Current Perspective on Sleep and Emotion Regulation

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Abstract. This article explores the correlation between emotions and sleep. Sleep plays an essential role in regulating our emotions and cognitive processes. Extensive research demonstrates the intricate connection between sleep and emotional well-being. During sleep, the brain engages in vital activities that influence emotional memory consolidation, regulation, and cognitive functioning. Insufficient sleep or sleep deprivation has detrimental impacts on various brain functions related to emotions. These include impairments in working memory and attention, disruptions in dopamine function, and altered processing of aversive stimuli. Sleep deprivation can also influence different components of the emotion regulation process model. Furthermore, sleep abnormalities have been linked to several mental disorders, including post-traumatic stress disorder (PTSD) and major depression. Understanding the intricate relationship between sleep and emotions can provide valuable insights into developing effective interventions for individuals with sleep disorders or mental health conditions. Promoting healthy sleep habits and addressing sleep disturbances can improve emotional regulation and overall well-being. Additionally, exploring the reciprocal relationship between sleep and emotional processes can contribute to advancements in therapeutic interventions for mental health disorders, ultimately improving the quality of life for affected individuals.

Keywords: Emotion regulation; Sleep deprivation; Mental health.

1. Introduction

Sleep is a vital physiological process that is essential for physical and mental health. In addition to restoring and repairing body functions, sleep is also essential in maintaining emotional regulation and psychological equilibrium. Decades of research have revealed a close connection between sleep and emotions. However, the specific mechanisms underlying this relationship and its impact are still being explored.

Many studies have shown a close association between poor sleep quality and psychological conditions like depression and anxiety. Negative emotional experiences like mood swings, irritability, and mental fatigue can arise as a result of sleep deprivation and insomnia. On the other hand, good sleep quality contributes to emotional stability, increased positive emotions, and enhanced ability to cope with stress.

This article delves into the interaction between sleep and emotions by reviewing relevant literature and research findings. It will focus on the impacts of sleep on emotional regulation at the level of brain function and discuss it from the perspective of the emotion regulation process model. Based on this foundation, researchers examine the connection between sleep and emotional disorders, specifically investigating sleep abnormalities in individuals with PTSD and major depression. Furthermore, the article discusses the practical directions and areas for improvement in research and implementation of sleep and emotion studies. The objective of this article is to deepen comprehension of the correlation between sleep and emotions while offering practical advice and guidance on how to optimize sleep patterns for enhancing emotional well-being. Further research on the impact of sleep on emotions will contribute to the development of more effective intervention measures and provide new avenues for the prevention and treatment of emotional disorders.

2. Overview of Sleep and Emotions

2.1. Neurobiology of Sleep and Emotions

Sleep has important effects on the neurobiology of the brain. During the sleep process, the brain undergoes a series of complex neural activities and changes. Sleep is believed to be an important stage for information integration and memory consolidation in the brain. During deep sleep, the brain undergoes synaptic remodeling and clearance to remove unnecessary synaptic connections and waste protein deposits (this process is believed to help consolidate learned memories and optimize brain function). Sleep is also closely related to the regulation of neurotransmitters in the brain, such as dopamine and acetylcholine, which play important roles during the sleep process. The levels of these neurotransmitters change with sleep stages, thereby regulating neural circuits and activities in the brain. Considering that the brain structures and chemicals that control sleep are often involved in emotional regulation [1], and almost all emotional disorders occur concomitantly with sleep disturbances, the connection between sleep and emotions is extremely close.

The human sleep process is primarily composed of two types of sleep: Non-Rapid Eye Movement (NREM) sleep and Rapid Eye Movement (REM) sleep. NREM sleep, also known as deep sleep, is believed to play a central role in the theory of emotional memory. Emotional memory refers to memories formed or recalled in specific emotional states. Studies have shown that the creation and strengthening of emotional memories are strongly linked to sleep, specifically REM sleep. During the stage of REM sleep, the pattern of brain activity resembles that of the waking state and is accompanied by rapid eye movements and vivid dreams that often involve strong emotions [2]. This stage is believed to be closely related to emotional regulation and memory consolidation. Studies have shown that REM sleep promotes the formation and processing of emotional memories, particularly for memories related to positive emotions and emotional events. REM sleep serves multiple functions: after an emotional event, REM sleep helps in reprocessing previous emotional experiences; before an emotional event, REM sleep helps restore the brain to an optimal state for emotional responses [1]. To summarize, REM sleep is essential in the creation, strengthening, and recall of emotional memories, while also promoting emotional regulation and cognitive functioning.

Furthermore, an alternative model suggests a different association between REM sleep and emotional memory. Researchers have proposed a reciprocal relationship between emotional memory consolidation and emotional response maintenance, suggesting that as negative memories consolidate, emotional reactions weaken; whereas experimental evidence shows that sleep may independently affect both memory and emotions; REM sleep can trigger emotional reactions, thereby enhancing the salience of emotional events [3]. There is evidence that supports various connections between REM sleep and emotional memory, highlighting the need for further research to elucidate the underlying mechanisms and processes involved.

2.2. The Fundamental Model of Emotion Generation and Regulation

Emotion generation and emotion regulation are inherently different processes: when individuals encounter emotion-triggering stimuli, they pay attention to and evaluate these stimuli, and then respond to them with emotional reactions. This constitutes a complete process of emotion generation, which can be summarized with the following timeline: stimulus-attention-trigger-response. The process model of emotions suggests that emotional stimuli influence our emotions by shaping our behaviors, and determining when and how people experience them. This model emphasizes five key processes that emotions can go through situation selection, situation modification, attention deployment, cognitive change, and response modulation. These processes take place throughout the timeline of emotional responses and have a vital role in regulating and molding our emotions [4]. Emotional regulation can be deliberate, such as diverting attention to alleviate anxiety in highly stressful situations, or unconscious, such as subconsciously avoiding distressing situations. In addition to directly affecting brain functional domains to influence emotions, sleep can indirectly impact emotions by influencing the events that trigger emotional changes in these emotion regulation

processes. These impacts can be significant but are often not explicitly addressed or overlooked in studies.

3. Impact of Sleep Deprivation on Emotions

3.1. Impact of Sleep Deprivation on Brain Functions Related to Emotions

3.1.1 Working Memory and Attention

Working memory pertains to the capacity to temporarily store and manipulate information in short-term memory, including control of attention, information processing, and manipulation. Working memory plays a pivotal role in cognitive processes like decision-making, problem-solving, and learning, and it has a strong connection to emotions. On one hand, emotions can influence the capacity and quality of working memory: positive emotions can enhance the capacity of working memory and maintain the accuracy of the information, aiding in better memory and retrieval; in contrast, negative emotions may affect the capacity and quality of working memory, leading to attentional distractions, difficulties in memory, and decision-making errors. On the other hand, working memory can regulate and adjust emotional experiences and expressions. Working memory helps individuals process emotion-related information and regulate emotional responses and expressions. It can assist individuals in better controlling their emotions in emotionally arousing situations, and adapting to different social and emotional regulation demands.

Sleep deprivation can have a pronounced negative impact on working memory. Apart from the effects of sleep deprivation on neural transmission and synaptic plasticity in the brain, studies have demonstrated that the deterioration in working memory quality is linked to decreased activity in the dorsolateral prefrontal cortex (DLPFC) and posterior parietal cortex, as well as alterations in thalamic activity.

In addition to directly impacting working memory, sleep deprivation can also affect attention, indirectly reducing the quality of working memory. Attention helps sustain goal-directed behavior, and increased sleep pressure and prolonged wakefulness can lead to highly variable and unstable attention, which can further affect the formation of working memory. Similar to the mechanisms of working memory impairment, the decrease in attention is associated with reduced activity in the DLPFC, and some studies suggest that attention can be maintained in cases of sleep deprivation if thalamic activity increases significantly; otherwise, attention is prone to lapses. This suggests that the thalamus is a critical gating center.

3.1.2 Dopamine Function

The neurotransmitter dopamine plays a pivotal role in regulating emotions. It is considered part of the reward system and is involved in the experience of pleasure and satisfaction when people undergo pleasurable events or achieve goals, promoting our pursuit of positive experiences and behaviors. At the same time, dopamine participates in neural circuits involved in emotional regulation, stabilizing our emotions. Adequate dopamine levels can help us pursue goals, explore new things, take on challenges, and cope with stress. Lower dopamine levels are often associated with emotional disorders such as depression and bipolar disorder. Consequently, a lack of dopamine not only makes it difficult to experience pleasure and excitement but also hinders the pursuit of positive experiences, leading to negative emotions and a vicious cycle.

Dopamine has a modulatory effect on sleep: elevated levels of dopamine are associated with decreased sleep propensity [5], and sleep pressure is related to different levels of dopamine receptors [6]. Sleep deprivation may lead to changes in dopamine receptor sensitivity and quantity, as well as directly impacting neurons, resulting in insufficient dopamine secretion, ultimately impairing the function of the reward system, making it more difficult for individuals to derive pleasure and satisfaction from everyday life, leading to low mood and depression.

3.1.3 Aversive Stimulus Processing

Aversive stimulus processing is a process of emotional regulation that involves coping with and processing stimuli or situations that evoke aversive feelings. Sleep deprivation can alter how individuals process negative emotions, including irritability, emotional fluctuations, anxiety, and aggression [7], as well as suicidal ideation, suicide attempts, and suicidal behavior.

The underlying reasons for these changes are that sleep deprivation affects basic emotional responses, emotional recognition, and emotional expression. Research indicates that after one night of sleep deprivation, the amygdala's reactivity increases by 60% when viewing negative images. Furthermore, researchers have found that this exaggerated amygdala response occurs even when subconsciously viewing negative images, indicating that this response is independent of conscious and deliberate emotional recognition. Sleep deprivation can also alter the brain's expectations of affective experiences and lead to a more general bias toward increased perception of negative threats (inaccurate) when judging the surrounding environment and interpreting others' emotions.

3.2. Sleep Deprivation's Impact on the Process Model of Emotion Regulation

3.2.1 Situation Selection

Situation selection involves choosing actions to regulate emotions when encountering emotion-inducing situations. Sleep deprivation may directly dampen the motivation to seek and engage in positive social activities. Individuals with low sleep quality often exhibit lower frequencies of social engagement and less regularity in social activities compared to those with good sleep quality [8]. Additionally, sleep deprivation at night can lead to daytime sleepiness and a decrease in social activity participation rates. Sleep deprivation can also alter individuals' situation decisions, where individuals are more likely to skip social activities due to fatigue. Studies have shown that sleep deprivation can directly affect social activities, possibly leading to an overall breakdown of social relationships, disrupted scheduling, and reduced physical activity, further exacerbating negative emotions.

3.2.2 Situation Modification

Situation modification refers to the active attempts made by individuals to modify or alter different elements of the current physical environment in situations that evoke emotions. Considering the influence of sleep deprivation on functional domains of the brain, it can weaken an individual's self-monitoring abilities and impair their ability to engage with others, recognize emotions, etc., thus further compromising decision-making and impulse control. In work settings, sleep deprivation can lead to reduced self-control (consistent with impaired reward mechanisms and difficulty with delayed gratification), and fatigue is often associated with decreased productivity. Moreover, it has been suggested that impaired conflict control and reduced attention to negative consequences may lead individuals to exhibit an inclination toward maladaptive behaviors (such as negative comments and insults). These implications can disrupt an individual's short-term and long-term professional aspirations in diverse ways.

3.2.3 Attention Deployment

In contrast to attention deployment in brain functions that assist memory, attention deployment within the framework of the process model of emotion regulation refers to an individual's shifting of attention towards or away from objects or situations associated with positive or negative emotions, including external shifts (e.g., shifting gaze) and internal shifts (e.g., changing thought content). It has been found that distraction weakens the neural activity of brain regions responsible for the processing of negative emotional content [9], while sleep deprivation may produce the opposite effects, hindering the ability and effectiveness of attentional distraction attempts. When faced with negative situations, individuals may be less likely to engage in behavioral attempts to shift attention. Furthermore, individuals experiencing sleep deprivation tend to focus more on negative and threatening information. Theoretically, this change may reflect individuals' adaptation to sleep deprivation, but it also influences emotional states.

3.2.4 Cognitive Change

Cognitive change entails reevaluating the significance of the situation that underlies the emotional state. Reevaluating negative situations is highly effective in reducing the experience of negative emotions and has both executive and physiological components. Hence, numerous cognitive-behavioral therapy (CBT) programs for emotional disorders instruct patients on utilizing techniques like reevaluation to mitigate negative emotions. Analyzing participants' emotional judgments when watching sad movie clips after a week of poorer sleep quality revealed reduced cognitive appraisal abilities; sleep deprivation also significantly decreased individuals' tendencies for positive thinking [10], thereby impacting the cognitive change process.

3.2.5 Response Modulation

Response modulation occurs after the complete emergence of emotions, involving the direct changes in experienced and behavioral responses to emotional stimuli to influence the generation of emotions. Expressive suppression is the most extensively researched form of response modulation, in which individuals try to conceal outward expressions of their emotions [11]. Sleep interruption-induced changes in emotional expression may influence response modulation and be influenced by it as well. Experimental evidence shows that adolescents and adults with sleep deprivation use fewer positive emotional words and more negative emotional words, and their vocal tones become more sad, anxious, and apathetic. Additionally, they display reduced emotional expressivity towards both positive and negative emotional video clips. Nonetheless, since these studies did not specifically instruct participants to regulate their expressions, it remains uncertain whether the variations in emotional expression observed are a direct consequence of impaired regulatory abilities. In a separate study, it was discovered that sleep-deprived individuals showed delayed facial reactions to emotional stimuli, indicating a slower response. However, the actual inhibition of facial expressions itself was not found to be impaired. Thus, while sleep deprivation may alter emotional expression, the capacity for reflective regulation may demonstrate some resilience against the impacts of sleep deprivation.

4. Universal Relationship Between Sleep and Mental Disorders

Sleep is closely related to mental disorders. Many individuals with mental disorders experience sleep problems. As an illustration, persons with depression frequently encounter symptoms such as trouble initiating sleep, unsatisfactory sleep quality, and premature awakening; individuals with anxiety disorders may face challenges when it comes to falling asleep and nocturnal waking. Insomnia is also commonly linked to mental health conditions and can serve as both a sign and a risk factor for the onset of other mental disorders. Sleep problems can exacerbate or trigger certain mental disorders. Prolonged sleep deprivation or poor sleep quality can lead to low mood, lack of concentration, and decreased cognitive function, which are features commonly observed in many mental disorders. Furthermore, sleep problems can also impact the balance of neurotransmitters in the brain, such as serotonin and dopamine, which are closely associated with emotions and mental states. Overall, sleep problems can both be symptoms of mental disorders and exacerbate or trigger them. From a clinical perspective, many mental disorders exhibit comorbid abnormalities in REM sleep [1].In certain specific types of mental disorders, such as post-traumatic stress disorder (PTSD) and major depression, there exist recognizable abnormalities in REM sleep.

PTSD is associated with decreased total REM sleep time and abnormalities in its quality. These abnormalities include fragmented REM sleep (indicating awakenings due to increased adrenaline) and increased sympathetic nervous system activity during REM sleep (reflecting enhanced adrenaline activity). Studies have indicated that objective disruptions in sleep following trauma exposure and heightened sympathetic nervous system activity during REM sleep are linked to a heightened risk of developing PTSD. Sleep abnormalities and increased REM sleep-related sympathetic nervous system activity are closely tied to substantial changes in the noradrenergic system in PTSD. Studies have found that relative to control groups, patients with PTSD exhibit excessive basal ganglia activity

during REM sleep, indicating that the noradrenergic system does not rest properly during REM sleep. Additionally, the noradrenaline levels of PTSD patients do not decrease at night as they do during the day but remain elevated. These REM sleep and noradrenaline abnormalities are correlated with the occurrence and severity of PTSD symptoms. These research findings provide important clues for understanding the relationship between REM sleep abnormalities and PTSD. In conclusion, REM sleep plays a significant role in the development and treatment of PTSD and requires further research and exploration.

Abnormalities in REM sleep, which encompass accelerated onset of REM sleep, heightened intensity of REM sleep, and extended duration of REM sleep episodes, are associated with major depression. Major depression is also associated with monoamine deficiencies, including noradrenaline. In the recalibration model of REM sleep [1], it is hypothesized that suppressing the activity of the locus coeruleus during REM sleep will lead to a gradual decrease in nocturnal noradrenaline levels, with the extent of reduction dependent on the dose administered. Thus, the frequently observed prolonged and/or intensified REM sleep patterns in individuals with major depression can potentially account for the commonly reported low levels of noradrenaline in this disorder. Moreover, due to the excess REM sleep-induced decrease in noradrenaline levels, binding to α-2 receptors in the prefrontal cortex ventromedial striatum will decrease. Due to decreased noradrenaline availability and reduced activation levels in the medial prefrontal cortex, the functioning of the medial prefrontal cortex and its ability to exert top-down control over the amygdala may be compromised. According to the sleep recalibration model, the abnormal REM sleep patterns, diminished noradrenaline availability, and resultant decrease in medial prefrontal cortex activation can account for the increased susceptibility of the amygdala to non-important stimuli and inability to discern emotional significance, frequently seen in individuals with major depression. To summarize, the atypical REM sleep patterns that are often seen in individuals with major depression can result in excessive inhibition of the adrenergic system the next day. At the same time, this phenomenon explains for the antidepressant effects seen with increased noradrenaline availability and reduced REM sleep characteristics, including the restoration of meaningful emotional discernment.

5. Conclusion

When discussing the impact of sleep deprivation on emotions, researchers tend to focus on the direct effects in terms of neurobiology. Through experiments, it has been discovered that sleep deprivation can cause changes in the levels of neurotransmitters and hormones within the brain. It can also affect the function and structure of the brain, resulting in limited activity within the prefrontal cortex (which is responsible for regulating emotions and decision-making) and increased activity within the amygdala (which is involved in emotional processing). Sleep deprivation can also affect the emotional regulation circuitry within the brain, potentially damaging the neural pathways connecting the prefrontal cortex and amygdala and leading to difficulties in emotional regulation. Additionally, sleep deprivation can lower activity within the hippocampus, an area associated with emotional stability and memory, which can further exacerbate emotional problems. These findings provide a clear picture of the negative impacts of sleep deprivation on working memory, attention, dopamine levels, and other facets of human functioning.

However, there are also indirect effects of sleep deprivation on emotions that can be easily overlooked. Sleep deprivation plays a significant role in the emotional generation process, leading to social deprivation, changes in decision-making habits, altered motivational mechanisms, and more, all of which can indirectly affect a person's emotions. Furthermore, these indirect consequences of sleep deprivation may interfere with a person's career goals, daily routines, and even behavior, and may result in longer-term negative consequences such as obesity or addiction. These negative effects can then further influence a person's emotions, creating a vicious cycle of "sleep deprivation - low mood - sleep deprivation".

While research into sleep deprivation and mental illness has made some progress at the neural level, there has been relatively little research into the emotional consequences. Moreover, certain professions that require high levels of attention but make it difficult to get adequate rest, such as detectives or pilots, perhaps require additional attention to this issue.

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