## Neurophysiologic Processes of Memory in Dreams

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**Summary**
Most times people wonder why it is necessary to remember their dreams after a long sleep and why they see the things often thought about, in the dreams. It is the oldest neuronal process which has been in existence since the origin of mankind. The human brain memory is the brain vital function which gives human the ability to make plans. The implication of the memory in dreams can be attributed from life instances and experiences, some of which can be integrated from short term memory to long term memory. So many articles have proven that dreams can be noticed more in REM sleep which involves the activation of the neural activity in the brain stem, thalamus, amygdala, and extrastriate temporo-occipital cortices while other structures such as the dorsolateral prefrontal cortex and the precuneus are inactive during REM sleep where dream is most common. The Lucid dream consciousness occurs when the precuneus, the medial prefrontal cortex, the dorsolateral prefrontal cortex and intra-parietal sulcus, are active at the same time which involves the activity of stored information in the brain memory. The dopamine and norepinephrine boosts focus, increases the ability to connect and integrate information, and facilitates pattern recognition and problem solving. It might also enhance the ability to recall details and memories from waking life while within the dream. The selective bilateral hippocampal lesions can have an impact in memory role during dream process. The essence of memory is for decision making, plans for the future and maintaining personality even while dreaming. This article aims to explain the neural role of the brain memory activation while dreaming, which is based on different ground breaking research of dreams, sleep and memory.
**Keywords:** Dreams, Lucid Dream, Memory, REM sleep, Consciousness, Neural Activity
**Abbreviations:** DMN- Default Mode Network; DAN- Dorsal Attention Network; EEG- Electroencephalogram ECN- Executive Control Network;

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**საძიებო სიტყვები:** სიზმრები, გაცნობიერებული სიზმრები, მეხსიერება, REM-ძილი, ცნობიერება, ნერვული აქტივობა
ადამიანების უმეტესობას აინტერესებს, თუ რატომ არის აუცილებელი ძილის შემდეგ სიზმრების დამახსოვრება, ან რატომ ხედავენ ისინი სიზმრებში თავისი ფიქრების,განცდების გამოძახილს. ეს არის უძველესი ნეირონული პროცესი მას შემდეგ, რაც კაცობრიობა წარმოიშვა. ადამიანის თავის ტვინის ერთერთი სასიცოცხლო ფუნქცია მეხსიერებაა, რაც აძლევს ადამიანს გეგმების შემუშავების საშუალებას. სიზმრებზე მეხსიერების გავლენა მიეწერება ცხოვრების შემთხვევებსა და გამოცდილებებს. ზოგიერთი მათგანი ხანმოკლე, ხოლო ზოგიც ხანგრძლივ მეხსიერებასთან არის ინტეგრირებული. მრავალ შრომაში აღწერილია, რომ REM-ძილში (ძილი თვალის სწრაფი მოძრაობებით) ხდება ძირითადად სიზმრების გენერაცია, რაშიც თავის ტვინის სტრუქტურები, მათ შორის ტვინის ღერო, თალამუსი, ამიგდალა, ექსტრა-სტრიალურიორბიტოფრონტალური ქერქი მონაწილეობენ, მაშინ როდესაც რიგი სტრუქტურებისა, როგორიცაა დორსო-ლატერალური ფრონტალური ქერქი, თხემის წილის ზედა და შუა ნაწილი (precuneus) ამ დროს ინაქტივირებულია. ლუსიდური ანუ გაცნობიერებული სიზმრების დროს, როდესაც პროცესში ცნობიერებაა ჩართული precuneus-ი, მედიალური ფრონტალური და დორსოლატერალური ქერქი, ინტრაპარიეტალური ღარი განიცდის აქტივაციას. ამასთან, ეს ის სტრუქტურებია, რომლებიც, სავარაუდოდ, თავის ტვინში ინფორმაციის შენახვაში უნდა მონაწილეობდნენ. არსებობს მოსაზრება, რომ დოფამინი და ნორეპინეფრინი ხელს უწყობს ინფორმაციის დაკავშირებისა და ინტეგრირების შესაძლებლობას და ნიმუშების (ხატების) ამოცნობასა და პრობლემების გადაჭრას. ეს, თავის მხრივ, ეხმარება სიზმარში ღვიძილის დროს განცდილი მოვლენების

NREM- Non-Rapid Eye Movement Sleep; REM sleep- Rapid Eye Movement Sleep;

## Introduction

Most times people wonder why it is necessary to remember their dreams after a long sleep and why they see the things often thought about, in the dreams. It is the oldest neuronal process which has been in existence since the origin of mankind. Dream is defined according to Merriam-Webster dictionary as series of thoughts, images, and emotions occurring during sleep. Every person must have encountered this, not often but most times. It becomes interesting when it is positive which can bring happiness to the dreamer on waking up, such as being in a paradise where there is no pain or stress and waking up to be more optimistic regarding the future but the complex process of dream occurrence remains a mystery (Windt, 2013). It can be as a result of subjective experience which is attributable by the memory like when a child is being scared with an ugly teddy bear; the child has the possibility of recalling such scenario in the dream which can cause REM sleep. Whenever some of the life activities occurs, the brain can store the information in which can be recalled in dreams. (Wamsley and Stickgold, 2009) This article aims in explaining the neural role of the brain memory while dreaming, which is based on the ground breaking research on dreams, sleep and memory.

The memory is one of the brain vital functions and gives human the ability to make some possible plans regarding the next step to take. Memory is the vast brain function to store, process and retrieve information. It provides the ability to interact with individuals and environment. The memory attributes to who we are such as a student who remembers the name of the lecturer or the course of study. There are various forms of memory some of which are short-term memory, intermediate long-term memories and long-term memory. The short-term memory includes memories that last for seconds or at most minutes unless they are converted into longer term memories, intermediate long-term memories can last for days to weeks but then fade away while long-term memory, which, once stored, can be recalled up to years or even a lifetime. The smaller animals have memory which helps them remember certain scenario like when the owner of the dog pursue the dog outside the house while eating; the dog has the chance of being outside in subsequent time whenever the owner wants to eat. The essence of memory in both humans and animals really helps

დეტალების გახსენებას. მეხსიერების არსი კი გადაწყვეტილების მიღება, სამომავლო გეგმების დასახვა და, საბოლოო ჯამში, პიროვნების შენარჩუნებაა სიზმრების დროსაც კი. წინამდებარე ნაშრომის მიზანია სიზმრებში მეხსიერების აქტივაციის როლის გარკვევის მცდელობა სიზმრების, ძილისა და მეხსიერების კვლევების მონაცემების საფუძველზე.

**აბრევიატურები:** ქსელის ნაგულისხმევი რეჟიმი- DMN; ყურადღების დორსალური ქსელი - DAN; აღსრულების მაკონტროლებელი ქსელი - ECN; ძილის ნელ-ტალღოვანი ფაზა - NREM; ძილი თვალის სწრაფი მოძრაობებით - REM sleep.

in proper communication with the environment which has positive or negative impact in dreams. (Almaraz-Espinoza and Grider, 2020)

**The Role of the Hippocampus**

The hippocampus is a convex elevation of gray matter tissue within the parahippocampal gyrus in the inferior temporal horn of the lateral ventricle. (Fogwe, Reddy and Mesfin, 2020) The damage to the hippocampus can cause negative effect on the memory (Miller, et al., 2017) but Solms research claims that the hippocampal damage has no impact on dreams (2013). This variance in analysis can be based on the samples of sleep stage and patients with psychiatric cases. It is still not clear whether the hippocampus plays a role in dreaming. (Spano, et al., 2020) Analyzing the forms of memory and its role in dreams, the long term memory develops from the short term memory with the help of certain neural activities but mainly in the hippocampus and then the cortex.

Spano et al., conducted a study on four patients with selective bilateral hippocampal lesions and a specific episodic memory deficit but they found that the dream frequency reduced compared to the control participants together with the few dreams they had, were less episodic-like in nature and lacked content (2020). This implies that for the effect of memory in dreams to occur, the hippocampus needs to be intact. This complex process is considered in the aspect of lesion indicating low dream frequency shows that the patient might just sleep and awake without having any dream.

**The Memory of Dream in REM sleep**

Many researchers have contributed to the fact that there are some neurotransmitters and neurohormones that plays major role in dreams which occurs at different phase of sleep. The neural activity in the brain stem, thalamus, amygdala, and extrastriate temporo-occipital cortices increases, while other structures such as the dorsolateral prefrontal cortex and the precuneus are inactive (Dresler, et al., 2012). Sleep comprises of rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep but dream is most common in the REM sleep. The electroencephalogram (EEG) is used to record the brain electrical activity commonly used among the scientist. It has both alpha (7.5 to 12.5 Hz) and beta (12.5 to 30 Hz) wave range which can be differentiated by the state of the brain in REM sleep.
(Jawabri and Raja, 2020)

Siclari et al., recorded that high-frequency frontal EEG activity between 20–50 Hz is higher in dreams that involve thinking dreams (2017). The Frontal lobe functions include planning, decision making, the collection of information from various sources, processing thoughts into words, voluntary movement, categorizing and making sense, forming memories, manage attention, impulse control, personality and empathy (Holzinger, and Mayer, 2020). Thinking dream is often common in REM sleep than perceived dream which occurs in NREM sleep. When the dreamer is thinking about the upcoming wedding event and sleeps, the frontal lobe which has various functions, can play a role such as during the conversation with friends and spouse in the dream. The serotonin, norepinephrine and acetylcholine are involved in switching the brain sleep to the next phase according to Payne, and Nadel (2004). Hobson et al., stated that REM sleep occurs when aminergic system reduces to allow the reticular system avoid the inhibitory effect (1975) but the serotonin and norepinephrine are absent during REM sleep (Payne and Nadel, 2004).

**The Neural Processes of memory in Lucid Dream**

The lucid dream is when the dreamer is aware of the dream while dreaming and can be able to control the dream as well (Spoormaker and van den Bout, 2006). Tholey and Utecht explained some characteristics of lucid dream like awareness of freedom of decision, memory of the waking state, and full intellectual abilities (1987). Most times, the dreamer is conscious and can change the negative dream. This is as a result of the roles most part of the brain plays. Some dreamers make decision in the dream like when confronted by the opponent. The opponent who must have done some things wrong in reality which can trigger the dreamer to fight back when confronted in the dream. The information collected can be stored but when the dreamer awakes, decisions can be carried out involving the essential parts of the brain such as the prefrontal cortex solely responsible for decision making.

In the study of consciousness, in regards to lucid dream three brain networks have been proposed which are the Default Mode Network (DMN) (Raichle et al., 2001) and the Dorsal Attention Network (DAN) (Corbetta et al., 2000). The DMN involves the precuneus, the medial prefrontal cortex, and the left and right inferior parietal cortices (Raichle et al., 2001) while the DAN comprises of the intraparietal sulci and frontal eye fields. The lucid dream occurs when the DMN and the executive functions are active at the same time. The executive control network (ECN) which is the third proposed, includes the dorsolateral prefron-

tal cortex, the intra-parietal sulcus, the salience network (anterior insula and orbitofrontal cortex), and the cingulo-opercular network including anterior cingulate and frontal operculum (Dosenbach et al., 2006; Holzinger, and Mayer, 2020).
Siclari et al., reported high frequency of activity in the right posterior parietal cortex stating that this region is active during spatial perception and visuospatial attention, based on spatial setting in dreams (2017) while dreamers sense of movement relates with increase in high frequency activity in the area of the right superior temporal sulcus (Siclari, et al., 2017). When the dreamer wakes up, there could be a chance of remembering how the environment looks like. In this case, proper description can be given for better understanding towards the dream and when the arena looks unfavorable, it can trigger awakening. The lucid dream can occur based on the reflection on the state of mind which can result to strong concentration (Holzinger, and Mayer, 2020). This is when the individual falls asleep due to lost in thought because of poor performance in the examination or death of loved one. The lucid dream is accompanied by neuronal hormones such as the norepinephrine, acetylcholine, dopamine, and serotonine (Yuschak, 2006). Acetylcholine helps cognitive function and learning ability and can also enhance lucid dream by allowing direct movement from the waking state into a vivid dream state without losing consciousness (Yuschak, 2006). Dopamine with norepinephrine boosts focus, increases the ability to connect and integrate information, and facilitates pattern recognition and problem solving. It might also enhance the ability to recall details and memories from waking life while within the dream (Yuschak, 2006).
Studies have suggested that the insula a brain structure between frontal, parietal and temporal cortex whose functions include control of conscious awareness, motor control, perception and self-awareness (Craig and Craig, 2009) can have a role in lucid dream (Holzinger, and Mayer, 2020). Dresler et al., found out that the dorsolateral prefrontal cortex and parietal lobules can be active during lucid dream (2012). This allows the dreamers to analyze the dream based on the memory and dream environment, decide and plan behaviors.

## Conclusion

Dreams cannot occur without stored information in the brain which has roles in different dreams that a dreamer might encounter. The ability to remember certain dreams lies on the fact that some of these neural activity participated in the dream during the process for instance in the REM sleep. The essence of memory is actually attributable in lucid dreams than in non lucid dream knowing that most of the dreams occur based on store information from experience. Some can be as a result of reflection on current state of mind before falling asleep which can reflect in the dream. This complex process helps in proper decision making and plans for the future on awakening.

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