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Opinion

# Does Consciousness Disappear in Dreamless Sleep?

Jennifer M. Windt,[1] Tore Nielsen,[2] and Evan Thompson[3,*]

**Consciousness is often said to disappear in deep, dreamless sleep. We argue that this assumption is oversimplified. Unless dreamless sleep is defined as unconscious from the outset there are good empirical and theoretical reasons for saying that a range of different types of sleep experience, some of which are distinct from dreaming, can occur in all stages of sleep. We introduce a novel taxonomy for describing different kinds of dreamless sleep experiences and suggest research methods for their investigation. Future studies should focus on three areas: memory consolidation, sleep disorders, and sleep state (mis) perception. Our proposal suggests new directions for sleep and dream science, as well as for the neuroscience of consciousness, and can also inform the diagnosis and treatment of sleep disorders.**

## Challenging the Default View of Consciousness in Sleep

Consciousness is often defined contrastively by pointing to cases in which it is thought to be absent. For example: 'everybody knows what consciousness is: it is what vanishes every night when we fall into a dreamless sleep and reappears when we wake up or dream' ([1], p. 216; see also [2]). According to this viewpoint, conscious experience in sleep consists mainly or even exclusively of dreaming, and dreamless sleep is a state in which **phenomenal consciousness** (see Glossary) fades or disappears [3,4].

We call this the 'default view' of consciousness in sleep [5]. Even when it is not articulated as clearly as here, its implicit endorsement is reflected in the fact that sleep-related experience is almost exclusively studied under the heading of dreaming, and in the resulting failure to appreciate the distribution of different types of experience during sleep.

We argue here that, contrary to the default view, dreamless sleep cannot accurately be described as a uniform state of unconsciousness. Instead, sleep supports a range of different types of experience that are distinct from dreaming and occur outside **rapid eye movement (REM) sleep.**

At the outset it is crucial to recognize that the concept 'dreamless sleep' is equivocal and imprecise. Taken literally, it refers to any phase of sleep in which no dreaming occurs. However, in the absence of a precise specification of what constitutes dreaming, the concept of dreamless sleep remains equally ill-defined.

This article presents a new conceptual framework for describing the range of sleep experiences that include but are not limited to dreaming, and that distinguishes different subtypes of dreamless sleep experience. The idea is that, by restricting the concept of dreaming to a subtype of conscious mental activity during sleep, we can develop a more precise framework for

### Trends

Dream science has mostly focused on REM sleep, but there is growing interest in serial awakening paradigms that collect reports from numerous awakenings throughout the night to contrast dreaming and dreamless sleep within the same sleep stage, including NREM sleep and SWS.

Studies of spontaneous cognition, including mind wandering and dreaming, are leading to an increased focus on understanding both mental activity and neural dynamics as being largely 'intrinsic' or self-generated rather than 'extrinsic' or stimulus-driven.

Although research on the neural correlates of consciousness has focused largely on the specific contents of consciousness, the investigation of global states of consciousness (such as sleep, dreaming, and wakefulness) and their relation to disorders of consciousness is receiving increasing attention.

[1]Department of Philosophy, Monash University, Level 6, Menzies Building, Clayton Campus, 20 Chancellor's Walk, Monash University, VIC 3800, Australia
[2]Department of Psychiatry, Université de Montréal, and the Dream and Nightmare Laboratory, Centre for Advanced Research in Sleep Medicine, Hôpital du Sacré-Coeur de Montréal, 5400 Boulevard Gouin Ouest, Montréal, QC H4 J 1C5, Canada
[3]Department of Philosophy, University of British Columbia, 1866 Main Mall, Vancouver, BC V6 T 1Z4, Canada

*Correspondence:
evan.thompson@ubc.ca (E. Thompson).

describing the range of sleep-related experiences. This framework can then be applied to the experimental investigation of the distribution of different types of sleep experience across all stages of sleep.

Notably, this is not to claim that conscious mental activity continues throughout sleep. Whether periods of unconsciousness occur in sleep alongside dreaming and dreamless sleep experience is, in our view, an open empirical question. The more pressing point is that, given the available evidence, it seems unlikely that all stages of sleep currently classed as dreamless necessarily or consistently involve a loss of phenomenal consciousness.

We identify three key areas of sleep research as particularly promising for future studies of dreamless sleep experience: memory consolidation in sleep, sleep behavior, and sleep-state perception and misperception. We also propose new research methods for investigating whether conscious experience sometimes occurs even in deep sleep, and we discuss their implications for sleep science and the neuroscience of consciousness.

## Beyond Dreaming and REM Sleep: Why a New Framework Is Needed

Early dream researchers believed that dreaming closely correlates with REM sleep, and that **slow-wave sleep (SWS)** generally is accompanied by a loss of consciousness [6]. Conscious experience during sleep was thought to consist mainly of vivid, bizarre, hallucinatory content during REM sleep, though the occurrence of less-vivid, thought-like content in **non-REM sleep (NREM)** was soon also recognized [7]. This viewpoint suggested both that the presence of rapid eye movements during sleep could provide the basis for an 'objective method' for the study of dreaming [6], and more generally that the overall changes in brain and muscle activity accompanying the transitions between different sleep stages could be used to mark the presence versus absence of conscious experience during sleep. To this day 'dreamless sleep' is often used synonymously with 'deep sleep', understood as stages 3 and 4 NREM sleep ('N3') or SWS [1,3,4].

This initial period of optimism about the prospects of scientific dream research was followed by controversy, with some researchers arguing that dreaming is expressed in its most qualitatively complete form during REM sleep (e.g., [8]) and others denying any strong or systematic link between dreaming and individual sleep stages (e.g., [9]). The controversy was in part empirical, concerning the types of neural activity required for dreaming and how they mapped onto categorically defined sleep stages. Even so, it was also in part conceptual, in that a clear and widely accepted definition of dreaming was lacking, with some researchers defining dreams as any mental activity in sleep [10,11] and others reserving the term for more specific types of complex hallucinatory dreams [8]. This disagreement was compounded by the adoption of an artificially categorical view of discrete sleep stages. Although some efforts to delineate interrelationships and overlaps among sleep stages were proposed (e.g., [12]), they were relatively short-lived.

Recent years have seen increasing convergence on 'simulation' views of dreaming, which hold that dreaming is characterized by the seemingly realistic experience of a world centered on a self [13]. Simulation views describe dreams in terms taken from virtual reality research. Similarly to computer-generated virtual environments, dreams are **immersive**: dreaming involves the sense of presence in a world simulation [14–18] and can be minimally defined as 'immersive spatio-temporal hallucination' (hallucination of a here-and-now world experienced from a first-person perspective) occurring in sleep or sleep–wake transitions [17].

We endorse here the simulation view because of its potential to unify different theories of dreaming [13] while also giving a rigorous sense to the concepts both of dreaming and of

## Glossary

**Global states of consciousness:** states that characterize the overall condition of a conscious organism, such as wakefulness, dreaming, or disorders of consciousness (e.g., coma or vegetative state); typically contrasted with local states or specific contents of consciousness (e.g., seeing a face or hearing a melody). Also described as background states, levels, or modes of consciousness.

**Immersion:** borrowed from virtual reality research; here used in the sense of feeling present in a fictive environment and experiencing it from an internal, visuospatial perspective (rather than from the outside, as when viewing a movie on a screen).

**Lucidity:** typically used to refer to lucid dreams, in which the dreamer is aware of dreaming; here refers to awareness of one's current state of consciousness, including dreamless sleep (witnessing).

**Mindfulness meditation:** a family of contemplative practices aiming to cultivate attention, awareness of one's mental states, and psychological wellbeing.

**Non-REM sleep (NREM):** refers to the stages of sleep that are distinct from REM sleep and range from sleep onset (SO) to deep sleep. Three stages are now commonly distinguished: N1, N2, and N3.

**Parasomnia:** in its literal sense refers to events occurring alongside sleep; here used to refer to sleep disorders including RBD as well as somnambulism and somniloquy.

**Phenomenal consciousness:** consciousness in the sense of subjective experience. A mental state is phenomenally conscious if it has a subjective experiential character for the person or animal in that state.

**Phenomenal self:** the subjective sense of being a self, often thought to include the experience of being a bodily subject and a cognitive agent. In dreams refers to the dream character with whom the sleeping subject identifies.

**REM sleep behavior disorder (RBD):** characterized by a loss of REM sleep paralysis and seemingly goal-directed and often aggressive behavior arising from REM sleep that is often followed by recall of dreams with matching fictive imagery.

**Rapid eye movement (REM) sleep:** characterized by rapid eye

### Box 1. A New Framework for Describing Dreamless Sleep Experience

In the simulation model, dreaming minimally requires 'immersive spatiotemporal hallucination' occurring during sleep or sleep–wake transitions [17]. This model provides precise criteria for determining which sleep experiences count as dreams, and hence for contrasting dreams with dreamless sleep experiences. We propose that three main subtypes of dreamless sleep experience can be distinguished.

**Non-Immersive Imagery and Sleep Thinking**

Experiences during sleep qualify as dreamless if they lack the immersive character of dreaming. Examples are isolated or static visuospatial, auditory, or kinesthetic imagery lacking a clear hallucinatory context, movement sensations, and propositional thought (sleep thinking). Such experiences typically lack the temporal dynamics and narrative complexity of dreams, and are frequent during SO and NREM sleep [7].

**Perceptual Experiences and Bodily Sensations**

Another subgroup of dreamless sleep experiences lacks the simulational character of dreaming in which the dream experience unfolds largely independently of peripheral sensory stimulation [14,15]. Although external stimuli are sometimes integrated into dreams – as in dreams that smoothly incorporate the sound of one's alarm clock – nevertheless the dream world, including dream characters and objects, as well as the dream self, are largely dependent on **spontaneous activity** and endogenously generated neurocognitive activity [17]. By contrast, if sleep experiences exist in which the balance has tipped from largely endogenous activity to largely exogenously modulated experience, these experiences will no longer count as dreams. Therefore, according to the simulation model, isolated bodily sensations or perceptual experiences during sleep count as dreamless experience. At the same time, the taxonomy admits cases in which there is genuine indeterminacy as to whether they count as dreaming or dreamless. An example would be an experience in which real pain and own-body perception are combined with a hallucinatory setting.

**'Selfless' States and Contentless Sleep Experiences**

Sleep experiences will also count as dreamless if they lack not only the immersive and simulational character of dreaming but also any specific imagery and conscious propositional thoughts. At issue here is the possibility of a form of conscious awareness during sleep that lacks imagistic or propositional contents [5,18,69]. Experienced meditators who cultivate attention and meta-awareness [72] sometimes report an experience they describe as 'witnessing sleep' – in which any specific thought contents or imagery, including ones pertaining to the phenomenal self, are absent from the sleep state [5,18]. If the existence of this kind of sleep experience can be rigorously established, it would count as a distinct form of dreamless sleep experience.

dreamless sleep experience (Box 1). In the following sections we propose three areas of sleep research in which this taxonomy can be put to work.

## Memory and Learning in Sleep and Dreams

Sleep is widely regarded as a period of continued information processing [19] that facilitates memory consolidation [20–22] and emotion regulation [23]. The strong and growing evidence of such continued cognitive activity suggests the possibility that some kind of conscious experience may likewise persist, even in SWS [24].

Memory consolidation in sleep was traditionally thought to be dependent on the stage of sleep, with declarative memory improving after SWS, and emotional processing and procedural memories such as motor skills benefiting from REM sleep [20,25]. Nevertheless, like the idea of a one-to-one correspondence between dreaming and REM sleep, the idea of a one-to-one match between different types of memory consolidation and distinct sleep stages is now being called into question [26] (Box 2). Instead of REM and NREM sleep subserving separate memory systems, memory processing in sleep may be sequential, requiring an interaction of different stages [20] or of microstructural features within stages (eye movements, spindles, slow oscillations, etc.) [27]. Moreover, because current research on memory consolidation in sleep does not typically make systematic use of experience reports, the role (if any) of sleep experiences from all stages of sleep is unclear.

Investigating the form, timing, and experiential attributes of memory sources that are reactivated during sleep and that contribute to **sleep mentation** could provide a valuable

movements, wake-like levels of brain activity, and near-complete loss of muscle tone (REM sleep paralysis); consistently associated with vivid dreaming.

**Sleep mentation:** here used as a blanket term for any type of conscious mental activity during sleep (dreaming as well as subtypes of dreamless sleep experience), but distinguished from (potentially) unconscious forms of cognitive activity.

**Sleep onset (SO):** defined here as sleep epochs or 'microsleeps', for example 1–5 s of N1. A transitional state from drowsiness into the early stages of sleep, SO is often accompanied by visual or auditory imagery or movement sensations, as well as dreamlike experiences.

**Somnambulism:** a parasomnia originating in deep sleep (SWS), involving walking or performing other complex behaviors while asleep.

**Somniloquy:** a parasomnia involving complicated monologues or dialogues, mumbling, or gibberish during sleep.

**Spontaneous activity:** an umbrella term describing intrinsic (as opposed to evoked or stimulus-driven) cognitive processes arising independently of experimental tasks and ongoing environmental demands; includes daydreaming, fantasy, and mind-wandering. Also used to refer to intrinsic (as opposed to evoked or stimulus-driven) brain activity.

**Slow-wave sleep (SWS):** also known as deep sleep, N3 sleep, or NREM stages 3 and 4 in earlier terminology. Characterized by low frequency, high-amplitude synchronized electroencephalogram (EEG) activity, the so-called slow waves.

### Box 2. From Fine-Grained Sleep Stage Scoring to Global States?

Levels, modes, and **global states of consciousness** [96] are key constructs in consciousness research. The idea of ordering conscious states along a single dimension, however, is problematic [96].

We propose that considering the entire spectrum of sleep-related experience can inform multidimensional accounts of global states. A key advance will be to refine phenomenological descriptions of sleep experience, sleep-stage scoring, and neurodynamical measures in concert (Box 3).

For example, the covert REM sleep model [7,97] predicts that dreams occurring in NREM sleep are related to REM-like brain activity that fails to be scored as such, in part because of limited and artificially categorical sleep-staging criteria.

Another example is SO, which is accompanied by changes in subjective experience ranging from isolated, snapshot-like, and mostly unimodal imagery to immersive, narratively complex dreams [98]. Within SO, nine EEG substages can be distinguished [99] and, through self-observation training, can be mapped onto different types of experience [98]. Further pressure on sleep-stage scoring comes from new standards for classifying sleep disorders. The view that parasomnias involve unstable dissociations between wakefulness, NREM sleep, and REM sleep implies that these states are not mutually exclusive [66]. New evidence suggests that local wake-like activity may coexist with sleep-like activity in other areas [100] and can be unevenly distributed over the hemispheres, as when sleeping in novel environments (the 'first-night effect') [101].

The association of sleep and wakefulness with local activation patterns supports our claim that NREM parasomnias may be associated with phenomenal experience, but also threatens to undermine the projects of describing sleep and wakefulness as global, whole-brain phenomena [102] and of defining discrete, multilevel states of consciousness. One possibility is that even refined objective scoring criteria allow borderline cases. For example, for a subset of cases involving a mismatch between subjective and objective measures, as in subjectively undetected microsleeps, there may be genuine indeterminacy as to their occurrence in sleep or wakefulness. In this case, the concept of state misperception would no longer apply.

Whether refining phenomenological categories in concert with sleep-stage scoring will produce a one-to-one mapping is, therefore, an open question. A more fine-grained taxonomy of sleep-related experience could complement the project of investigating the neural correlates of waking consciousness. If, however, the appropriate grain for individuating phenomenal states is different from the criteria for individuating cognitive functions (such as attention or memory) [103] or behavioral states (such as wakefulness, NREM sleep, and REM sleep), the prospects for distinguishing discrete global states of consciousness [104] may be limited.

window into the cognitive side of memory consolidation in sleep [28,29] (Figure 1). REM sleep dreams are rich in motor imagery and emotions [8], and an association between REM sleep dreaming and the reactivation and consolidation of motor and emotional memories therefore seems plausible.

Nevertheless, the integration of dream research and research on memory consolidation in sleep is hampered by several practical problems. Much of the research on sleep-related memory consolidation is conducted with animal models, especially rodents. In humans, the short-lived nature of dream recall means that special steps – such as timed awakenings, interview techniques, or training – need to be taken to investigate the memory sources of dreaming [30]. Dream amnesia may even raise doubts about the claim that dreaming contributes to sleep-related memory consolidation [31]. Furthermore, recent research on memory consolidation has focused largely on SWS, whereas dream research, in line with the default view, has tended to focus on REM sleep.

Future studies could aim to integrate these lines of research by focusing more specifically on mentation during NREM sleep, including SWS. Given that NREM sleep takes up more of the sleep period and is generally characterized by a broad range of experiences, the precise nature and scope of which remain incompletely understood, researchers could aim to align different types of memory tasks with different forms of NREM sleep experience, both dreamful and dreamless.

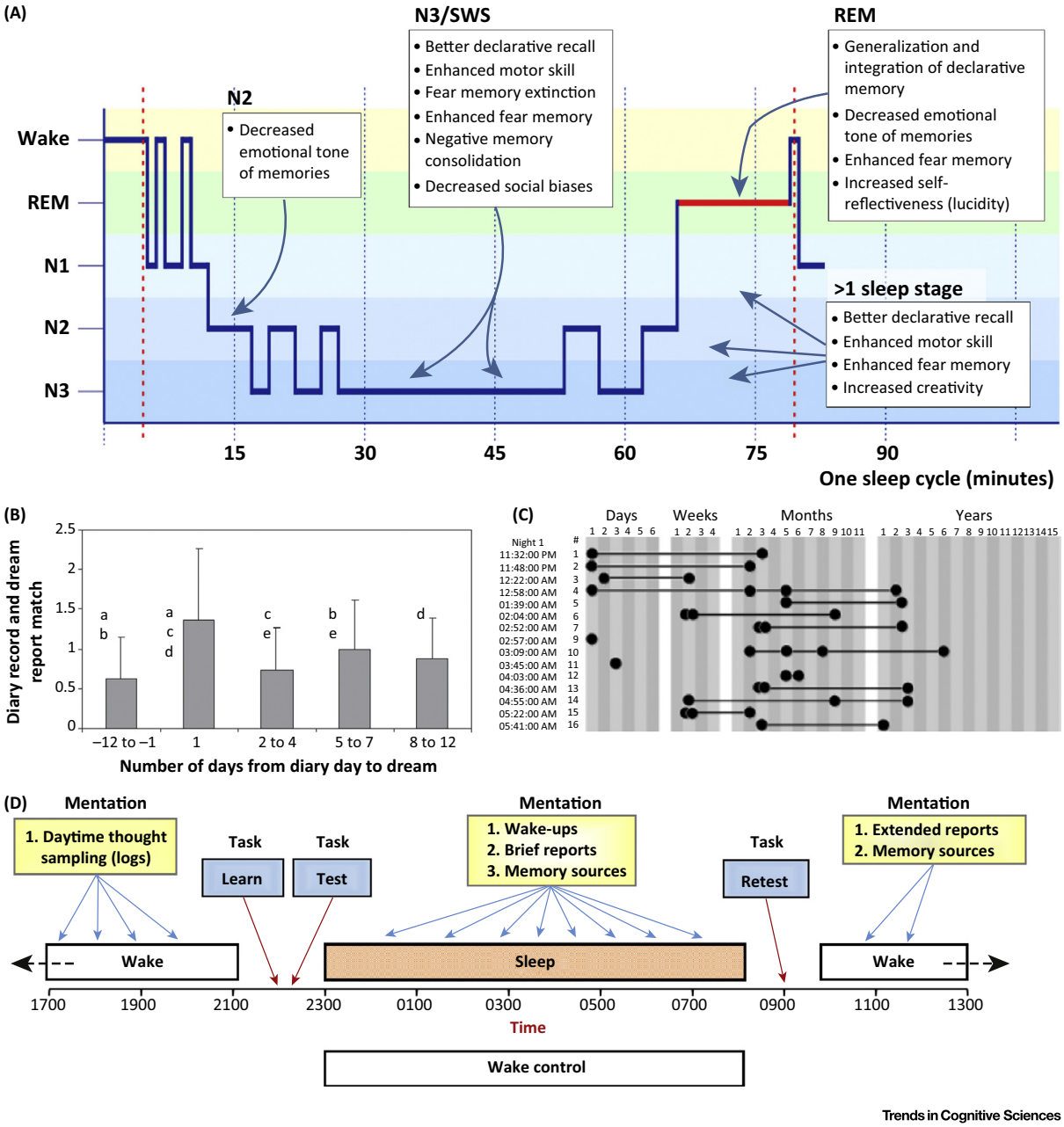


Figure 1. Selectivity of Sleep-Related Memory Consolidation and the Memory Sources of Dreaming. A central problem for research on memory consolidation in sleep is its selectivity. (A) Targeted memory reactivation (TMR) through sensory cues [32] may help to investigate the time-course of consolidation over the sleep–wake cycle [106], shedding light on which memories are strengthened during different sleep stages. Memory reactivation in dreams is similarly selective, with a direct replay of waking memories occurring in only 1–2% of dream reports [107]. (B) Nevertheless, a remarkable temporal pattern exists in which reactivation of waking memories is highest the same day (day residue) and after 5–7 days (dream-lag), but lower for days 2–4 [108,109]. (C) Sleep onset (SO) imagery is mostly related to recent, pre-sleep memories. Throughout the night, memory sources increase in temporal remoteness while remaining semantically related (as in dreaming of pets from different periods of one's life) [98]. (D) To investigate the memory sources of sleep-related experiences and their relation to memory consolidation, we propose a laboratory protocol optimized for sampling mentation and task-related memory sources in addition to assessment of sleep-dependent learning (test–retest) changes. Participants are trained and tested on a task, given an 8 h opportunity to sleep or engage in a controlled waking state such as mind-wandering [110], awakened randomly from any stage of sleep, and asked to report sleep mentation and memory sources briefly so as not to prevent returning to sleep, then retested in the morning. A later interview concentrates on details about dream content and memory sources that may reflect reactivation of the learning task. An equally long period of waking-state consciousness during either the nighttime or daytime controls for the passage of time and the presence/absence of specific types of mental experiences. Panel (A) adapted from https://commons.wikimedia.org/wiki/File%3AHypro_nrem_1_en_101.svg. Panel (B) reproduced, with permission, from [109]. Panel (C) reproduced, with permission, from [98].

To date, evidence that the reactivation of pre-sleep visuospatial tasks in sleep [32] is associated with sleep mentation comes mostly from daytime naps (involving NREM sleep) [33] and **sleep onset (SO)** [34,35], and more rarely from REM sleep [36,37]. The reactivation of task-related memories is often indirect. For instance, a pre-sleep maze-navigation task may lead to the experience of being in a maze-like environment, but also to thinking of the upcoming retest or hearing the associated music during sleep [33]. An association with improved task performance is plausible [33], but owing to small sample sizes remains speculative.

Targeted reactivation of memories during sleep [32] can be achieved through the use of sensory stimulation – such as odors paired with pictures or tones – either before [38] or during sleep [39]. Evidence indicates that odors that were previously paired with pictures can have an effect on dream imagery [40]. So far, however, this effect has been investigated only for REM sleep dreams, and the association (if any) with memory consolidation is unknown. Nevertheless, given that the association between odor presentation in sleep and learning is strongest for SWS [38,39], future studies could investigate related SWS-experiences ranging from dreams to isolated olfactory (or auditory) [41] sensations in sleep.

In addition to memory consolidation, the relationship between sleep-related experience and prospective memory or future planning deserves investigation. Dreams have been suggested to facilitate adjustment to novel situations through 'preplay' [42] because they combine sensorimotor imagery and emotionally significant memories. REM sleep dreaming is thought to involve key areas of the default-mode network (DMN) [43], which is linked to a broad range of self-generated thoughts, including autobiographical and prospective memory [44] as well as future planning and self-referential cognition [45]. Although SWS is normally characterized by a breakdown of large-scale effective connectivity in the brain [46], recent findings suggest that hippocampal ripples [47] may be associated with bursts of activity in the DMN both in wakefulness and in sleep [48]. The emergence of this functional network during SWS, together with the role of both the DMN and hippocampal replay in memory consolidation [49], supports the view of sleep as a period of continued information processing, parts of which may be associated with the persistence of conscious experience [24].

## Sleep Behavior: Unconscious Automatism versus Dream Enactment

The alleged dichotomy between unconscious dreamless sleep and conscious dreamful sleep is paralleled by the view that behaviors arising during NREM sleep are unconscious automatisms, whereas behaviors arising in REM sleep – most notably **REM sleep behavior disorder (RBD)** – involve the outward enactment of subjective dream experience [50]. We argue here that this sharp contrast between unconscious NREM automatism on the one hand, and REM-sleep related dream-enactment on the other, is overstated.

First, there is some evidence that NREM sleep behaviors can be associated with subjective experience instead of being completely unconscious. According to subjective reports, **somnambulism** episodes are sometimes accompanied by dreamlike experiences that are mostly short, consisting of a single visual scene, and unpleasant [51]. **Somniloquy** has been found frequently to match mentation reports, both from REM and NREM sleep [52]; at other times, the verbalizations are completely discordant with mentation. Dreams associated with somnambulism and somniloquy are often threatening, but the types of threats are different from those reported by RBD patients. In addition, a majority of sleepwalkers report dreaming of their actual sleeping environment, which is rarely the case for RBD dreams [53]. Therefore, casting sleepwalkers and sleep-talkers as temporary zombies lacking any kind of phenomenal experience [15] seems implausible.

Second, some evidence suggests that somnambulistic behavior can be related to pre-sleep experience and memory consolidation, as in the re-enactment of a recently learned motor

task [54]. Again, this raises the question of a possible association with subjective experience. One case study recorded an episode of behavior arising from sleep stage N3; the video showed the patient suddenly standing up in bed and raising his arm, and he later reported that he was trying to support a collapsing roof [55]. Because the episode appears to have been subjectively immersive and to have borne no relation to actual events, it may be classified, according to our simulation model, as a dream (Box 1). In other cases, such as somnambulistic driving [56], some form of continued perceptual (and hence dreamless) experience may be preserved. This suggests that NREM sleep behavior may be associated with a range of sleep experiences, only some of which can be described as immersive dreams.

Third, the association between RBD, heightened dream recall, and frequent nightmares of being chased or attacked is largely anecdotal and remains controversial [57,58], although it has gained some empirical support [59–61]. Importantly, some RBD patients never report any dreams [62] and, with few exceptions [63], studies of RBD enactment behavior have not attempted to match dream reports to individual behavioral episodes.

For these reasons, the exact relationship between sleep behavior and sleep experience remains far more of an open question than is commonly assumed, and importantly this is true for both NREM and REM sleep.

An intriguing possibility is that there may be varying degrees of concordance between sleep behavior and associated experience in both REM and NREM sleep. Sleep behaviors from the different stages of sleep may be associated with a range of different types of experiences, including not only dreams but also subtypes of dreamless sleep experience. Other instances of sleep behavior may involve a complete loss of phenomenal consciousness.

This issue becomes more pressing when we consider that sleep behavior is not restricted to sleep disorders. Healthy sleep is punctuated by an array of behaviors that occur regularly throughout sleep; these range in complexity from gross body movements (e.g., shifts in posture) to complex limb movements (e.g., adjusting covers) and fine muscle activity (e.g., facial and limb muscle twitches). Even fully fledged dream-enactment behaviors are not exclusive to RBD, but can also occur in healthy subjects [64], and the range and experiential correlates of subtler sleep behaviors have been only minimally studied [65].

Questions about the relationship between sleep behavior and experience have implications beyond consciousness research. For diagnosing RBD, video polysomnographic documentation and reports of dream-enactment behavior are thought to be crucial [66]. By contrast, for NREM sleep **parasomnias** it is common to focus on their occurrence in the first half of the night and on the absence of mentation recall [67]. These diagnostic criteria, however, reflect the dichotomous view we are questioning here.

There may also be legal implications. For crimes (such as murder or sexual assault) committed during sleepwalking, some argue that lack of accountability depends on the absence of any experience, perception, or mental interaction with the environment, as well as complete amnesia [68]. In our view, however, requiring NREM parasomnias to be completely unconscious automatisms seems too strong.

## Sleep Perception and Misperception: Witnessing, Dream Lucidity, and Insomnia

So far we have proposed that dreamless sleep experiences can range from non-immersive imagery and sleep thinking to continued bodily experience and perception of the environment.

Even so, could there also be types of sleep experience that lack imagistic or propositional contents altogether?

The question of whether some form of experience persists throughout deep, dreamless sleep, even when all types of imagery and propositional thought contents have ceased, is inspired by a classical Indian philosophical debate [5,18]. Many Indian philosophers argue that there exists a state of deep, dreamless sleep in which a bare form of conscious awareness remains present, but without the subject–object structure of ordinary experience and the phenomenology of being a cognitive agent [18]. In this state the immersive structure that characterizes dreaming and waking consciousness is said to have disappeared, and even the **phenomenal self** or the basic type of self–other distinction required for experiencing oneself as separate from the world is absent. In cognitive science terms, although the 'phenomenal self-model' [14] whereby the organism represents itself as a self is inactive, a minimal mode of 'selfless' phenomenal consciousness is preserved [69].

Exactly how to describe this purported type of consciousness is a complicated issue [5,69]. One candidate might be temporal experience in the form of a phenomenal 'now' and perhaps some sense of duration [69]; another is that the experience comprises a minimal mode of sentience consisting in the feeling of being alive [5,18]. In either case, 'selfless' and 'contentless' sleep experiences could involve a minimal form of phenomenal consciousness that marks a salient point of transition between unconsciousness and phenomenologically richer forms of dreamless or dreamful (immersive) sleep experiences.

Indian and Tibetan meditative traditions not only describe dreamless sleep experience as lacking imagery and propositional thought contents, but also assert that it is possible to develop a type of meta-awareness of this state [5]. An analog exists in lucid dreaming, in which dreamers are aware that they are now dreaming and have some level of dream control [70]. An intriguing possibility is that **lucidity** in dreamful sleep, which is increasingly being investigated scientifically [71], is paralleled by lucidity in dreamless sleep.

Empirical support for the possibility of lucid dreamless sleep comes from scientific studies of **mindfulness meditation** practices [72,73]. Experienced meditators, who cultivate mental attention and meta-awareness, sometimes report the experience of 'witnessing sleep' in which specific thought contents and imagery, including ones pertaining to the phenomenal self, are absent [5,18]. Electrophysiological studies have shown that such individuals have NREM sleep and SWS brain rhythms distinct from those of non-meditators and inexperienced meditators [74–77], including having enhanced gamma-band activity [75,76].

This finding of enhanced gamma-band activity is suggestive given that gamma-band activity is associated with a range of cognitive functions, including selective attention and memory [78], as well as with 'open monitoring' meditative states of heightened meta-awareness [79]. In addition, enhanced gamma-band activity differentiates lucid from nonlucid REM sleep dreaming [80], and gamma-band current stimulation over frontal areas during REM sleep may induce meta-awareness of dreaming [81]. Hence similar neural activity patterns may underlie meta-awareness of one's ongoing conscious state, both in dreaming and dreamless sleep, as well as in wakefulness.

Finally, conceptualizing 'witnessing sleep' as lucid dreamless sleep is attractive because, in some lucid dreams, phenomenal selfhood takes a minimal form or is lost completely [17]. In such cases there may be fluid transitions between lucid dreaming and lucid dreamless sleep.

Whereas the Indian and Tibetan sources focus on meta-awareness of dreamless sleep, we can also ask – again analogously to the contrast between lucid and nonlucid dreams – whether

nonlucid forms of dreamless sleep experience exist. Awakenings from NREM sleep stages 2 and 3 result in roughly equally reported amounts of dreaming, non-dreaming, and so-called 'white dreams' of having dreamt but being unable to recall any specific contents [82,83]. We conjecture that a subgroup of reports of white dreams may result not from forgetting but may accurately describe a transitional conscious state between unconscious sleep and more complex forms of sleep experience involving imagery or propositional thought. In keeping with this idea, even (immersive) dream reports from NREM sleep stages 2 and 3 often describe static content, in other words experiences lacking movement sensations and narrative progression, and having a subjective duration between 30 and 60 s [82,84].

Another possible candidate for nonlucid dreamless sleep experience is sleep-state misperception [69] in normal sleepers [85] or, more prominently, in subjective insomnia. Patients with subjective insomnia overestimate SO latency and underestimate total sleep time [86], and, following awakenings from NREM stage 2 or REM sleep, they are more likely than good sleepers to say they were awake [87]. Neuroimaging studies suggest that in subjects with insomnia, sleep onset, NREM sleep, and wakefulness are associated with specific regional activation patterns characterized by atypical levels of brainstem and limbic activity [88]. According to one model, selective attention to sleep, coupled with the explicit intention to sleep and heightened effort, can disrupt the automaticity of sleep [89]. This may lead to heightened awareness of the process of falling asleep [90] and increased monitoring of external cues, thoughts, and bodily sensations [87]. If heightened attention to sleep also enhances awareness of sleep-related experiences, and if these experiences are then misinterpreted as occurring in wakefulness, this misperception would explain the mismatch between subjective sleep perception and objective measures of sleep: individuals with subjective insomnia might misperceive sleep as wakefulness [86].

Another example of sleep-state misperception is 'microsleeps' [91]. These are very brief (sometimes less than 1 s) episodes of SO during which a lack of behavioral responding and a shift in neurophysiological measures indicate that the individual is truly asleep, although many will vigorously insist that they were awake.

Consistent with the idea that some cases of sleep-state misperception may involve dreamless sleep experience, as well as with our earlier remarks on witnessing sleep, is that mindfulness training may improve sleep quality in insomnia [92–94]. In addition, sleep-state misperception in insomnia is associated with heightened gamma activity during SO and NREM sleep [95]. Although a range of sleep-related experiences may give rise to sleep-state misperception (such as sleep thinking, bodily sensations, or realistic dreams), a subgroup may involve a state that is similar to witnessing during sleep or lucid dreamless sleep.

## Concluding Remarks and Future Directions

We have argued that the investigation of dreamless sleep experience is both conceptually sound and empirically plausible. Whereas the simulation model of dreaming offers a unified conceptual framework for specifying dreams and differentiating them from other sleep experiences, the investigation of dreamless sleep experience promises to unify lines of research and experimental paradigms that hitherto have remained largely separate, namely (i) sleep research, including work on memory consolidation in sleep, NREM parasomnias, and insomnia; (ii) dream research, which traditionally has focused mostly on REM sleep and SO; and (iii) consciousness research, which increasingly investigates dreaming [17] but has largely neglected the possibility of experience in dreamless sleep.

An integrated, multidisciplinary research program that aligns detailed phenomenological reports with fine-grained sleep-stage scoring (Box 2) while being informed by philosophical considerations from multiple cultural traditions [18] has the potential to make substantial progress on

### Outstanding Questions

What is the relation between sleep-related experience and memory consolidation? Does analyzing the memory sources of sleep-related experience cast light on the spontaneous reactivation of memories during sleep?

Do unconscious sleep automatisms exist, or is complex, seemingly goal-directed behavior in sleep (such as sleepwalking) always related to some form of phenomenal experience?

Do reports of witnessing in dreamless sleep, including reports of selfless or contentless states, constitute a robust subgroup of dreamless sleep experience? What is the relation of such reports to lucid dreaming, on the one hand, and sleep-state misperception in healthy participants and subjective insomnia on the other?

Which (if any) parts of sleep involve a genuine loss of phenomenal consciousness?

How can the analysis of sleep-related experience inform the debate on global states, levels, or modes of consciousness? What is the relationship between sleep-related experiences and altered states of waking consciousness (including meditative states), as well as psychopathologies – and how might their joint investigation help to identify new diagnostic and therapeutic methods?

Will refined sleep-stage scoring, coupled with a more precise taxonomy for describing dreams and different types of dreamless sleep experiences, enable a mapping of types of sleep-related experiences to types of brain activity during sleep or sleep stages? Or is the grain for individuating sleep-related experiences different from that required for sleep-stage scoring, such that a one-to-one mapping of conscious states to sleep stages will be impossible?

What are the fluctuations in phenomenal experience and spontaneous thought over the sleep–wake cycle? In other words, what is the relationship between spontaneous fantasy and waking mind-wandering, on the one hand, and sleep onset imagery, dreams, and also sleep thinking and other types of dreamless sleep experience on the other?

### Box 3. Methodological Advances in Investigating Conscious Experience in Sleep

To make progress on investigating dreamless sleep experience a multilevel strategy is needed that combines detailed mentation reports with a refined understanding of cognitive functioning during sleep, sleep behavior, and advanced measures (such as high-density EEG or neuroimaging) of neural activity.

This proposal is guided by the research program of neurophenomenology [103] in which detailed, first-person reports about moment-to-moment subjective experience are related to ongoing neural dynamics as a means to investigate underlying spontaneous brain activity. It also extends the method of gathering dream reports following timed awakenings coupled with polysomnography – the gold-standard method of scientific dream research [17]. Instead of assuming the contrast between dreamful and dreamless sleep to align with the contrast between REM and NREM sleep, our proposal emphasizes changes in experience within the same sleep stage.

Possibly the most important recent methodological advancement is the use of serial awakening, within-state paradigms [82,83,98]. Whereas traditional studies focusing on REM sleep perform no more than 4–5 awakenings per night, these studies use multiple awakenings (up to 12 per night) at short time-intervals from the same sleep stage. Coupled with high-density EEG and/or transcranial magnetic stimulation (TMS) [105], this is a powerful method for correlating within-state changes in brain activity with different types of experience reports.

Existing studies have focused on contrasting the presence and absence of conscious experience, thought-like versus perceptual experience, and different types of contents (such as faces, spatial settings, movement, and speech) [83]. In the simulation model, however, fully fledged dreaming is characterized not so much by a particular type of content as by a structural feature, namely, the organization of an integrated, mostly visuospatial scene around a subjective first-person perspective.

Following the neurophenomenological approach [103], we propose combining within-state, serial awakenings with more fine-grained phenomenological categories. Our taxonomy of dreamless sleep experience (Box 1) could be used to develop specific probe questions and scales for categorizing sleep mentation reports. Phenomenological reports from trained participants and specific participant groups (lucid dreamers, experienced meditators, and patients experiencing insomnia or parasomnias) could be used to chart the range of dreamless sleep experience. While this approach relies strongly on retrospective reports, this limitation is arguably intrinsic to all attempts to study the phenomenology of sleep-related experience, and of subjective experience more generally [17]. A multilevel approach integrating different types of data (e.g., from retrospective mentation reports, and also from behavior and polysomnography, eye-movement signals from lucid dreams, pre-and post-sleep performance on memory tasks, etc.) could then render this approach even more powerful (Figure 1).

these issues (Box 3). We have argued that the common characterization of dreamless sleep as a uniform state of unconsciousness is implausible. Instead, different subtypes of dreamless sleep experience exist. NREM sleep, including the deepest stages of sleep (or SWS), is a potentially rich and largely untapped source for their investigation. NREM and especially SWS may also be particularly promising for contrasting dreamless sleep experience with unconscious sleep (see Outstanding Questions).

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