CURRENT OPINION

Exploring the role of dreams: insights from recent studies

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Purpose of review
Dreaming has only recently become a topic of scientific research. This review updates current findings on dream studies, emphasizing recent research on the neural mechanisms of dreaming. Additionally, it summarizes new evidence on the functional role of dreams, including insights from studies on dreams and nightmares during the coronavirus disease 2019 (COVID-19) pandemic.

Recent findings
Recent advances on the neural basis of mental activity during sleep have shifted towards dream-related phenomena, such as dream experiences in relation to parasomnias and hypnagogic hallucinations. Although some findings are consistent with the main models explaining dream recall (i.e., continuity hypothesis; activation hypothesis), some results contrast with the role of parieto-occipital region in dream experience. Moreover, recent findings – related to COVID-19 pandemic – underlined that dream experiences could express emotion regulation processes as well as provide a simulation of reality to prepare for future dangerous or social interactions.

Summary
Overall, we highlighted the intricate interplay between brain regions in dreaming and suggest that dreams serve multiple functions, from reflecting waking-life experiences to simulating adaptive responses to threats. Understanding the neural bases and functions of dreaming can provide valuable insights into human mental health, nevertheless, further research is needed.

Keywords
activation hypothesis, continuity hypothesis, nightmare, parieto-occipital cortex, simulation theory

INTRODUCTION

Dreaming is a captivating aspect of human sleep that occurs across various stages and multiple times at night (for a review, see [1]). Except for parasomnia conditions expressing dream enactment behaviors (i.e., REM sleep behavior disorder, RBD [2▪]), mental sleep activity cannot be accessed directly. Therefore, the primary focus of most investigations has mainly been on dream recall (DR), which involves the recollection of dream experience immediately after waking up [1]. Dream content may include different emotions and sensory experiences [3▪] with vision as the most prevalent sensory modality [4▪▪,5].

Starting from the 'continuity hypothesis' – positing that the personal concerns and mental conceptions characterizing waking thoughts are expressed into mental sleep activity ([e.g., 6*]) – recent studies emphasized the existence of a 'neurobiological continuity' between sleep and wakefulness for what concerns the mechanisms responsible for cognitive processes (e.g., [7]). Similarly to what is observed during wakefulness in the consolidation and retrieval of episodic memories, some findings revealed that increased theta oscillations during REM sleep and decreased alpha activity during NREM sleep predicted DR [7].

Moreover, structural brain imaging studies have explored the morphoanatomical parameters and interindividual variability of dream features; correlations between hippocampal and amygdala characteristics and qualitative dream features such as bizarreness, emotional load and dream length have been found [8]. Overall, it appears that shared mechanisms for cognitive and emotional processes operate across different states of consciousness.

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KEY POINTS

- The same neural mechanisms underpin conscious experiences during parasomnias and typical dreaming.
- High arousal levels contribute to dream experiences.
- Frontoparietal networks are associated with dream-like experiences during the wakefulness-to-sleep transition.
- Dreams may serve as emotional regulation and psychological preparation by simulating social situations or threats.
- Dream analysis could be useful for monitoring mental health.

Another issue to consider in dream research regards the 'activation model' which hypothesizes that brain activation during sleep enhances DR [1]. Accordingly, recent studies have shown that DR is associated with increased sleep fragmentation (e.g., [9]). Also, EEG findings suggest that the local presence of slow waves in certain regions may interfere with dream encoding and recall, while high-frequency brain activity predicts DR [10,11]. Moreover, high-frequency beta activity during REM sleep appeared to be linked to better recall and recognition of the audiobook content, indicating that this dream-related pattern also supports memory consolidation during sleep [12■■].

Overall, on the one hand, research on dreaming has been focused on the neural correlates promoting dream experience. On the other hand, in the last years, sparse investigations tried to explore the functional role of oneiric activity [13–15,16■]. Dreaming may serve as an emotional regulator, with neurobiological evidence supporting this hypothesis [13]. Furthermore, it has been proposed as a simulation of reality that helps individuals cope with daily challenges [14,15].

Considering this context, the current review aimed to provide an update of findings on dream research, with an emphasis on recent studies focused on the neural mechanisms underlying dream experience. We also summarized new evidence about the functional role of dreaming, taking into consideration the latest investigations about dreams and nightmares during the COVID-19 pandemic.

UPDATE ON NEURAL BASES OF DREAM EXPERIENCE

Recently, the study of consciousness experience has been extended to parasomnia conditions. Specifically, Cataldi *et al.* [17■■] provided significant insights into the neural bases of dreaming by investigating the EEG correlates of NREM parasomnia, particularly focusing on how these experiences relate to conscious episodes during sleep. By analyzing 75 episodes of parasomnias (i.e. disorders of arousal) in 22 patients, the authors identified that parasomnia episodes accompanied by dream experiences were characterized by distinct EEG patterns, namely a low delta power (1–4 Hz) and a high beta power (26–34 Hz) in posterior cortical regions, especially in the 20 s preceding the onset of movement. These patterns were predominantly observed in the primary visual cortex and extended to temporal and parietal areas, mirroring the neural activity associated with both NREM and REM dreaming [11]. These findings suggest that the same neural mechanisms may underpin conscious experiences during parasomnias and typical dreaming. The activation of the primary visual cortex and adjacent regions during these episodes highlights the brain's role in generating vivid sensory experiences, even when the individual is not fully awake. This aligns with previous research indicating that the visual cortex's activity is crucial for the formation of the vivid imagery often reported in dreams [18] and provides further support to the idea that the same regions are responsible for imagery processes in sleep and wakefulness (i.e., neurobiological continuity) [1].

Findings by Cataldi *et al.* [17■■] also suggest the potential contribution of arousal systems to dream experience. In this investigation, they induced parasomnia episodes using loud, stimulating sounds, and noted that reported dream themes often revolved around imminent danger or threat. This implies a relation between the stimulating nature of the stimulus and the content of dreams. Interestingly, while the actual alarm sound was seldom mentioned in experiential reports, the concept of threat consistently emerged [17■■]. This raises the possibility that activations of nonspecific systems, which encode the significance of the stimulus rather than the specific sensory pathways, may preferentially influence experiential content during sleep. It is tempting to hypothesize that sudden arousal system activations, whether induced or spontaneous, are perceived as danger signals by individuals and subsequently contextualized, provided the brain is in a dream or conscious state prior to arousal, allowing interpretation. Overall, this result is consistent with the idea that a greater activation facilitates the presence of a conscious experience [1]. Accordingly, a study that implemented a closed-loop auditory stimulation (CLAS) technique found that enhancing posterior slow oscillations during NREM sleep reduces the likelihood of dreaming compared to not enhancing these oscillations. Interestingly, this research confirmed that more desynchronized cortical activity promotes mental activity during sleep and demonstrated the potential to directly modulate the presence or absence of dream experiences [19▪].

Beyond the study of traditional dream activity, a recent study focused on exploring the neural correlates of hypnagogic hallucinations as a manifestation of reflective awareness. This aspect involves voluntary cognitive control and reality testing, distinct from phenomenal awareness, which pertains solely to the presence of consciousness [20▪▪]. Specifically, the authors explored the spatiotemporal properties of the EEG microstates (e.g., occurrence, duration, contribution, and mean global field power) and their association with dream-like experiences during the transition from wakefulness to sleep [20▪▪]. EEG microstates are brief periods during which the brain's electrical activity remains stable before rapidly transitioning to a different state. Diezig *et al.* [20▪▪] found that dream-like experiences were marked by an increased presence of microstate class 4, which is characterized by synchronized activity in the superior and middle frontal gyrus and the precuneus. The topography of microstate 4 in this study was consistent with the findings of Bréchet *et al.* [21], which decreased when subjects reported dreaming compared to the absence of dream reports and mainly localized in posterior and frontal regions. Accordingly, previous findings underlined that microstate class 4 is linked to neuronal activity in the frontal and parietal regions [22▪]. This microstate is associated with cognitive control networks, particularly the salience and default mode networks (e.g., [22▪,23,24]). Additionally, processes such as inhibitory control [25], attention [26], and external awareness [27] are linked to the frontoparietal network. Furthermore, they observed a decreased presence of microstate class 2, which is associated with activity in the middle and inferior temporal gyrus, middle occipital gyrus, and fusiform gyrus. Microstate class 2 is commonly associated with visual and visuospatial processing, increasing in prevalence after visual stimuli and during eyes-open conditions [22▪]. However, Diezig *et al.* [20▪▪] found that the presence of this 'visual' microstate 2 is inversely related to hypnagogic imagery, challenging the idea that dream-like experiences during sleep transition involve sustained activation of primary visual and parieto-temporal areas [11,17▪▪,28▪,29▪].

The results of this study provide valuable insights into the neural mechanisms underlying dream-like experiences and the transition from wakefulness to sleep. On the one hand, these findings underscore the importance of frontoparietal networks in maintaining reflective awareness and provide a framework for further exploration of the neural correlates of different aspects of consciousness. On the other hand, the authors found some inconsistent results about the involvement of the parieto-occipital cortex in dreaming, considered 'the hot zone' for conscious experience [11]. This might be explained by the fact that Diezig *et al.* [20▪▪] examined a different subject of study (hypnagogic hallucination) than other investigations (e.g., [11]). Moreover, these results have potential implications for understanding the neural bases of various psychopathological conditions, such as hallucinations in psychosis, which may involve disruptions in the normal patterns of brain activity and conscious awareness.

Together, these studies, only partially consistent with existing literature, advance our understanding of the neural bases of dreaming, highlighting the intricate interplay between different brain regions and their activity patterns in producing and sustaining dream experiences.

INSIGHTS ON DREAM FUNCTION

In recent years, the interest in the relationship between human health and oneiric features has garnered significant attention. Notably, numerous studies exploring the relationship between dreaming and the coronavirus disease 2019 (COVID-19) pandemic revealed increased DR and nightmare frequency [30▪▪]. The COVID-19 outbreak indeed provided a unique context for investigating the functional role of dreaming and its potential impacts on human psychology.

Many findings support the above-mentioned continuity hypothesis [1] that actually attributes a passive role to dream experience [31▪]. For instance, Scarpelli *et al.* [32▪] found that subjects with greater or equal levels of distress after one year from the first COVID-19 wave had higher nightmares than improved people. Accordingly, another study revealed that people affected by long-COVID had a high frequency of nightmares along with a high percentage of other sleep complaints [33▪▪]. People with a greater number of postacute symptoms and with less psychological well being also had more nightmares [33▪▪]. In this view, again, oneiric activity seems to mirror the people's well being during wakefulness.

Along this vein, Raffaelli *et al.* [34▪▪] reported that participants who self-reported greater COVID-19 concern rated their dreams as more negative and unconstructive, a relationship that was moderated by trait rumination. Together, these results support a relationship between dreams, current concerns, and mental health.

Moreover, in the last year, some studies have investigated oneiric activity in relationship to other disturbances such as insomnia [35▪▪], suicidal ideation [36▪▪], or parasomnia-like events [37▪,38▪]. Meaklim *et al.* [35▪▪] found that in collective stressful events like the pandemic, participants experienced increased dream activity characterized by vivid, high-definition, and negatively charged dreams. Interestingly, individuals with insomnia used more negative, anxious, and death-related words to describe their dreams compared to good sleepers. Negative dream changes were linked to worsening mental health symptoms over time, especially in those with insomnia. Also, by a 3-month follow-up, all groups reported a significant reduction in dream activity [35▪▪]. Quite consistently, Proença Becker *et al.* [39▪] revealed that participants who dreamed about the COVID-19 pandemic also reported shorter sleep duration, more frequent nocturnal awakenings, and more frequent recall of nightmares. Common dream themes included sickness, death, inefficiency, and work-related concerns. Health professionals frequently experienced dreams about inefficiency and work-related issues.

Additionally, Bolstad *et al.* [36▪▪] explored the link between nightmares and suicidal ideation across 16 countries. They found that suicidal ideation was more prevalent among participants with long-COVID compared to those with short-COVID, and frequent nightmares during the pandemic heightened the likelihood of reporting suicidal ideation. This is in line with the idea that nightmares may represent an index of emotion regulation difficulties during sleep [40,41▪]. Dreams could serve as a mechanism for emotional regulation, helping individuals to integrate their experiences and reduce the impact of stress and regulate waking affect.

Other findings about the functional role of dream experience have been interpreted according to the so-called ‘simulation theories’ [14,15,42]. In this view, a recent study by Abbas and Samson [43▪▪] examined dream and waking reports from undergraduate students showing that dreams may function to simulate and practice responses to social threats. Specifically, they found that dreams were more negative and featured more interactions with unfamiliar individuals compared to waking life, providing support to the threat simulation hypothesis [43▪▪]. Accordingly, dreams with direct references to the pandemic showed a greater rate of threatening events and these threats appeared to be more severe than dreams without direct references to the pandemic [44▪]. From this perspective, the content of mental sleep activity could represent a psychological preparation, aiding the dreamer in confronting similar negative events in the future. Moreover, the sample investigated by Abbas and Samson [43▪▪] exhibited a higher frequency of positive social situations in waking life compared to dreams. This provides partial support for the social simulation hypothesis, which posits that dreaming simulates important social bonds and interactions, thereby strengthening them [15,42].

In other words, several findings about oneiric activity during the pandemic could support the hypothesis that increased DR and nightmares during periods of heightened stress, such as a collective emergency, might reflect the mind’s attempt to process and cope with emotional and psychological challenges.

CONCLUSION

The newest evidence on the neural correlates of dreaming has provided valuable insights into phenomena such as parasomnias [17▪▪] and hypnagogic hallucinations [20▪▪], elucidating specific brain regions and neural activity patterns involved in these experiences. Identifying distinct neural patterns associated with parasomnias and hypnagogic hallucinations holds the potential to improve diagnostic accuracy and lead to more targeted interventions. Moreover, managing external stimuli that influence dream experiences [19▪] can help clinicians mitigate distressing dreams and enhance sleep quality.

Although these findings show how various brain regions and their activity patterns are involved in the generation and maintenance of dream experiences, it is worth noting that they do not directly inform us about the functional role of dreaming.

Notably, the current review underlined that the COVID-19 pandemic offered a unique and valuable opportunity to test hypotheses about the role and significance of dreaming in natural settings. Findings from this period suggested that dreams may play an active role in providing a ‘safe’ space to experience and process emotions, particularly negative ones, thereby facilitating more effective emotional regulation during wakefulness. Additionally, recent studies support the notion that dreams serve to simulate threats and rehearse coping methods in a virtual context (e.g., [43▪▪]). In this view, it could be suggested that nightmares are strictly related to high levels of distress (e.g., [32▪]) and may indicate a failure in emotion regulation processes [45].

The correlation between dream content and psychological states during the pandemic implies that dream analysis could be a valuable tool for monitoring mental health, allowing early identification and intervention for individuals at risk of heightened stress or anxiety. Therapeutically, understanding dream content can aid in emotional regulation and stress processing, helping patients integrate stressful experiences and enhance resilience.

Additionally, from a research perspective, further exploration of the specific brain regions and networks involved in dreaming is necessary to deepen our understanding of the neural mechanisms at play. Indeed, despite recent advances, comprehensive studies testing the various theories about the functional role of dreaming from a neurobiological perspective are still lacking [46]. Future research should aim to bridge this gap and explore the intricate interplay between different brain regions and their activity patterns in producing and sustaining dream experiences.

Finally, we believe that creating a large dataset of polysomnographic recordings with dream recollection could provide a significant opportunity to investigate the neural correlates of the dream experience [47▪].

Overall, integrating these findings into clinical practice and continuing research efforts will enhance our understanding of the dreaming brain, leading to improved preventive strategies for sleep disorders and mental health.

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Conflicts of interest

There are no conflicts of interest.

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▪ of special interest
▪▪ of outstanding interest

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