24 hour sleep monitoring. The sleep tests “were terminated after 20 min if no sleep occurred and after 15 min asleep if sleep occurred” (Vernet, Leu-Semenescu, Buzare, Arnulf, 2010, p. 526-527). Those in the control group were paired up with the hypersomnia patients according to sex and age to provide more accurate answers. The patients reported longer sleep times than the control subjects, as well as having more difficulties awakening in the morning and from naps. Conditions that helps awakening, the patients reported they needed help from others or due to stress of being late more than the other subjects (Vernet, Leu-Semenescu, Buzare, Arnulf, 2010, p. 527-529). The study provides evidence that idiopathic hypersomnia is an actual sleeping disorder and not just a symptom of another sleeping disorder, even though there is still a chance that that is the case.

**Sleep, Dreams and Learning**

 It is clear that sleep has various physical effects on the body, but what about the psychological effects? In 1974 Rosalind D. Cartwright performed a study on sleep and its correlation with problem solving. The study included twenty-four students that were asked to take three types of tests. The first test was a crossword puzzle, which only has one correct answer. The second test was a Remote Association Test (RAT), here the students were given three unrelated words which they connected to one word. Cartwright’s example to the RAT test was the words “snow,” “base,” and “costume” got linked with the word “ball” (2010, p.151-152). The third test was a Thematic Apperception Test (TAT), which Cartwright explained “the TAT picture problem was designed to compare solutions to emotional interpersonal dilemmas, for which there is no one right answer” (2010, p.152). Here the students were shown two cards containing a picture, and a “problem story” that went with the picture. The objective was to write a dramatic “ending” to the story behind the picture (Cartwright, 2010, p. 152). Giving the students three different tests made the results more reliable, as the possibility of a more thorough research can be made. One student might be good at crossword puzzles, so a different test might be needed to really understand if sleep effects learning.

 The students had ten minutes to work on the tests before getting stopped, which would not be enough to complete them. Before getting another ten minutes to work on the tests, they were then given two different intervals of 3.5 hours each, one in daytime waking, and the other in sleep. Only one of the tests was worked on at a time over 3 days and 3 sleeping nights in the lab (Cartwright, 2010, p.152.) Focusing on only one test at a time might provide better results as the other tests cannot interfere with their way of thinking. The students sleeping in the laboratory were given 7 hours of sleep. To ensure higher proportion of sleep, the students were awakened at the first sign of REM sleep for the first half of the night. They were given ten more minutes of test time after each 3.5 hours of sleep (Cartwright, 2010, p.152).

 The results concluded that there were no additional correct solutions followed by an interval of waking or the sleep heavy on REM sleep. The crossword puzzles and the RATs yielded improved results by both conditions. It was the TATs that provided a different outcome. The students that were awake gave more often a happy ending to the stores, in contrasts to the students that had slept that had given a more “realistic” ending to the story. Realistic in a way that the main character in the story might not have gotten what her or she wanted, and that a compromise with other characters could have been a possible ending (Cartwright, 2010, p.152-153). Cartwright speculated the results could possibly be coming from the disrupted REM sleep might have made en effect on the results, that the unpleasant awakening provided the students with a mood bias that influenced the story endings (2010, p. 153).

 Cartwright uses a metaphor to explain the continuously active brain’s two major alternating states of waking and sleep, “…we speak prose while awake and poetry in sleep” (2010, p. 157). The idea behind the metaphor is that during the waking period a person receives both internal and external information, and can respond more to the external world. In sleep a person is confined to new and old internal information received from the surroundings when awake. Another way of looking at it is that a person’s attention is driven towards monitoring the facts of the immediate situation at hand, while in sleep some of the waking experiences will be reactivated “with preference given to those that carry an emotional kick” according to Cartwright (2010, p 158). If no major emotional happening occurs throughout the day, and the sleep is adequate, a person’s emotional well-being becomes updated and in balance, meaning that negative emotions get down-regulated overnight leaving the person calmer the next morning (Cartwright, 2010, p 158).

**Future Sleep Research**

 There have been made good progress on the sleep topic over the last century, but there are still much more to research. Researchers and scientist can work more on the role of the specific parts of the brain, as it has not been determined what part of the brain affects the sleep cycles for example. Sleep disorders are a big problem in today’s society so more research on the causes, and prevention should be investigated in the future. Cartwright’s study on sleep’s effects on learning can also be further investigated, perhaps with a larger audience and different time frames for taking the tests. She also stated that disrupted REM sleep might also have had its effects on the tests, so more research should be done to investigate her theory. Several new articles are written each year, providing people with more information about sleep, and a general awareness of its importance. Sleep has become more than just something people do between their days; it has made it into an important activity not to be taken too lightly.

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