Dream Recall and Content in Different Sleep Stages

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Many researchers have attempted to characterize the association between sleep physiology and dreaming, with some consensus that both dream recall frequency and dream content fluctuate in predictable ways across a night of sleep. Dream recall and content seem to be tempered, on the one hand, by the cycle of sleep stages which occurs approximately every 90-minutes, termed the ultradian rhythm, as well as by the total duration of sleep and the time of night, linked to the circadian rhythm, the approximately 24-hour long cycle.

The REM sleep = dreaming paradigm

The study of dreams in scientific research laboratories began with the discovery of rapid-eye-movement (REM) sleep by Aserinsky and Kleitman (1953), who are credited with having the first sleep research laboratory that discovered the "rapid, jerky, binocularly symmetrical movements" of the eyes, characteristic of that sleep stage, and intuited that these eye movements correspond with the visual activity of dreaming—what's now known as the "scanning hypothesis". They further associated dreams with these eye movements, finding that 74.1% of participants recalled dreams from REM sleep, whereas only 17.4% recalled dreams from Non-REM sleep (NREM). In 1957, researchers Dement and Kleitman conducted a similar study eliciting 351 awakenings in nine participants during different stages of sleep, which corroborated earlier findings of a very high percentage of participants recalling dreams from REM sleep (80%), whereas only 6.9% recalled dreams from NREM sleep. These early studies instituted the notion that dreaming may be a REM sleep phenomenon and research continued for many years under that assumption with several other laboratory studies observing similarly high recall from REM sleep and low recall from NREM sleep. Some researchers even referred to REM sleep as dream sleep or D-sleep. To date, researchers find the correlation of dream recall and REM sleep to be consistently high (around 80% on average), suggesting that the neurophysiology of REM sleep is a strong enabling condition for vivid dreaming and for cognitive processes, such as attention and memory, that underlie dream recall upon awakening.

Despite the evidence that dreams could be recalled at least some of the time from NREM sleep, initially it was presumed that the relatively infrequent NREM dream reports were actually due to memories of prior REM sleep dreams occurring earlier in the sleep cycle, as it was thought that NREM sleep itself could not give rise to dreaming. Nevertheless, in 1962, researcher David

Foulkes conducted a study collecting 134 dream reports across the night, which demonstrated that in fact dream recall can be observed from any stage of sleep and at any time of the night, including in a NREM sleep stage that preceded any REM sleep. This meant that the NREM dream recall could not be attributed to a prior REM dream. Since then, many researchers have confirmed that dream reports can be obtained from all NREM sleep stages.

Further, there has been an increase in the percentage of NREM dream recall found in studies over time, though this data remains inconsistent (Nielsen, 2011). Inconsistencies are likely due to the varying definitions of dreaming used by experimenters. Some use a more inclusive dreaming definition, such as 'sleep mentation', which is characterized by any cognitive activity, whereas the original concept of dreaming was more qualified as hallucinatory, predominantly visual, imagery (see also chapter 5). The questions used by an experimenter can alter a participant's interpretation of dreaming. For example, the question, "what was going through your mind just before I called you", will encourage more frequent dream reports than, "what were you dreaming about?" In fact, in the aforementioned 1962 study, Foulkes discovered that by modifying the question posed to participants on awakening, by asking whether they were thinking of something before being signaled rather than if they recalled a dream, he was able to obtain 70% recall rates from NREM sleep; in other words, the majority of participants reported having had some thoughts in mind prior to awakening from NREM sleep. Although initially criticized, these observations have since been confirmed by other researchers, proving again that dream reports can be obtained from all stages of sleep if sampled appropriately.

As another methodological consideration, the circumstances around an awakening also play a significant role in frequency of dream recall. For example, if a participant has a task to complete immediately upon awakening, this distraction will interfere with and reduce dream recall compared to participants who are allowed to lie in bed and collect their memory of a dream. Sudden awakenings are also shown to induce better recall than gradual awakenings. In effect, anything that distracts an individual upon awakening will interfere with their ability to compose and gather their memory of a dream. Lastly, not recalling a dream is not a proof of absence of an experience during sleep. There may be many factors that contribute to remembering and forgetting of an experience, including individual introspective and motivational factors.

Variations in dream content by sleep stage

In modern day dream research, mentation can be sampled from 4 major sleep stages, with NREM sleep being split into stage 1 sleep which occurs at the transition between wakefulness and sleep, to stage 2 light sleep, and finally to stage 3 deep sleep. The majority of researchers agree that some quality of mentation can occur in any of these three stages of NREM sleep, and of course is most frequent in REM sleep. However, while dreams may be recalled from any stage, there are differences in the type and quality of mental activity occurring in these different stages. For example, dream reports are longer after REM than after NREM awakenings, and REM dream reports are consistently more elaborate and immersive than are NREM dream reports, which are more thought-like, and even mundane.

Several studies in the past decade have explored dreams occurring in the brief transition between sleep and wakefulness which can occur both at sleep onset, and upon awakening, termed

the hypnagogic and hypnopompic states, respectively. The dream reports obtained at the moment of sleep onset can surpass the frequency and length of dream recall obtained from other NREM sleep stages. A comprehensive review by Nielsen (2011) found that anywhere between 31-76% of stage N1 sleep reports contain dream imagery. The content of stage N1 (sleep onset) dream reports is often brief but with vivid visual and auditory experiences and even sensations of movement in the body, as in the common sensation of 'falling' or 'dropping' off to sleep. Another interesting phenomenon that occurs in hypnagogic and hypnopompic states is the incorporation of external sensory detail into imagery, such as the alarm clock going off and creating a dream of a dog barking. This sort of imagery where a real world stimulus seems to give rise to an image was noted in the famous guillotine dream of Maury, where the headboard of the bed fell and Maury dreamt of a guillotine dropping on his neck (see also chapter 7). Numerous examples in the literature gave rise to the theory, known as the "cassette theory of dreaming" that posits that dreaming in fact occurs only at the moment of awakening, as the conscious mind interprets sensory stimuli through imagery, and mentally "rewinds" the memory to create a longer and a more coherent narrative. For many scholars, surprisingly, this theory was perceived as more rational than supposing that cognitive activity could possibly occur in the sleeping state. With the advent of neuroimaging and more precise methods of assessing cognitive activity during sleep, including work in lucid dreaming, researchers now concede that dreaming and cognitive activity do occur within the sleep state itself.

Stage N2 dream reports have been the most thoroughly collected and studied compared to other NREM sleep stages, and in the past 15 years the percentage of awakenings that are associated with some report of mental activity from stage N2 sleep has hovered around 60-70%. Despite this high recall frequency, comparative analysis between stage N2 and REM sleep dream reports has consistently found stage N2 dreams to be less frequent and shorter than REM dreams, to have less perceptual content, characters, places, actions, and emotional content, and to be less personally involving. Stage N2 dream reports also seem to be less bizarre, to have logical thought similar to that in wake, and to incorporate fragments of recent waking life episodes. Several of these differences have been verified in multiple studies, and it has become common practice to refer to the brief dreams characteristic of stage N2 sleep as more 'thoughtlike', while the narrative REM dream reports are often described as more 'dreamlike'. Some authors have contested whether stage N2 mentation can be categorically qualified as 'dreaming' per se, due to these qualitative differences. Nevertheless, these are not absolute qualities, as there is a broad spectrum of individual differences in quality of stage N2 dream reports, and in fact, a small minority of dreams reported from stage N2 sleep are actually quite 'dreamlike' and even indistinguishable from typical REM sleep dream reports.

Finally, deep slow wave sleep (stage N3 NREM sleep) has also been associated with dream activity, particularly by Cavallero and colleagues (e.g., 1992). In this study, 65% of slow wave sleep awakenings were accompanied by some mental activity, and although many reports were quite short, they still showed clear signs of dream imagery of self, perceptual, and emotional qualities. Early researchers considered it physiologically impossible for cognitive processes to occur during the relative depth and neural quiescence of deep sleep. More recently, neuroimaging and behavioral studies have found that slow wave sleep is in fact far from being a period absent of activity, and indeed may be involved in processes of memory consolidation and cognitive

enhancement. In general, the existence of dream generation and veridically recalled dreams from all stages of NREM sleep is now admitted by the majority of researchers.

It is well accepted that REM sleep dreams are the most 'dream-like' in their immersive and narrative, yet bizarre nature. And given that REM sleep is much more predominant in the early morning, these are the types of dreams that people most often awaken from and remember in their daily life. Recent research suggests that certain REM dream qualities, such as emotional intensity, are driven by the neurophysiology of the REM sleep state. For instance, activity in the limbic system, which is associated with emotional processing, is heightened in REM sleep and is somewhat inhibited in NREM sleep stages. The emotional intensity of REM sleep dreams is part of what makes them so engaging and memorable. Another common attribute of REM sleep dreams is their reference to recent waking life concerns and incorporations of recent waking life memories. This pattern of incorporating memories for experiences from the previous day, termed the day residue, as well as memories for those experiences from about a week ago, termed the dream-lag effect. The combination of recent personally relevant and emotional memory traces woven into the long narrative nature of REM dreams, suggests that dreams may contribute to some mnemonic process attempting to integrate and make sense of those experiences, which are of most import in waking life.

Nevertheless, there is some contention over whether stage-related differences in content may be simply due to the duration of a dream, with longer dreams occurring in REM sleep, which then allow for longer and greater descriptive detail in dream reports. Dream report length can be assessed either by counting the number of content-bearing words in a report, or by counting the number of temporal units in a report, e.g., each action or interaction is a distinct temporal unit. Some researchers have suggested that the qualitative differences mentioned above are only secondary to a simple quantitative difference in dream length, and indeed, certain REM/NREM dream content differences tend to disappear when word length is controlled, although not all: in particular, REM dreams remain more emotionally salient than NREM dreams.

Further, support for claims that REM dreams differ qualitatively from NREM dreams exists in the various forms of intensified dreams which are more frequently recalled from REM sleep. For instance, lucid dreams, which are dreams where the dreamer is aware that they are dreaming, are specifically recalled from REM sleep. In experiments led by LaBerge (1986), frequent lucid dreamers were recruited to sleep in the laboratory, where they reported emotionally and perceptually vivid dreams marked by a mental capacity strikingly similar to that of waking life, including access to logic, voluntary control of thoughts and actions, and memory, and were able to recall these experiences quite clearly on awakening. These experiences were in large part occurring during REM sleep, and only rarely during Stage N2 sleep. In another example, nightmares are a form of emotionally intense and arousing dream that often result in a sudden awakening. These dreams likewise occur most frequently in REM sleep, corresponding with claims that REM dreams are specifically marked by emotional intensity.

In general, certain dream features remain significantly different between REM and NREM sleep even when word length is controlled, and consistent reports suggest that REM dreams are more self-reflective, bizarre, visual, emotional, have more self-involvement, and more narrative

quality than do NREM dreams, whereas NREM dreams are more brief, 'thought-like' and mundane than REM dreams.

Variation in recall and content across the ultradian sleep cycle

Because stages of NREM and REM sleep are defined categorically, a hypnogram of a normal night of sleep seems to follow a pattern of abruptly transitioning from one type of sleep to the other (see chapter 2). However, many studies indicate that transitions between sleep stages are in fact much more fluid than previously thought, following a 90-minute cycle that continuously ebbs and flows from deep NREM to light NREM to REM sleep and back. Collecting dream reports at multiple time points within a given sleep stage conforms with this cyclical pattern, with both frequency and content of dreaming showing oscillatory changes throughout a sleep cycle, as opposed to sudden changes in dream quality occurring in concert with categorically determined sleep stage boundaries.

For instance, when relationships between dream report length and time elapsed in REM or NREM sleep are assessed, dream length fluctuates in a cyclical, sinusoidal pattern over time. Report length is thought to measure the overall quantity of dream content, and, as mentioned earlier, REM dream reports are consistently longer than are NREM dream reports. However, more detailed empirical work suggests that dream length in fact oscillates over consecutive REM and NREM episodes in an ultradian pattern. A study by Stickgold and colleagues (1994), found that, for REM sleep dream reports, overall report length is lowest at the beginning (0–15 minutes) and at the end (45–60 minutes) of a REM period, and length is highest in the middle of the REM period (15-45 minutes). NREM sleep dream reports show the opposite pattern, with dream length decreasing into the middle of the period, before increasing again when nearing an oncoming REM period.

Similar results have been found in other studies that assessed dream report length in concert with duration of time spent in REM or NREM sleep. For instance, several studies have found that NREM dream reports are longer and more frequent when they are sampled in close proximity to a REM period, whereas those sampled further from REM sleep are shorter and less frequent. Finally, the most reliable indicator of dream recall to date is the underlying patterns of brain activity. Studies show that in both REM and NREM sleep certain brain rhythms (in particular, decrease in low frequency delta activity) predicts whether or not the sleeper will be able to recall a dream upon awakening at that moment (Esposito et al., 2004; Scarpelli, 2017). In other words, dream recall is better predicted by transient brain rhythms than simply by a sleep stage.

As is the case for measures of dream recall and length, evidence indicates that various features of dream imagery progressively amplify with increasing time in REM sleep, and may decrease with increasing time in NREM sleep. For instance, dreams are considered more 'dream-like' when collected from shorter as opposed to longer NREM sleep periods, as well as being more 'dream-like' collected in close proximity to a neighboring REM period, e.g., when sampled from a NREM sleep period just 5 minutes after a previous REM period ended. For REM sleep, dream reports from longer REM sleep episodes become more dreamlike in several respects than those

from shorter REM periods; longer REM sleep reports have been described as more active, emotional, and vivid, with more visual features and narrative immersion than shorter REM sleep reports. In general, these attributes are thought to show linear increases over time in REM sleep. Nevertheless, these measures are not always consistent between studies, and some have found that certain features of REM dreams do not change as a function of stage duration.

In general, the findings for recall and length show clear patterns in sync with the 90-minute ultradian sleep cycle, whereas the specific quality of dream content shows some, but less consistent, patterns of ultradian variation.

Variation in recall and content across a night of sleep

A growing body of research suggests that the frequency and content of dreaming evolves over the course of a night, with dreams becoming more realistic and immersive in later sleep cycles. In general, the dreams collected from the first or second 90-minute cycle of sleep are markedly different from those in later cycles, and especially from the dreams occurring at the end of a sleep period in the morning.

There is a great deal of evidence that dreams late in the sleep period are longer than early dreams. Pivik and Foulkes (1968) were the first to empirically demonstrate that dream length changes across the night, with the finding that NREM dream reports became longer with each successive sleep cycle. Since then, several other researchers have followed suit with varying sleep paradigms, for instance, showing that dreams collected in the first half of the night are shorter than those collected in the second half of the night, and that longer sleep durations are associated with longer dream reports. Other qualities of dream content also seem to reliably amplify across the night. In general, studies have found that perceptual details, including visual features, are augmented in late morning dreams, and laboratory studies, have shown there is a positive correlation between the time of night and the vividness, bizarreness and emotional intensity of dreams - for both REM and NREM dreams across the night. In other words, dreams from all stages of sleep become more ‘dreamlike’ as the night goes on. There is also some evidence that dreaming across the night exhibits some continuity in thematic content, for example, dreams sampled from different stages and across a single night may all carry an overarching theme related to work or occupational concerns, even if the perceptual or emotional quality and specific details of the dream report change. This suggests there is some continuum of dreaming processes occurring across the night.

It is thought that the circadian peak, which occurs at the end of the sleep cycle in the early morning, stimulates higher dream recall and a greater predominance of attributes such as character interactions, emotional contents, and dream vividness. However, some researchers have suggested that increasing dream vividness is tied to the duration of the sleep period, as opposed to the 24-hour circadian rhythm. Evidence for a specific circadian influence on dreaming has been shown in studies that alter the timing of a sleep period without altering sleep duration. For instance, delaying sleep by 3 hours was associated with more vivid dreaming in one study (Antrobus, 1995). Others have used nap protocols to assess dream content outside of a normal sleep period. For example, one experiment used an ultra-short nap protocol where participants took 20-minute naps every hour for 78 hours and reported dreams after each nap. Consistent with a circadian explanation, it

was found that NREM dream intensity peaked in the morning, even though NREM sleep duration is shortest in the morning (Suzuki et al., 2004). Finally, a recent study used a morning nap paradigm, and found dream recall rates for NREM (89%) and REM (96%) sleep that were even higher than those seen for a typical night of sleep (Carr & Nielsen, 2015). This suggests that a circadian peak in dream generation may occur in the morning, regardless of the duration of the sleep period.

While dreams sampled from both NREM and REM sleep seem to intensify across the course of the night, the two types of reports continue to differ in some qualitative respects. In particular, REM dream reports continue to exhibit elevated levels of bizarreness and emotional content, and more vivid perceptual experiences, which suggests that certain stage-related content differences may persist across the night. Additional research comparing dreams sampled at different time-points throughout the day and night is needed to determine the qualities of REM and NREM dream reports that are more influenced by circadian or stage-related mechanisms.

In general, it seems that both circadian- and ultradian-rhythms exert some influence on dream content, and while late-REM dream reports continue to be more emotionally intense and vivid than late-NREM dream reports, both REM and NREM dream reports are more bizarre, dreamlike, and longer later in the night.

Conclusion

Dreams, while initially associated only with REM sleep, are in fact possible in all stages of sleep. Though REM sleep continues to be consistently associated with higher dream recall than NREM sleep, variations in methodology, sleep stage duration, and time of night, can influence the content or increase the frequency of dream recall from NREM sleep. In general, the quality of NREM and REM dream reports differs in consistent ways. NREM dreams are typically shorter, more fragmented and more thought-like whereas REM dreams are longer, more emotional, and more bizarre. Attributes such as length, bizarreness, and perceptual vividness increase for both NREM and REM sleep reports across the night, although REM sleep dreams continue to be more emotionally and perceptually vivid than NREM dreams. While these results require more clarifying research, they demonstrate that various features of dreaming are driven by both ultradian and circadian cycles, with the time-of-night increase in dream vividness likely due to circadian influence, and the REM/NREM differences driven by ultradian influence.

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