*How does sleep deprivation damage cognitive function and memory in the brain?*

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**Part** **I: Introduction**

When you’re thinking of staying up all night, either for work or play, you may want to rethink your decision making before you compromise your brain’s capabilities. An article by *Everyday Health* explains the danger just one night can cause: “The consequences of sleep deprivation at 24 hours is comparable to the cognitive impairment of someone with a blood-alcohol content of 0.10 percent” (Theobald). The dangers of just 24 hours staying awake is equal to the dangers of drinking at least 2, 40% alcoholic drinks. That is the same as being intoxicated beyond legal limits. Also according to the Centers for Disease Control in the U.S. about 40.6 million American adults sleep for 6 hours or less a day, some of which are shift workers for warehouses, transportation and many health care industries. The Flexibility in Duty Hour Requirements for Surgical Trainees (FIRST) trial, published in 2015, randomized 118 general surgical residency programs to be apart of the 2011 Accreditation Council for Graduate Medical Education (ACGME) regulations that prohibit more than 80-hour work weeks. Sleep deprivation affects us on such a large scale that surgeons now have to have regulations on their shift worker’s hours to insure they are well rested for medical procedures to avoid mistakes and deaths.

To be clear, sleep deprivation is the situation or condition of suffering from a lack of sleep. Climatically the effects of sleep deprivation naturally damage the brain’s cognitive functions including the reduction of visual working memory by impairing our abilities to interpret visual stimuli and filter information.

**Part** **II: Historical Content**

Studies of sleep deprivation affecting the brain started in the mid-late 1800s. A Russian scientist, Marie de Manaceine, started experimenting on puppies to test sleep deprivation. The result was unexpected and all of the 10 test subjects died; “I have found that by experimenting on 10 puppies that the complete deprivation of sleep for four or five days (96 to 120 hours) causes irreparable lesions in the organism and in spite of every care these experiments could not be saved. Complete absence of sleep during this period is fatal to puppies, in spite of the food taken during this time”(Stanley Finger 47). Another experiment in 1898 with dogs showed similar results to Manaceine’s. Italian scientists Lamberto Daddi and Giulio Tarozzi [kept dogs awake](http://www.ncbi.nlm.nih.gov/pubmed/9322273) by continuously walking them. All subjects died after 9-17 days and their survival was unrelated to food consumption. Again in 1898, the psychiatrist Cesare Agostini, interested in the psychic phenomena caused by prolonged insomnia in humans, derived the dogs of sleep by keeping them in a reflective cage in order to avoid fatigue. The dogs survived about 2 weeks, and degenerative changes were observed in their brains. The historical article *The Pioneering Experimental Studies on Sleep Deprivation* evaluate that; “In these experimental paradigms, the effect of sleep loss was confounded by motor exhaustion and/or intense sensory stimulation.” (507-6). All of these studies prove that even while being properly fed and taken care of, our brains and bodies are not meant to go without resting.

The studies in past research proved if anything, that a lack of sleep can ultimately cause death, whether you stay up continuously or have chronic partial sleep deprivation. Other damages include; memory loss, false memories, emotional distance such as anger, slurred speech, impaired wit, hallucinations, the habit of making risky decisions, lack of awareness, and several types of brain damage [cerebral shrinkage, cronut binges, ect.] Newer studies have shown that “People who sleep fewer than six hours a night are [12% more likely to die prematurely](http://www.sciencedaily.com/releases/2010/05/100504095109.htm) than people who sleep between six and eight hours. An average of [7 hours a night](http://www.sciencedaily.com/releases/2010/09/100930161837.htm) for older women has been correlated with the best chance of living longer”, according to a study done by the University of Warwick and Federico II University Medical School in Naples. They found that sleep deprivation is also associated with heart disease, high blood pressure, obesity, type 2 diabetes, and high cholesterol which are all fragments of an unhealthy body that is likely to decay quicker. It’s important to recognise the difference between acute and chronic sleep shortage. Short term, or mild symptoms may result from losing a night’s sleep but you will likely make a full recovery after 2 or 3 days of well rested sleep. Chronic sleep deprivation is when you are unable to make up the amount of sleep loss you have, which results in more serious physical and emotional symptoms.
 As noted earlier, the neurobiological effects of sleep deprivation are damaging and causes your brain to impair your reaction time, memory and cognitive functions. In the *Indian Journal Of Medical Research*, Abhirup Chatterjee et al says, “Most of the studies reported on cognitive impairment after sleep deprivation are based on neuropsychological test performances after sleep deprivation” (4). Therefore we can prove sleep deprivation causes damage through neuropsychological test performances.

**Part** **III: Research and Analysis**

When our brains do not get enough rest, they start to lose blood circulation which causes major damage to the neuron receptors in different regions. They are responsible for storing information, filtering it out, working through problems, understanding and showing emotion, and even physical movement. With a lack of sleep you may notice a loss of memory or having memories that never happened (false memories). It also causes cerebral shrinkage and overall kills brain cells causing severe brain damage. Your cerebrum is responsible for the integration of complex sensory and neural functions and the initiation and coordination of voluntary activity in the body. An infographic from brainconnection.brainhq.com; "Healthy adults getting poor sleep lose volume in frontal, temporal, and parietal lobes…”. It is dangerous for any part of our brain to change in size and long term this could cause permanent brain function damage.

Lack of sleep can’t be repaired in just one night. Many people believe that one good night’s sleep is sufficient enough to make up for previous poor sleep, but research has found that chronic sleep loss has returning negative effects, especially when sleep is lost during our circadian rhythm. Circadian rhythm is the time when we are asleep that our biological clock inside is regulating our sleep/wake cycles. The rhythm has dips and rises through every 24 hours before our clocks reset. For a healthy adult the circadian dip is around 2 and 4am and the rise is around 1 and 3pm. If we throw off our clocks then the dips and rises happen at different times of the day which can result in hard sleep ‘crashes’. This has negative effects on anyone who has to work during the day because they can make more mistakes in their work. It can also have negative effects on night shift workers. Shift work has many health effects but sleep distribution is the most commonly seen. In 2003, Torbjörn Åkerstedt did a study with shift work observing the three main shifts, morning, afternoon and night based on the patterns of sleep and wakefulness. “The most troublesome acute symptoms are difficulty getting to sleep, shortened sleep and somnolence during working hours that continues into successive days off.” Though these don’t seem like critical issues, they can result in more pressing damages in our brains. A person’s circadian clocks being off kilter can also be the cause of many car accidents, usually occurring in the early to mid-afternoon due to lack of sleep the previous night(s) before. Disturbance in the circadian rhythm causes downfalls in wakefulness during prime times of the day instead of its intended time during our sleep cycle.

 Sleep deprivation causes [hypnagogic](http://www.wisegeek.com/what-are-hypnagogic-hallucinations.htm) hallucinations, or feelings of ‘altered reality’ because of the invasion of REM sleep (rapid eye movement) activity resulting in waking up. Hypnagogic hallucinations occur during REM sleep, and may be accompanied by [sleep paralysis](https://www.sleepassociation.org/patients-general-public/narcolepsy/sleep-paralysis/), and are where the subject is physically immobile, but is fully conscious. Dr. Ronald Hoffman in his article on healthy sleep gives insight into this anomaly of not having brain function to move but to be consciously awake simultaneously. “...it appears that sleep is a biochemical web of enormous complexity. The brain must send out chemicals to silence parts of itself and the body. It’s as if the brain is in a constant tug of war between a chemical web that keeps it awake and one that keeps it asleep.” Prolonging these conditions can lead to severe moral and emotional impairment and ultimately psychosis. But whether psychotic, sleep-deprived or just high, our brain’s visual system cannot avoid altering blank or boring settings. It becomes poor at theorizing objects based on visual clues, therefore visualizing your surroundings may become substantially difficult, things may not seem truly as is. In the book *Sleights of Mind*, neuroscientists Susana Martinez-Conde and Stephen L.Macknik bring up that, “your brain is constantly making up its own reality whether it receives actual reality-driven input from your senses or not. In the absence of sensory input, your brain's own world making machinations keep on truckin' nevertheless”(37). This would make it very easy for false realities to occur during sleep loss due to the minimal amount of visual activity being reserved.

When studying the effects of sleep deprivation, scientist focus on how noticeably it changes the way humans and some animals perceive and tell apart important information and how well they remember it. Important information is referred to as relevant and irrelevant stimuli and during testing, the subjects are instructed to pay attention to the relevant objects and to ignore the irrelevant ones. Filtering efficiency is the ability to focus on and filter out relevant and irrelevant stimuli quickly and efficiently. Drummond and his colleagues hypothesized that, “...if one is good at filtering out irrelevant distractors, then performance should be better in the filtering conditions with only two targets, than in the baseline condition where there are 6 targets”(Drummond, 6). This is assuming that if the subjects have performed well on a difficult filtering task then they are almost obligated to do better on a lower difficulty level. So if a person is lacking a strong filtering efficiency is means their brains are having a hard time picking out the relevant or important bits of information because of the irrelevant or insignificant information that their senses absorb. Damaging important functions like this causes us to put ourselves in serious danger. Groggy vision perception could lead to letting dangerous stimuli slip through our minds. Ultimately sleep deprivation could potentially cause us to harm ourselves.

Visual working memory is required for almost any cognitive demand involving the storing of multiple visual stimuli simultaneously or selecting target objects in crowded displays. It is also an important process for reasoning and the guidance of decision making and behavior. It’s in high interest because it is correlated with your overall cognitive abilities, it’s easy to measure, and it can be observed at the level of neural circuits in the brain. Visual working memory capacity differs considerably across all groups and individuals. To test how well visual working memory has been impacted by sleep loss in some individuals, Sean P.A. Drummond et al, studied 44 healthy young adults’ abilities to remember important stimuli after one night of total sleep loss, and after 4 nights of only receiving 4 hours of sleep each night. “The task measuring capacity involved a target image composed of four to eight colored squares presented for 100 milliseconds (ms), followed by a fixation screen lasting 900 ms and then a probe image with an identical number of squares as the original image”(Drummond, 3). They were told to remember as many of the colored squares as possible from the first image, then to identify if the probe image was the same or different from the most recent target image. “Overall, we found one night of total sleep deprivation impairs the ability to determine relevant vs irrelevant stimuli within a visual scene, while four nights of partial sleep deprivation restricted to 4 hours in bed/night does not”(Drummond, 6). These results show that while a total night of sleep deprivation reduces visual working memory, partial sleep deprivation over minimal time has no readable effect. This suggests that as long as you are getting some sleep you shouldn’t notice visual working memory impairment but rather only when you do not sleep at all. Students and shift workers should take into consideration when thinking about pulling an all-nighter, that even if the benefits seem worth it now, they won’t be in the future. Students will have a harder time remembering what the studied for if they are sleep deprived because their brains haven’t gone through the process of replaying the information enough to imprint it into their cerebral cortex.

**Part IV: Conclusion**

Sleep deprivation damages cognitive function and memory in the brain by damaging many functions of the brain and its cells. It causes our bodies to slow down inside and out. Sleep deprivation has been found to decrease or disturb blood flow to certain regions of the brain. This lack of a constant pressure in blood flow causes neuron receptors to shut down or be damaged which then stops the brain’s process to do things such a save memories, distribute between different types of information, and even deciding on proper emotions. Sleep deprivation targets the cerebral cortex of the brain, slowly but critically, restricting important functions responsible for everyday life.

Studies have dug deep into these general areas of damage by examining first, how one’s ability to filter out important information and ignore unimportant information changes over time following sleep deprivation, and then how the number of objects one can remember from one set of information to another decrease. Testing how these brain functions are altered gives an insight on why driving tired is extremely dangerous, why students are more likely to fail a test when staying up all night studying, or why important jobs that are critical to detail would be jeopardized by being done while sleep deprived. Some facilities have taken into consideration the amount of work one is allowed to complete during one’s shift in order to stray away from any misjudgments on the job. Some of the research found stated that they would have required more testing to see how partial sleep deprivation affects us over time.

Further research into this topic sould be to looking into circadian rhythm and how it changes throughout the day after final sleep deprivation and maybe even how or even if we can change our circadian clocks over time. I think analyzing the behavioral changes during circadian rhythm highs and lows following the lack of sleep would provide more evidence for why driving tired is an extremely dangerous daily activity. What should also be done next is to study how we can achieve successful sleep because it is so uncommon and what else is a bad night’s sleep takes away from our full brain’s capacity and power. Another piece would be to look into exactly how quickly information is lost or forgotten once received after total sleep deprivation. This could have some connection to the feeling of forgetfulness when walking into a room and once entering, having almost no understanding of what you needed. I personally would like to research the correlation between sleep loss at a young and elderly with alzheimer's disease.

**Bibliography**

Åkerstedt, Torbjörn. "Shift Work and Disturbed Sleep/wakefulness." *Occupational Medicine*. Oxford University Press, 01 Mar. 2003. Web. 27 Feb. 2017.

Chatterjee, Abhirup, et al. "Meditation As An Intervention For Cognitive Disturbances Following Total Sleep Deprivation." *Indian Journal Of Medical Research* 136.6 (2012): 1031-1038. *Academic Search Premier*. Web. 23 Jan. 2017.

Drummond, Sean P. A., et al. "The Effects Of Two Types Of Sleep Deprivation On Visual Working Memory Capacity And Filtering Efficiency." *Plos ONE* 7.4 (2012): 1-8. *Academic Search Premier*. Web. 23 Jan. 2017.

Finger, Stanley. "Origins of Neuroscience." *Google Books*. N.p., n.d. Web. 27 Feb. 2017.

Hoffman, Ronald, Dr. "Healthy Sleep: Recharging Your Batteries." *DR RONALD HOFFMAN Intelligent Medicine*. Dr. Ronald Hoffman, 04 Oct. 2013. Web. 17 Feb. 2017.

Macknik, Stephen L., S. Martinez-Conde, and Sandra Blakeslee. *Sleights of Mind: What the Neuroscience of Magic Reveals About Our Brains*. London: Profile, 2012.

Smith, Rebecca. "People Who Sleep for Less than Six Hours 'die Early'." *The Telegraph*. Telegraph Media Group, 05 May 2010. Web. 27 Feb. 2017.

Theobald, Mikel. "What Happens When You Don't Sleep for Days." *EverydayHealth.com*. Everyday Health, 22 Feb. 2016. Web. 27 Feb. 2017.\

Bentivoglio, M., and G. Grassi-Zucconi. "The Pioneering Experimental Studies on Sleep Deprivation." *Sleep.* U.S. National Library of Medicine, 20 July 1997. Web. 13 Mar. 2017.