Why Humans Dream: A Review of Sleep and Brain Biology, and Diseases in the Context of Dreams

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Abstract

While there is much research around sleep and its function, there is a seeming lack of research into the purpose of dreaming that if addressed could open a lot of research and clinical benefits. Specifically, dream research around certain diseases like PTSD and Parkinson's can increase understanding of dreams, and therapies pertaining to dreams. Here we review the biology of sleep in the context of dreams, review some popular dream theories, and dive into some deeper research around brain biology and disease research around dreams. By using the biology of sleep as a frame to understand dream theories we can evaluate the theories validity, and extend those theories into deeper concepts like small parts of the brain, and how disease affects dreams. The goal of the paper is to both assess dream theories for their validity and how certain diseases pertain to that, but also to encourage and prove how further research on dreaming could have widespread impacts in many fields.

Introduction

It is unknown exactly why humans dream, however dreams are a part of a normal healthy night of sleep. Exploring the biological role of dreams could illuminate both an unexplored metric of sleep health and novel insights into certain diseases. While there is not a predominant theory, a multitude of theories exist around the role of dreams, such as dreams as a byproduct of memory consolidation, threat simulation theory, activation synthesis, continual activation theory, dreams for strengthening semantic memory, and reverse learning theory. There is a clear connection between the biological role of sleep and the theories behind dreams, though it is not as often researched. Making that connection is important for finding out why we dream, which in turn could open the door for understanding many facets of general health and sleep quality giving insights into disorders like PTSD, where dreaming has been shown to aid in recovery (Cowdin et al.).

As dreams are a part of sleep, it is important to understand what is known about sleep and current theories about dreams. In this paper I will discuss the architecture and biology of sleep. We will also explain several dream theories, including threat simulation, reverse learning, and continual activation theories. Finally I will cover some more specific biology that pertains to dreams, like certain research around the role of the amygdala and hippocampus in dreams, and some disorders like Parkinson’s and PTSD. The goal of the paper is to add to the theories around dreams, and make useful connections to the biological role of dreams.

What is sleep

Dreams occur during sleep. As such, understanding the architecture and components of sleep is essential for understanding theories and biological roles of dreams. Topics to be discussed include the basic biology of sleep, such as the role of synapses, the stages of sleep, and areas of the brain involved in sleep. There are two sleep types: non-rapid eye movement (NREM) and rapid eye movement (REM). While dreams can happen in both, most occur during REM, so most studies about dreaming are focused on REM.

i. Brain Biology

While the impact of sleep on the brain is still debated, a consensus has been reached on the parts of the brain involved in sleep. There are three main sections of the brain: cerebrum, brainstem, and cerebellum ("Brain Anatomy"). The hypothalamus, which sits above the brainstem, is one of the most important sleep regulating centers and monitors many unconscious bodily functions. It contains neurons that regulate arousal, or wakefulness. Much like the hypothalamus, the brainstem is important for unconscious behaviors, including communicating with the hypothalamus to transition between sleep and wake and relaxing muscles during REM sleep, keeping us from acting out our dreams. The thalamus, which sits above the brainstem in the middle of the brain, has a key role in memory formation during sleep. The thalamus relays information from the senses to the cerebral cortex, in the cerebrum, helping convert information to memory. The thalamus is less active in NREM sleep, but becomes more active in REM sleep, influencing dreams by transmitting images and sensations to the cortex. The amygdala and hippocampus are vital for sleep and dreams ("Brain Basics"). The amygdala is an almond shaped collection of nuclei found in the temporal lobe. The amygdala plays important roles in emotion and behavior. When we are exposed to fearful stimulus, the information is first sent to the amygdala, which then can then send signals to other parts of the brain. In addition to initiating a fear response, the amygdala is important in forming fear and anxiety associated memories. For example, when a tone is played near mice then the mouse is shocked, the mice with an intact amygdala will display a fear reaction when the tone is played; however mice with a impaired amygdala will not. The amygdala is not just concerned with fear; it also is involved in the formation of positive memories so a popular definition is that the amygdala is involved with evaluating environmental stimuli, determining their importance, and generating responses to the stimuli ("Know Your Brain: Amygdala")("Know Your Brain: Limbic System"). The hippocampus, which is also found in the temporal lobe plays a critical role in memory consolidation, including spatial navigation memory and orientation ("Know Your Brain: Hippocampus"). In sleep, hippocampal sleep spindles support memory consolidation (Ferrara et al.). This function is important to dreams, as many theories place memory as important for the generation and function of dreams.

Synapses are an essential target for the restorative properties of sleep. A synapse is the region where two neurons connect and communicate through chemical or electrical signals. The space between the two neurons is called the synaptic cleft. The presynaptic neuron is the signaling neuron that releases neurotransmitters into the synaptic cleft. The postsynaptic neuron is the neuron that receives the signal, based on the signals received, a postsynaptic neuron may release an action potential, or a rapid event that causes a neuron to signal to other neurons. The type of neurotransmitter, excitatory or inhibitory, can influence the odds of an action potential. Excitatory neurotransmitters, for instance glutamate, promote the generation of an action potential, while inhibitory transmitters, like GABA, prevent it ("What Are Neurotransmitters?"). Recent studies demonstrated that sleep directly impacts synaptic strength (Cline). One leading theory summarizing this effect, is the synaptic homeostasis hypothesis (SHY). SHY states that when awake synapses strengthen, but while asleep most synapses weaken with select ones strengthening impacting memory consolidation (Tononi and Cirelli). As many theories propose that dreams strengthen memory formation, synapses may play a role in the creation, presence, or function of dreams. Furthermore specific theories, such as the reverse learning theory, directly discuss the connection between synapses and dreams.

ii. NREM Sleep

Of the two types of sleep, NREM sleep is about 75 to 80 percent of sleep in adults with its three stages, N1, N2, and N3 (Colten). N1 is the lightest stage of sleep and lasts about 7 minutes. During N1, heart rate and breathing slow down, and the brain produces alpha and theta waves. N2 lasts around 25 minutes. In N2 one is much less likely to be awakened, and heart rate and breathing continue to slow, as the body temperature drops. During this stage the brain activity is synchronous and consists of bursts of activity called sleep spindles and k-complexes which are important for memory consolidation, and learning. The last NREM stage is N3, or slow wave sleep. This stage lasts about 40 minutes and is essential for key restorative bodily processes including repairing muscle and tissue, encouraging growth and development, and improving immune function. This stage has no muscle movement, and the brain produces slow delta waves (Pacheco)(Suni)("What are the Sleep Stages").

iii. REM Sleep

REM is where the bulk of dreaming happens, although some dreaming does occur in NREM. In REM the brain becomes nearly as active as awake, and the brain activity is asynchronous with theta and alpha waves being frequent and connected to dreaming and successful dream recall. During REM the body has fast and irregular breathing, increased heart rate, blood pressure, and the muscles become paralyzed to prevent acting out dreams. REM is important for concentration and mood regulation, and even helps humans be more emotionally sensitive (Suni)("What are the Sleep Stages").

An important concept to note is the connection between REM, NREM, and dreaming. While a majority of dream research surrounds REM, dreaming also happens during NREM which, if researched, could open up a new perspective into dream research as the two types of sleep are very different in their brain and bodily activity. Similarly, understanding different aspects of sleep is important to make useful connections about dreams and the human brain. Some of those facets are the biology of different parts of the brain and what they do, the synapses that make up the brain, and all of the stages of sleep. With these three we can make connections between memory, emotion, and other brain functions that could be important to dreams.

Dream Theories

It is unknown why humans dream; however there are a multitude of popular theories that try to explain why we dream. The three theories I'm touching on are the threat simulation, reverse learning, and continual activation theories. The threat simulation theory was first introduced in Antti Revonsuo in 2000, the reverse learning was introduced by Francis Crick and Graeme Mitchison in 1983, and the continual activation theory was introduced in Jie Zhang in 2004. All three are fairly prominent theories, but more importantly they each highlight different aspects of sleep, such as memory consolidation and negative emotion. It is important to note that these theories are older and have been expanded on multiple times over the years.

i. Threat Simulation Theory:

The threat simulation theory deals mostly with fear and how humans evolved (Revonsuo). The theory is based on six propositions:

1. Dream consciousness is an organized and selective simulation of the perceptual world.
2. Dream consciousness is specialized in the simulation of threatening events.
3. Nothing but exposure to real threatening events fully activates the threat-simulation system.

4. The threat simulations produced by the fully activated system are perceptually and behaviorally realistic rehearsals of threatening events.
5. The realistic rehearsal of these skills can lead to enhanced performance regardless of whether or not the training episodes are explicitly remembered.
6. The ancestral environment in which the human brain evolved included frequent dangerous events that constituted extreme threats to human reproductive success. They thus presented serious selection pressures to ancestral human populations and fully activated the threat-simulation mechanisms.

The first proposition means that dreams are far too organized and lifelike to be accidental. Adding to this, there is a notable disconnect between daily activities and dream content, with activities like reading and writing not appearing in dreams. Together the first proposition suggests that dreams are a simulation of the real world.

Building on this, the second proposition states dreams are a simulation of specifically threatening events.The first part of this proposition deals with dream content representing threatening elements. Supporting this, most emotions in REM dream reports are negative, with fear, anger, and stress being the most frequent (Hall and Van de Castle)(Strauch and Meier). He states that negative emotional dreams increase fitness in dangerous scenarios, which leads to increased reproductive success. The second part of this proposition suggests that dream content is more aligned with our ancestral environment than our present one. Studies indicate that in dreams the most common aggressors are unknown males and animals, even though such encounters are rarely aggressive in today's world (Hall and Van de Castle). This supports the idea that our dreams are reflecting our evolutionary environment.

The third proposition states that only realistic threatening events can activate the threat simulation system and is mainly supported by studies on REM sleep. Such as, patients with PTSD and anxiety spend more time in REM than control patients and had increased brain activity during REM. Another study shows that children exposed to trauma had better dream recall than non-trauma exposed children, suggesting dreams create stressful or dangerous simulations of real life events of which the patients of these studies have more of, which activates the threat simulation system.

Proposition four works off of the third one, saying that, to be useful, dreams need to be realistic threat simulations. A supporting study showed that dreams contain vivid, real images and that dreamers lack awareness of their dreaming state which ensures an authentic experience, and enhances the motivation to defend themselves (Boeve et al.). Supporting this, mental imagery of motor actions uses the same neural mechanisms as actual motor action, making dreamed actions realistic, adding to the authenticity of the threat simulations.

Proposition five states the threat avoidance skills performed during dreams enhances real life responses. Because motor imagery and mental training can improve muscular strength, learning motor skills, and sports, then dreams can have similar effects, thus enhancing threat-avoidance skills (Yue and Cole)(Hall et al.)(Lejeune et al.). Supporting this, amnesic patients can learn motor skills and implicit emotional memory, demonstrating that we can learn implicitly, or without consciously remembering the dreams, and still gain threat-avoidance skills.

Proposition six states that our dangerous ancestral environment supported the threat simulation of dreams, through practically natural selection. Our ancestors had an intense pressure to reproduce, as 25% of people died before entering a reproductive age and 70% of those people died before reproducing (Meindl). Being able to recognize and perceive threats would aid in avoiding and coping with danger, all skills gained while dreaming.

The threat simulation theory posits that dreams were evolved as a way to prepare us for threatening situations, ultimately improving our chances of reproductive success. It says that dreams are intentionally realistic and draw from our most negative long-term memories to help implicitly learn skills. More recent reviews continue to support and expand on this theory, such as the review paper published in 2009 Katja Valli and the original author Antti Revonsuo. In the review they found that the original evidence still stood, and the theory was valid. The major strength of the theory is that it accounts for prevalence of threats in dreams. They do note that its largest weakness is that there is no direct evidence for the effects of the threat rehearsal of dreams; however they do note that could be addressed through video game or virtual reality simulations (Valli and Revonsuo).

ii. Reverse Learning Theory

The reverse learning theory says that the purpose of REM sleep is to remove unneeded information and memories, which in excess can lead to the brain not functioning properly, as they call it, ‘parasitic modes of behavior’ (Crick and Mitchison). The theory is based on the idea that our brain is a network of interconnected cells that support many different types of activity, and that its nature leads to it having parasitic modes, or unneeded memories. During REM sleep, these modes are detected and suppressed. Memory in the brain is stored by groups of synapses with different strengths that retain associations, or what we would call memories. The theory posits a few characteristics of memory. First, memory is distributed over many synapses and information will not be lost if a few synapses are removed. Furthermore, one synapse stores several pieces of information. The theory states that humans accumulate vast amounts of information, including many parasitic modes, which cause a drain on the brain. To maintain functionality, the brain employs a mechanism that sends a signal through the brain that removes the parasitic modes. The proposed mechanism excites parts of the brain and more easily excites parasitic modes than important memories, which require specific signals. The mechanism dampens the modes that are excited, removing the unneeded memories. The theory places dreams as a byproduct of this mechanism. During REM sleep the brain is removed from external inputs, but remains highly active from the random signals that excite memories, which are reflected into dreams. To end, the reverse learning theory states that dreams are a byproduct of the brain removing unneeded memories during REM sleep.

While written in 1983, the theory continues to be supported by some researchers (Langille). A paper written in 2019 by Jesse Langille supports and slightly modifies Crick’s theory. Langille notes and supports the idea that sleep has a role in memory consolidation, but also in “adaptive forgetting,” supporting Crick. Langille modifies the argument, pointing that there may be a cellular mechanism for sleep forgetting as well. Langille goes on to say that the established sleep stage rhythms consolidate new memories in the cortex and hippocampus, and that the same rhythms simultaneously help the forgetting of older memories in those brain regions. Not only does Langille agree in that regard, Langille also refines the idea of random signals that Crick proposed. Langille proposes that the brain uses its oscillations, specifically sharp waves, to stabilize any adaptive information, and to isolate and remove non-adaptive data.

iii. Continual Activation Theory

The continual activation theory was proposed in 2004 by Jie Zhang. Zhang says that dreams are experienced when the conscious brain hits a certain level of in-activity and, through a certain mechanism, becomes active and retrieves memories. (Zhang)One distinction to understand in the theory is between declarative and procedural memory. Declarative is conscious memory and procedural is non-conscious. The theory also separates brain function into three parts: awake, NREM, and REM.

As shown in figure 1, when awake the sensory memory system is constantly receiving information from the senses. The brain needs to store this information and make sense of the surrounding environment. When sensory information is received, it is temporarily stored in the sensory memory. That information is then passed to the “ conscious working memory,” or the conscious memory used daily. The conscious working memory retrieves relevant data from either the declarative temporary or long-term memory associated with the stimuli.

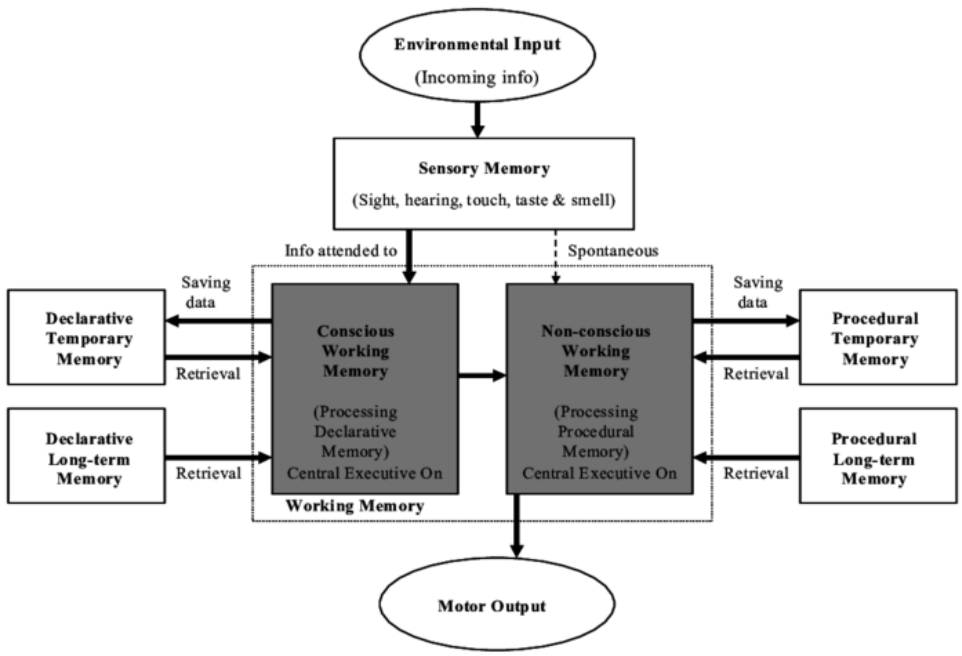

Fig 1: Memory model for the waking brain from Zhang

The processed information is sent to the declarative temporary memory for rapid memory saving. At the same time, the non-conscious working memory retrieves corresponding procedural memory from either the procedural temporary or long-term memories. The ensuing memories are also rapidly stored, similar to how declarative memory works while awake. Notably, procedural temporary memory retrievals influence motor output.

While awake, both the declarative and procedural long-term memories are in retrieval mode only, while the temporary memories are constantly saving and retrieving memories. This means that during waking time, both the conscious and non-conscious systems of working memory are continually activated.

During NREM, the brain is mostly engaged with the conscious working memory. The brain goes through the declarative temporary memory and compares it with the declarative long-term, and removes any unwanted, overlapping, or duplicated data. The new or updated data is transferred to the declarative long-term memory. Differing from wake, both declarative and procedural temporary memories are in retrieval-only mode as there is nearly no sensory memory to be added. If awakened during NREM, a thought-like brain activity happens, which is defined as a type I dream. Because the procedural memory is not getting engaged with by the brain, the continual-activation mechanism is triggered, and random data is retrieved from the procedural memory stores. This data flows through the non-conscious working memory to maintain brain activity. Because our muscles are locked during NREM this data is not acted out, however sometimes the data is too strong or the muscles are not fully locked, so things like sleep walking, sleep talking, and periodic limb movement disorders can happen.

During REM, the brain is mainly engaged with the non-conscious working memory. Similar to the declarative in NREM, the brain files the procedural memory for long-term storage, the process causing the rapid eye movement of REM. While the brain is mainly engaged with the procedural memory, the continual-activation mechanism randomly retrieves declarative memories. The easiest data, like residue from the day, will go first as it is more salient. This data causes thoughts similar to the type I dream. Soon, as the declarative memories flow through the conscious working memory, the brain engages and attempts to make sense of the data. With the associative thinking system and emotion system of the brain engaged, vivid dreaming (type II dream) starts. Then the level of brain activation from the conscious working memory is increased. Based on the dreamer's thinking, the brain retrieves memories to turn into pictures and realistic events. While the random data retrieved from the continual activation mechanism is still interpreted by the brain, the type II dream is mainly influenced by the dreamer's thinking.

To conclude the continual activation theory, the working memory has two systems: the conscious and non-conscious systems. Both have to be continually activated, and when the flow of data drops below a threshold, the continual activation mechanism randomly retrieves memories. Dreaming as an experience, is the result of the conscious system of the brain getting involved in the continual activation data stream.

Biological Factors Affecting Dreaming and its Theories

While there is much to understand with the basic biology and some of the theories around dreams, even knowing one theory and some of the basics can help to make important connections. This section's purpose is to look into specific factors that may affect dreams and its theories. The first thing to cover merges brain biology with fear and dreams. Then the last connection to cover is how certain disabilities affect dreams. Because dreams cannot be studied in lab animals like mice, research on dreams can be hard to conduct. To counteract this researchers use people with disabilities that highlight certain parts of the body as important for dreams.

i. Brain Biology

One illuminating connection is how the amygdala and hippocampus affect dreams. While it is fairly agreed upon that the hippocampus is important for memory consolidation, a paper about both the hippocampus and amygdala adds support to the idea and connects both to dreams (De Gennaro et al.). This paper shows a solid correlation between hippocampal volume and density and vividness and bizarreness of dreams. Because dreams and REM specifically are established to affect memory consolidation, the fact that the hippocampus affects dreams and is highly active in REM means that it too is important to memory consolidation. This paper also lends support to the idea that the hippocampus is important to spatial navigation and orientation because the bizarreness seen in patients with a smaller hippocampus could be because their hippocampus is less effective in making dreams make spatial sense. The paper connects the amygdala even more concretely than the hippocampus. The research shows that the amygdala is connected to the emotional load of dreams and patients word count in describing them. While this may mean a lot of different things, it places the amygdala as important to dreams and shows that it functions the same awake and asleep. The amygdala's volume also negatively correlated with bizarreness, meaning the higher the volume of amygdala the less bizarre the patients' dreams were. This could be because the amygdala deals with the processing of fear response and is one the first parts of the brain to receive stimuli and chooses whether a response is necessary and therefore the larger the amygdala the more the dreams emotions would be dealt with sensibly rather than bizarrely.

Another paper connects the amygdala to dreams (Blake et al.). The paper looks at patients with Urbach-Wiethe Disease(UWD) which affects the basolateral amygdala. The dreams of these patients were shorter, less complex, and more pleasant than the control patients. This study is similar to the first however it does add complexity. It agrees with shorter dream recalls, however it says that the amygdala is more important to negative emotions in dreams than positive ones. The dreams of the patients with UWD still had emotions, however they were more positive. This insight could be useful as the amygdala is important for both positive and negative emotions and responses in wake. The studies solidly place the hippocampus and the amygdala as important for dreaming. The papers also show that the amygdala is connected to the emotional content of dreams, and more specifically the basolateral amygdala is important for negative content of dreams.

ii. Dreams and Disease, Disorders

Dreams are a hard thing to study in humans as specific parts of a human cannot be tested like with lab mice. Because of this, many studies around dreams and REM sleep use patients that have disorders like PTSD, Parkinson’s, Urbach-Wiethe Disease, and others. Because many of these diseases target specific parts of the brain, scientists are able to look at the effects of losing some function in certain parts of the brain. These studies around diseases can tell us many important things like what the dopaminergic system does to dreams, and how emotions and the amygdala affect dreams.

One disease that can be used for study is Parkinson’s Disease. While it affects many parts of the body and brain, like the limbic system, cholinergic system, and the cortex it can be very useful to study in the context of dreams because of its effect on the dopaminergic system (Valli et al.). One study says that a hypodopaminergic state, which is a state of reduced dopamine activity in the brain and is identified by higher doses of dopamine agonists, may be associated with impoverished dream reports, in the sense that they lack bizarreness and emotional load (De Gennaro et al.). This connection is a strong support for the importance of the dopaminergic system in dream experience and generation.

Another disorder that presents a novel way to look at dreams is Post Traumatic Stress Disorder(PTSD) because of its connection to sleep through its connection to memory, and because of the nightmares that are a symptom of PTSD. One study found that the theta frequencies produced in REM are reduced in patients with PTSD (Sopp et al.). The researchers continued by saying that REM theta activity could have a role in emotional memory processing. This was backed up by their findings that REM theta activity is correlated to reduced re-experiencing of trauma. Another study agrees, finding that ‘resilient’ patients have increased REM theta activity, and that that activity shows the capability of adaptive emotional memory processing (Cowdin et al.). The study goes on to say that because patients with PTSD have altered activity in the amygdala and thalamus in both wake and sleep, that reduced REM theta activity could mean a weaker communication between the structures. The study also supports the idea that REM sleep functions to integrate and eventually remove traumatic memories.

While some diseases and disorders have fairly large populations and thus are generally more useful to study, there are many other diseases that are less widespread and can be illuminating to the study of dreams. One example is Urbach-Wiethe Disease(UWD). One of UWD's symptoms can be a calcification of the basolateral amygdala. Because of the clear focus on the basolateral amygdala on dreaming, the study found first that the basolateral amygdala is not indispensable for dreaming (Blake et al.). The study also found that the patients with UWD had shorter, more pleasant, and less complex dreams than the control patients. Another infrequent disorder is Charcot-Wilbrand syndrome(CWS) which is dream loss following brain damage. The study focuses on one case in 1997, where a 73 year old woman had a bi-lateral deep occipital stroke (Bischof and Bassetti). The woman had a wildly vivid dream that resembled a hallucination the second night after her stroke. The study postulates that the damaged visual processing areas are responsible for the vivid dream, however that damage is also responsible for the total dream loss found later. This observation supports a link between dreaming and hallucinations, at least in certain clinical situations. The study's final takeaway is that there must be a dissociation between REM sleep and dreaming. The patient continued to sleep with normal REM traits however no recall of dreams ever when awakened during REM. The studies proposed that while REM and dreaming may be linked, they could be generated independently. These two studies show us how researching uncommon diseases and how they affect dreams illuminates new facets of dreams.

Discussion

Proper sleep is known to be essential for health, but what still remains a mystery is the role of dreams. Sleep is known to involve many brain regions, such as the hypothalamus or cortex, and profoundly affect synapse dynamics. We discussed the potential of dreams to play a role in these functions of sleep and theories behind dreams, such as the threat simulation theory, the reverse learning theory, and the continual activation theory. The theories all lend insights into dreams and may suggest what biology is at play.

The hippocampus and amygdala are important brain regions for dreaming. De Gennaro et al. and Blake et al. show that the amygdala is important for, if not drives, the emotional intensity of dreams, and more specifically the basolateral amygdala which is important for negative content of dreams. These findings indirectly support the threat simulation theory, as the amygdala deals with threat response in wake, and is important to dreaming; connecting dreams to threat response. Future studies could examine if experiencing threats improves performance in a given task, possibly using virtual reality technology to test the threat simulation theory.

The papers also lend support to the idea that the hippocampus is essential for cognition such as spatial navigation and orientation memory. A smaller hippocampus increases the bizarreness, or non-realistic people, events, or objects, of patients' dreams. This could mean that their hippocampus is less effective in having their dreams make spatial sense. The import of the hippocampus could also support the continual activation theory as the hippocampus is crucial for memory and the continual activation theory says that dreams are a byproduct of our memory systems.

The Parkinson's disease studies indicated the importance of the dopaminergic system, suggesting dreams are not a byproduct of certain aspects of sleep like some theories claim. The dopaminergic system is important for our bodies reward system and the motivation for actions (Bromberg-Martin et al.). Connecting the dopaminergic system to dreams could mean dreams are an active choice by the body instead of a byproduct of a mechanism like the continual activation mechanism. This would lend support to threat simulation, and reverse learning, however it is in contention with the continual activation theory. Because Parkinson's is such a widespread disease, there is a lot of research about its effects and causes, but not on its relation to dreams. In the future it would be valuable to see more targeted dream research with Parkinson's as its concrete connection to the dopaminergic system and dreaming.

PTSD allows useful connections to dreams because of its connections to memory and certain parts of the brain. Challenging the belief that sleep deprivation is useful in the aftermath of traumatic events, Sopp et al. shows that sleep reduces overall symptoms and specifically re-experiences of trauma. Cowdin et al. also shows that REM sleep reduces amygdala reactivity to previously encountered emotional stimuli. These findings are an example of why specific research around certain disorders can be so potent. Using dreams and sleep as a basis for research these studies showed that while nightmares and other potent dreams face a challenge to patients with PTSD, ultimately the cure is sleep, and not sleep deprivation which worsens the problem.

The research on less widespread disorders lead to even more potent connections. The research on UWD shows that the basolateral amygdala is not indispensable for dreaming. It also shows that the basolateral amygdala is important for the negative emotions in dreams, which would make sense as it functions with anxiety and defensive behaviors in wake (Blake et al.)(Beyeler and Dabrowska). Based on the paper's findings one could argue that because the loss of the basolateral amygdala, the part of the brain that deals with anxiety and defense in wake, has such a big impact on dreaming, then dreaming has a large function for simulating threats and dealing with anxiety. However, one could also challenge that by the idea that the basolateral amygdala is not necessary for dreams, and emotional content is still present in the UWD patient's dreams. Either way the paper shows the importance of studying disorders as the information on the basolateral amygdala offers insights for a wide range of problems. Similarly Bischof and Bassetti could highlight the importance of dream research. The idea that REM sleep and dreaming are linked is an insight that can be linked to the dream theories. It challenges the continual activation and reverse learning theories as they place dreams as a byproduct of a mechanism of REM sleep, however it would support the threat simulation theory as it proposes a specific mechanism and purpose for dreams.

To end, the connections made between diseases, biology, and sleep can lend helpful insights into dreams. Not only that but dream research, especially in the context of diseases, can illuminate how to help people with those diseases. As targeted dream research helps provide novel ways to look at disease and sleep health, it is an important area that, if researched more, would help different areas of study greatly.

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