

Memory ability declined due to sleep deprivation

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Abstract. This passage focuses on whether memory ability will decline due to sleep deprivation. As the pressure on people's lives increases, people tend to sleep less to finish more work. The sacrifice of sleep time for the work product is worth it. So this paragraph will summarize this issue by analyzing articles, and the conclusion is lack of sleep will cause irreversible damage to the brain. So, people should recognize that they probably cannot afford the cost of sleep deprivation.

Keywords: Brain wave; Sleep deprivation; REM; NREM.

1. Introduction

Sleep is a physiological response that is part of the brain's neurological activity and results from inhibiting nerve cells within the cerebral cortex after sustained excitation. When the cerebral cortex is inhibited, a person sleep. This inhibition protects the nerve cells, allowing them to re-excite and will enable the person to continue working. At the same time, sleep is also a process of memory cell metabolism. If sleep deprivation is chronic, memory cells cannot live normally and are prone to aphasia, spasms, convulsions, shock, fainting, and other disorders. Over time, it is also susceptible to cancer. Age, lesions, sleep, excessive mental activity, and memory affect memory. On the other hand, lack of sleep causes irreversible brain damage. The following section will describe the connection between sleep and memory and the research progress.

2. Memory formation and mechanisms

Memory is the reflection of past experiences in the mind. Things perceived, problems thought, emotions experienced, and actions performed in the past can be recorded in the form of images stored in the brain, and can be extracted from the brain under certain conditions, which is memory. Memory can associate people's past and present mental activities, enable people to build up knowledge and experience, and recognize the nature of things and the inner connection between things through thinking activities such as categorization and contrast.

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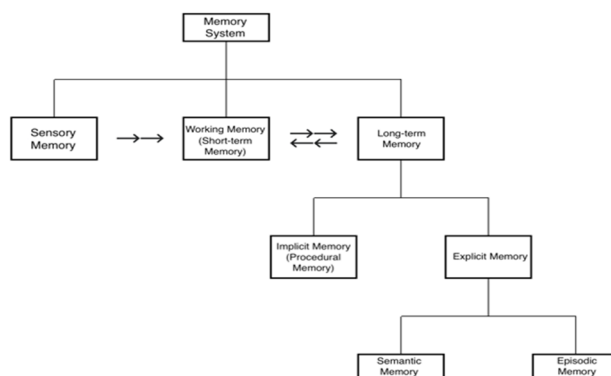


Figure 1. Memory system and different kind of memory

The memory system is an organized whole of the memory process, based on the time interval elapsed between information input and extraction and the way in which the information is encoded. It can be classified into three different subsystems: the sensory memory system, the short-term memory system, and the long-term memory system. According to Tulving's theory of multiple memory systems, long-term memory is subdivided into implicit memory and episodic memory.

Implicit memory is a form of long-term memory. It means memory about techniques and processes. Memory is sometimes stored in procedural memory and is activated when a person performs a specific physical action. Expressive memory, sometimes called episodic memory, is a form of long-term human memory. It refers to a type of memory that enables explicit recall of an event or fact. Explanatory memory includes semantic memory and situational memory. Semantic memory is a type of memory that is formed through the abstract comprehension of factual and common-sense ideas through language, words, numbers, algorithms, etc. Semantic memory is typically formed through episodic memory, which is an objective knowledge and is not related to personal experience. Emotional memory is an "autobiographical" subjective memory that may be unique to humans and can be associated with a specific time and place in the past, associated emotions, and other relevant knowledge, and is a clearly identifiable memory that is a collection of personal experiences that happened at a particular time and place in the past.

The hippocampus is an area of the brain that helps humans deal with long-term studies and remember things like sounds, lights, and tastes, and is in charge of short-term memory, known as "working memory". In medical terms, the "hippocampus" is an internal fold of the cerebral cortex that forms an arch-shaped bulge around the "choroidal fissure" at the base of the "lateral ventricles" and consists of two fan-shaped sections. It consists of two fan-shaped parts, sometimes called hippocampal structures.

Some research showed that the imprinted cells are mainly found in the hippocampus and are closely related to memory formation. The specific machinery of them is not precise. During the process of imprinted cells compiling and extracting memories, their internal chromatin is reorganized. Some positions, mainly for enhancement, become loose to allow the noncoding sequences that promote the genes' expression to attach to the target genes quicker. These target genes are always related to the protein synthesis on the synaptic sites and the increase in synaptic spines. These are beneficial for establishing a stable connection between two neurons and consolidating memory.

Neuroscientists at MIT have identified a cellular pathway that strengthens particular synapses during memory formation. The findings reveal for the first time the molecular mechanism by which long-term memory is encoded in a hippocampal region called CA3 (Joshi, V. V., Patel, N. D., Rehan, M. A., & Kuppa, A. (2019). *Mysterious Mechanisms of Memory Formation: Are the Answers Hidden in Synapses?* *Cureus*, 11(9), e5795. <https://doi.org/10.7759/cureus.5795>). A protein called Npas4 regulates the intensity of links between neurons in CA3 and neurons in another part of the hippocampus called the dentate gyrus. Without Npas4, long-term memory cannot be formed.

3. Brain and eyes activity during sleep

Rapid eye movement (REM) sleep behavior disorder is a type of sleep disorder. During this time, vivid, usually unpleasant dream behaviors are expressed through sounds and sudden, violent arm and leg movements - sometimes referred to as dream behavior. During REM sleep, the person usually does not move, a normal stage of sleep that occurs many times during the night. Non rapid eye movement (NREM) sleep is sleep without rapid eye movements. In this type of sleep, brain activity is reduced to a minimum, allowing the body to be completely calm. Unlike REM sleep, there is little eye movement during this time. Dreaming is also rare during this time, and muscles are not paralyzed during NREM sleep. In addition, during NREM sleep, the body is in a state of parasympathetic innervation.

Regular sleep is divided into two-time stages: fast-wave sleep and slow-wave sleep, which can be interchanged. The sleep cycle consists of one slow-wave sleep and one fast-wave sleep, and each cycle duration is about 90 minutes. Persons normally go through 4-6 sleep cycles per night. REM sleep is a stage of sleep-in which brain waves become faster and lower in amplitude, while heart rate increases, blood pressure rises, muscles relax, and eyes constantly swing from side to side. Slow-wave sleep, or SWS for short, represents the third and fourth sleep stages. People who awake in this stage may feel disoriented and not very alert.

Slow-wave sleep, the third and fourth stages of human sleep, is dominated by θ and δ waves. When the θ wave is the dominant brain wave, the person's consciousness is interrupted, and the body is deeply relaxed, which is a high-level mental state. In such a state, the disruption of consciousness causes the critical or moral filtering mechanisms usually present when people are awake to be buried, thus opening the mind's door to a hyper-suggestibility state of external messages. This is why people are prone to receiving external instructions when hypnotizing. In addition, theta waves have a direct relationship with the limbic system of the brain. They are beneficial in triggering deep memory and strengthening long-term memory (LTP), which is why they are called "The Gateway to Learning and Memory" in the scientific community.

When the δ wave is the dominant brain wave, it is deep sleep and unconscious. There is a straightforward correlation between the quality of sleep and the delta wave. δ wave sleep is a dreamless and deep sleep state, which usually occurs four to five times a night in a normal sleep cycle, and the first cycle that appears at the beginning of sleep is the dreamless δ wave (NREM) state. But it can also occur in young children during non-sleep.

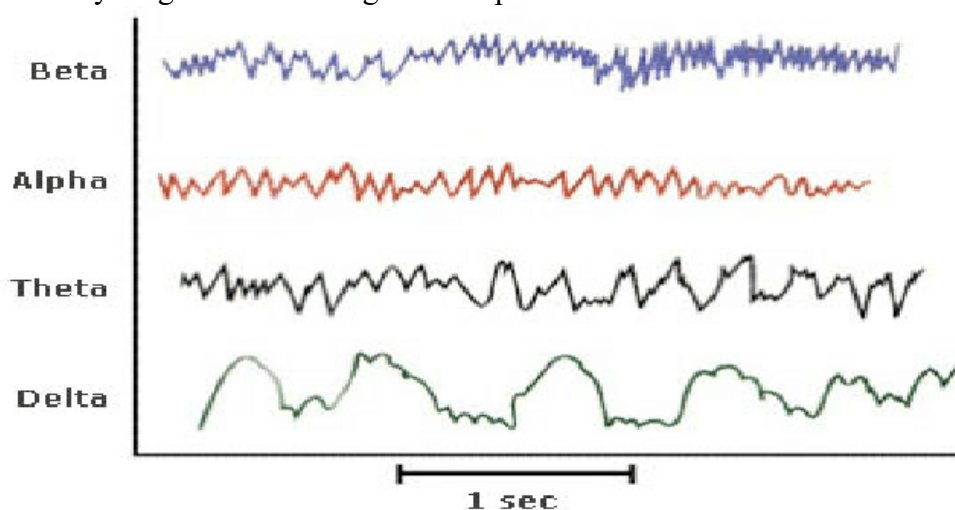


Figure 2. Types of brain waves and waveforms (Guerrero-Mosquera, C., Malanda, A., & Navia-vazquez, A. (2012). EEG Signal Processing for Epilepsy. Epilepsy - Histological, Electroencephalographic and Psychological Aspects, 49–74. <https://doi.org/10.5772/31609>)

After studying NREM, or slow wave sleep (SWS), a specific comparison of REM and NREM sleep appears. Whereas some research pointed to a more beneficial effect on memory enhancement of REM sleep than NREM, other studies found no difference between the two states, or demonstrated better recall of verbal material associated with predominant NREM sleep compared to REM sleep (Ficca, G., & Salzarulo, P. 2004).

Although rapid eye movement is beneficial for recalling verbal material, rapid eye movement sleep behavior disorder is a type of sleep disorder. During this time, vivid, usually unpleasant dream behaviors are expressed through sounds and sudden, violent arm and leg movements - sometimes referred to as dream behavior. During rapid eye movement sleep, the person usually does not move, a normal stage of sleep that occurs many times during the night. NREM sleep is sleep without rapid eye movements. In this type of sleep, brain activity is reduced to a minimum, allowing the body to be completely calm. Unlike REM sleep, there is little eye movement during this time. Dreaming is also rare during this time, and muscles are not paralyzed during NREM sleep. In addition, during NREM sleep, the body is in a state of parasympathetic innervation.

As previously reported, the frequency of eye movements during REM sleep was much higher than that during NREM sleep (Hirshkowitz, 2004). Previous studies indicated the frequency of eye movements is higher during REM sleep than wakefulness in human (Andrillon et al., 2015). However, in mice, we found that the frequency of eye movements during wakefulness was higher than that in REM sleep (Meng Q, Tan X, Jiang C, Xiong Y, Yan B and Zhang J 2021).

4. Relationship between sleep and memory

Sleep and memory have a complex relationship. When people wake up, sufficient break time can help them to deal with new information. Also, when people sleep after studying, it can help consolidate this knowledge, becoming a memory stored in the brain.

People produce four different waves during sleep: δ , θ , α and β waves, which correspond to the other sleep states of people. However, only the alpha wave is the bridge between the conscious and subconscious mind and is the only available way to access the subconscious mind. It promotes inspiration, accelerates information gathering, enhances memory, and is the perfect brain wave to facilitate studying and thinking. When the brain is filled with α waves, the person's awareness activity is restrained and cannot perform logical thinking and deduction activities. At that time, the brain takes in and delivers messages through instinct, inspiration, and imagination.

An important theory of sleep function - the "synaptic homeostasis hypothesis" - indicates that during sleep, synchronization across the brain is generally diminished. This is thought to equalize the overall reinforcement of connections when we are awake and studying. By trimming excess connections, sleep effectively cleans up these connections, so we can learn again the next day. In some cases, interfering with this narrowing process may lead to stronger memories.

The significance of sleep for maintaining optimal brain activity as we age may be reflected in changes in our sleep patterns. Infants and kids sleep much longer than adults, possibly due to the fact that their developing brains are learning and being introduced to more new environments. In later life, sleep duration decreases. This may reflect the fact that as we age, our need for sleep decreases.

Sleep is also needed to do some brain "housework". A recent study of rats found that sleep clears toxins that accumulate while awake. During sleep, the spaces among brain cells are increased, allowing toxic chemicals to be excreted from the body.

Behavioral studies on the consolidation of memory during sleep provide strong evidence that the search for different types of messages is superior after a period of sleep-in contrast to the waking state (Ken A. Paller, Jessica D. Creery, and Eitan Schechtman 2021). When a person enters deep sleep, brain neurons grow new synapses that strengthen the connections between neurons, thus consolidating and enhancing memory. The eye movement period will only occur during the sleep period. During this time, the brain will begin to organize the memories of the alarm clock you have present. In NREM sleep period, the brain prepares for the next day's knowledge reception. So lack of sleep can reduce learning ability by 40%.

5. Conclusion

Sleep is not as detrimental to memory as one might think. On the contrary, sleep helps the brain integrate and store memories. A reasonable amount of sleep allows students and office workers to remember things from the day and improve productivity. The results of the research, which was published in the edition of the Journal of Neuroscience, showed that chronic sleep deprivation led to the death of 25% of brain cells in the brains of experimental rats. So if a person is sleep-deprived or has chronic insomnia, it may lead to permanent brain cell loss, memory loss, and reduced efficiency. But people sometimes face situations where they have to sacrifice sleep to get things done. For patients with insomnia, we can treat the patient's insomnia with a non-pharmacological treatment, namely Repetitive Transcranial Magnetic Stimulation (rTMS). Transcranial magnetic stimulation (TMS) is a pain-free, minimally invasive therapy. The magnetic signal can be stimulated through the cranium to the brain nerves without attenuation. Its practical application is not restricted to stimulating the brain and peripheral neuromuscular. However, people who stay up late can only reduce the damage to brain cells by increasing sleep time and relaxing the brain properly.

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