

Book review: Zadra, A., & Stickgold, R. (2021). When brains dream: Exploring the science and mystery of sleep.

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Summary. The book is full of personal anecdotes and examples of empirical studies the authors carried out; this is fun to read and illustrates the enthusiasm of both authors regarding dreams. The book is also full of useful information, starting from a brief overview regarding the history of dream research to current research topics like lucid dreaming, nightmares, and sleep-dependent memory consolidation. The authors propose a framework called “Network exploration to understand possibilities” (NEXTUP) indicating possible function(s) of dreaming, the conscious experiencing during sleep that might be different from the functions of sleep per se. Although, some aspects of the model seem plausible and are based on previously formulated hypotheses about dream function, the major caveat is the testability of functions of unremembered dreams. Based on the findings so far, my bet would not be to focus on weak and previously unexplored associations for explaining how dreams relate to waking-life issues but pursue the idea that dreams are straight-forward depictions of waking-life emotions and basic behavioral patterns using graphic, dramatic metaphors to make sure the dreamer understands the importance.

Keywords: Dreaming, nightmares, sleep-dependent memory consolidation

The book “When brains dream” is a treasure trove of information about current dream research, with some sleep-dependent memory consolidation (evolution was the term the authors used) research on the side. Both authors have been doing dream/sleep research for over thirty years (the earliest publications I found: Stefanakis et al., 1990; Stickgold et al., 1991) and are still active in the field. Due to their broad knowledge and the studies they conducted, the book is full of interesting facts and empirical findings. Some of these will be highlighted in this review. The second aim of the book was to present a new hypothesis about dream function called “Network exploration to understand possibilities” (NEXTUP). Given the fact that the book is a popular science book, it is understandable that previous theories that form the foundation of NEXTUP are not explicitly mentioned. For example, “When brains dream, they tend to select ongoing concerns that have emotional salience (p. 272)” was formulated within the mathematical model of the continuity hypothesis (Schredl, 2003) and was empirically tested (Malinowski & Horton, 2014; Schredl, 2006) quite some time ago. Interestingly, this style of not acknowledging predecessors properly was used by Sigmund Freud (Freud, 1900/1991) and was heavily criticized by the authors in Chapter 3. In my view, several basic concepts within the NEXTUP framework are somewhat “muddy” and the question as to what aspects of the model are new is debatable.

The second part of the review will point out a few thoughts regarding the possible function(s) of dreaming.

I was very glad to see that the authors tackled the problem of defining dreaming and dreams (Chapter 1) and went beyond a previous paper (Pagel et al., 2001) that highlighted the fact that different academic disciplines and different cultures understand dreaming differently (which is to be expected). Dreaming is defined as conscious experiencing during sleep and the dream or dream report is the recollection of this experience after awakening (see also: Schredl, 2018). The authors highlight the fact that for young children dream experiences are real and they – Tony’s nephew is mentioned in the book as being annoyed about a nosy dream researcher asking him about his dreams – have to learn that dreams are internally generated experiences. The fact that dreams are experienced as real as waking life while we are within the dream is one of the most basic characteristics of dreams. The only exceptions are lucid dreams in which a dreamer is aware that s/he is in a lucid dream. The topic of definition is elaborated further in Chapter 6 entitled “Do dogs dream?” As the dream experience cannot be measured from the outside (EEG or with brain imaging techniques), the researcher (and the dreamer himself/herself) has to depend on the dream report, i.e., remembering upon awakening what happened beforehand. However, what about rats, dogs, cats, or babies? Do they have conscious experiences during sleep even if they cannot provide verbal reports after awakening? The studies of Michel Jouvet showed that cats with lesions in the brain stem move during REM sleep – like humans with the rare REM sleep behavior disorder which is also mentioned in the book – and show similar behaviors (grooming, chasing, etc.) as in waking life (Jouvet, 1979). Most researchers (e.g., Chen & Wilson, 2017; Wilson & McNaughton, 1994) agree that the brain activity of the sleeping brain is – at least in some aspects – comparable with the brain activity related to the activity in waking but a very strict definition of dreaming as conscious experiencing would not

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include dogs, cats, and rats. Without their scientist hats, though, the authors argue that dogs, cats, rats, and babies do have dream-like experiences during sleep (p. 86).

In Chapters 2 to 5 the authors briefly review the contributions of previous scholars to the study of dreams, with Sigmund Freud's book "Die Traumdeutung" published in 1899 and the discovery of REM sleep published in 1953 (Aserinsky & Kleitman, 1953) as two of the milestones. The authors present a brief and selected overview of the literature on dreams published before 1900 in order to demonstrate that Freud's ideas rooted in the current thinking of the time. Unfortunately, many books have not been translated into English and are only available in German, French, or Italian. I personally would like to read the very influential book of Alfred Maury (Maury, 1861) but French was my worst subject in school. I was very happy that the French book about lucid dreaming (Saint-Denys, 1982) was translated into English. The authors refer to a very interesting study of Harvey de Saint-Denys; he associated a specific odor with a specific location, e.g., countryside, and reported that dreams of the countryside increases if his valet put the specific odor (perfume) on the pillow before his typical awakening time. We were able to use a modern experimental approach matching odors with pictures in the evening, and – at least partly – corroborated the findings of Saint-Denys (Schredl et al., 2014). A German dissertation (Weygandt, 1893), for example, focused on the effect of internal (e.g., pain) and external stimuli (in one experiment, the apprentice was singing to the sleeping person) and produced interesting results (Schredl, 2010). Another German research group discovered cycles of 85 minutes on average of penile erections (Ohlmeyer et al., 1944) which we now know are associated with REM sleep. They often do not get credit as it was published in German. If you are interested in a more comprehensive history of dreaming, the book "Our Dreaming Mind" by Robert Van de Castle should be your first choice (Van de Castle, 1994).

In Chapter 7, the authors very briefly review the efforts of previous researchers when coming up with possible functions of dreaming. As NEXTUP is building on these research efforts, the depictions and discussions of these theories is – in my opinion – too short. For example, the Social Simulation Theory (Revonsuo et al., 2015) does account for the fact that dreams often include social interactions (sociality bias). If you take a look at what students are doing during waking-life, like studying, meeting with friends and so on, the time spent with academic tasks (if the student is diligent) per day is considerable but, nevertheless, academic tasks in dreams are quite rare, as dreams often revolve around social relationships (Hartmann, 2000; Schredl & Hofmann, 2003). These findings were not integrated into NEXTUP. I was also astonished to find no reference to Allan Hobson's protoconsciousness theory (Hobson, 2009) that aimed to explain why children have more REM sleep and sleep in general than adults. A more thorough review might have interfered with the authors' claim "we propose a new and innovative model of why we dream (p. X)".

Chapter 9 is an excellent review of the findings of dream content analysis, e.g., the research efforts of Calvin Hall and his co-workers (Hall & Van de Castle, 1966). For example, one question that is often asked is whether we dream in black-and-white or in color. Interestingly, this question was not important before the introduction of black-and-white media; and after the introduction of colored films, TV and so on, only a very small minority of persons still thinks dreams

are in black-and-white (König et al., 2017). Studying the underpinnings of that would be very interesting.

Research on typical dreams, recurrent dreams, and nightmare content is the subject of Chapter 10. The question as to why typical dream themes, e.g., being chased, flying, falling and so on are typical, i.e., reported by many individuals in different cultures (Schredl, 2019), is still unanswered. One explanation might be that dreams, especially nightmares, reflect waking-life emotions and behavioral patterns that are common in waking life (Schredl, 2015). For example, the falling dream could be conceptualized as an exaggerated version of the fear of losing control; in a falling dream there is only one thing that is certain: No matter what you do you will hit the ground (most often dreamers awake before this happens). Or, dreams of being chased (experiencing fear/panic and running away) are dramatized versions of avoidance behavior which is quite common in waking life (on much smaller scales regarding the emotional intensity); thus, the high frequency of persons experiencing dreams of being chased could be explained. This line of thinking is not exactly compatible with NEXTUP (see below).

In Chapter 11, the authors addressed the link between dreaming and creativity. Especially when discussing the link between dreaming and memory consolidation, it is important to emphasize that we can dream about things we have never experienced in our waking life, e.g., certain painful experiences (Schredl, 2011b), flying (Schredl, 2011a) or bizarre elevator rides (Schredl, 2020). The anecdotes indicating that scientists, artists, musicians obtained inspiration from their dreams, e.g., Paul McCartney dreaming the melodic line of the song "Yesterday", can be found throughout the literature (Barrett, 2001). We were able to demonstrate that dreams with some kind of inspiration for waking life also occur in "normal" persons; about 8% of the dreams include something helpful for writing a thesis, an idea for a present or a holiday destination (Schredl & Erlacher, 2007).

Studying creative processes during sleep onset systematically has a long history (Silberer, 1909) and has been revived using modern technology (Haar Horowitz et al., 2020). The Dormio device presents verbal stimuli; the authors illustrate the procedure with an example using the word "fork" and collect sleep-onset dreams. The dreams included forks but in more or less bizarre contexts – indicating that the mind is very creative at sleep onset. As creativity is important in a variety of professions these approaches might provide promising applications in the future.

Chapter 13 is dedicated to phenomena that are associated with dreaming and that might require treatment, e.g., the rare sleep disorder narcolepsy, posttraumatic stress disorder, sleepwalking, REM sleep behavior disorder, and the nightmare disorder. The authors provide very helpful information; especially since surveys have indicated that health professionals and affected individuals do not know much about these phenomena, let alone about treatment options, e.g., for the nightmare disorder (Nadorff et al., 2015; Schredl, 2013; Thünker et al., 2014).

In chapter 15, the authors tackled the sensitive topic of telepathic and precognitive dreams. I am very empathetic with Tony regarding the requests of persons who approach dream researchers and want them to confirm their story of having dreamed something beforehand they could not have predicted. It can be very annoying if you offer a dream workshop, teaching and practicing techniques for understanding your dreams and linking them to your waking-life experi-

ences and some participants just want to tell their stories and not talk about their dream life – just telling their precognitive dreams. Depending on the study population, about 50% of the participants have reported having these experiences (Schredl, 2009). One extreme case was a young man who contacted me reporting a nightmare of being shot. As this nightmare was an extraordinarily vivid dream for his standards, he developed an anxiety disorder, thinking that the day of his death is in the near future. As precognitive dreams are reported so frequently, it does make sense to study this parapsychological phenomenon (if you can call such a frequently occurring phenomenon paranormal) and the way persons deal with it. If you are interested in this topic, I strongly recommend reading the very instructive book about the Maimonides dream studies (Ullman et al., 1989).

Knowing Tony Zadra personally, I enjoyed reading that a nightmare turning into a lucid dream had a profound effect on his choice of career, that is of becoming a dream researcher. So, this was a very influential dream as Tony – being one of the leading dream researchers worldwide – has contributed a lot to the field. These personal experiences reported by both authors increase the readability of the book and illustrate how fascinated Bob and Tony are by dreams and dreaming. Lucid dreaming is currently a “hot topic” in the general public, boosted by movies like “Inception”. So, the information about the phenomenon, its application, and induction techniques (How to increase the frequency of lucid dreams?) comes in handy. I can add that experiencing lucid dreams – typically for a maximum of 5 to 10 minutes during a total night – does not interfere with the feeling of being refreshed in the morning (Schredl et al., 2020). The possibilities that lucid dreams offer, e.g., two-way communication with a sleeping person, sound like science fictions but are actually studied in different labs around the world (Konkoly et al., 2021).

As I was myself active in the field of sleep-dependent memory consolidation, the claim of the authors “... , it wasn’t until 2001 ... that an article from Bob’s laboratory entitles ‘Sleep, learning, and dreams: Offline memory processing’ ... finally pushed the research community into taking the idea of sleep-dependent memory consolidation seriously.” is somewhat strong. Thinking back, my boss approached me with two papers shortly after they were published in 1994 in “Science” (Karni et al., 1994; Wilson & McNaughton, 1994) and asked me whether I could set up a research program addressing sleep-dependent memory consolidation in the elderly (Hornung et al., 2007; Schredl et al., 2001) since one of her research interests was Alzheimer’s disease. So, I was astonished to read in Allan Hobson’s book “Dream life: An experimental memoir” (Hobson, 2011) the following sentences: “Bob noticed an early report in the journal Science that the retention of learning required REM sleep. That report was written by the Israeli scientists Avi Karni and Dev Sagi ... and Jean Ashkenasy (p. 168)”, i.e., Bob Stickgold read the same paper we did. The fascinating aspect was that the Karni et al. paper not only showed that sleep reduced the amount of forgetting (possibly explained by no input of new information that might interfere with retention of the learned material) but clearly indicate that active processes during sleep must be at work, as the participants were faster in the visual discrimination task after sleep. For me, this paper was the driving force in the renaissance of the sleep-dependent memory consolidation research and stimulated, for example, Jan Born and his associates carrying out many

sophisticated studies in the field (Diekelmann et al., 2009) even before the 2001 Science paper that Bob Stickgold read. Typically, the scientific field is more impressed when different labs obtain the same findings compared to efforts of a single research group.

I was very astonished to read “Dreams normally show little transparent relevance to or usefulness for ongoing concerns.” (p. 272). Let me illustrate my objections using a recent dream of my own:

“I’m in a large pub (more like a basement) and sit at a small table with a young man and a woman (built-in tables, ours is on the wall). I’m supposed to teach the young man statistics, very simple things. He takes a break and goes away. I would like the woman to continue writing it down; I complain that things are going so slowly. However, she doesn’t want that. The young man comes back, is bumbling, I get gasoline on my pants when he fiddles with a gasoline hose. I say that I don’t feel like teaching anymore. However, this is not so easy because the young man belongs to a criminal organization. Such a rejection may be punishable by death. That may be true but I don’t care. It’s just a torture. A man comes into the pub who apparently wants to challenge some of the mafia. They are close to each other. I’m a little afraid that it will hurt me. (March 19, 2021)”

The evening beforehand I was talking to a friend on the phone about a basic pattern that was enforced on me during childhood by my father but is still active today, my fear of frustrating other persons. For me, the dream was a creative way to embody this fear, also embellishing the associated emotions as you typically are not killed if you reject teaching someone simple statistics. However, the dream also shows that I am not willing – despite the fear – to subordinate myself to this pattern anymore. So, the dream was straight forwardly related to a topic in my current waking-life since I had spoken with my friend about this pattern due to a recent situation that activated the conditioned fear. Having recorded over 15,500 dreams since 1984, I cannot agree with the above cited statement of the authors.

In Figure 8.2 on page 111, the authors present a study demonstrating that participants do not respond as quickly to strongly associated word pairs after being woken up after REM sleep compared to doing the task when being fully awake (or after being awakened from REM sleep). This so-called carry-over effect, also called sleep inertia because the brain has problems doing a lot of things when in this state (Tassi & Muzet, 2000), is based on the fact that the brain needs time to switch from the sleeping mode to the waking mode. The findings indicate that the brain having the task of sleep-dependent memory consolidation (REM sleep) is not able to process externally presented stimuli in the expected manner, which makes sense. The leap holding that this finding supports that dreaming (based on processing internal information) is guided by weak associations (one building block of NEXTUP) is – in my opinion – a big one.

The link between another experiment presented on page 66 and NEXTUP is also not straightforward: the study indicates that participants who learned words associated with doctor but not the word itself falsely recall the word doctor after sleep more often than after a similar period of wakefulness; the authors conclude “Dreams don’t replay memories exactly; they create a narrative that has the same gist as some recent memory ... (p. 67).” For me, this experiment

supports the idea of strong associations between waking life and dream elements, and not weak associations as postulated by NEXTUP.

The NEXTUP model postulates a different function for dreams of the different sleep stages (sleep onset, NREM, and REM): Hypnagogic dreams are overtly related to current waking-life concerns, NREM dream incorporate recent episodic memories, and REM dreams incorporate older and weaker semantic associations (pp. 272-273). In my view, there is a much simpler explanation for these observations. Imagine you had an intense quarrel with your partner; immediately afterwards you think about what you said and what s/he said. After some time (an hour or two) you think of other quarrels with her/him, and several hours after the incident you will think about a lot of things that might or might not be related to quarrel experiences. That is, it is a matter of time. And research has indicated that the time of the night is indeed related to the remoteness of the temporal references of dreams elements (see: Schredl, 2003). Moreover, research indicate that NREM dreams of the second part of the night often cannot be distinguished from REM dreams (Antrobus, 1991). This would indicate that the function of dreaming (subjective experiences during sleep) might not differ qualitatively between sleep stages but the associations processes progress smoothly with sleep duration.

I like the idea in which the authors postulate that dreaming as conscious experiences during sleep might serve another function beyond the sleep-dependent memory consolidation that takes place on a neuronal or systems level (with conscious processing involved); we don't dream about word-pair associations – a commonly used task to study slow-wave sleep dependent memory consolidation (Plihal & Born, 1997) – or mirror tracing (Schredl & Erlacher, 2010). Formulating this in an explicit way is new.

But what exactly is the benefit of exploring unexpected association? Let's consider Bob's dream example about an aspect of his work that he didn't like. It's about operating on dogs for scientific and/or educational purposes. In his dream, this daytime topic was picked up but the dog changed into his daughter whom was operated on. Luckily, the dream changed and the wounds due to the operation healed without leaving scars. Interestingly, the dreamer was just watching and not doing anything, also reflecting his waking-life behavior: avoiding the topic by asking colleagues to supervise these dog studies, that is, not launching a campaign addressing the violence against animals in the name of science.

But for a dream to have a function, biological, and/or evolutionary, there should be an effect on subsequent behavior. In the example, the decision was already made, so the dream reflected the experiences of Bob in a creative way, even exaggerating the related emotions by replacing the dog with his daughter but the question as to whether the dream was in any way helpful (for survival and/or reproduction) is left open. The authors indicate an emotional association between the dog and Bob's daughter: both are small and helpless (p. 113).

This reminded me of the Contemporary Theory of Dreaming formulated by Ernest Hartmann (Hartmann, 2011): The connections are guided by the emotions and/or the emotional concerns of the dreamer; for a brief summary of Hartmann's theory see Schredl (2012). One might speculate as to whether the authors' claim that dreams explore unexpected and often previously unexplored associations is based on

a cultural bias – as modern Western thinking is focused on reason and not emotion. Moreover, Hartmann's postulate that the function of dreaming – whether remembered or not – is to weave new material into existing memory systems (Hartmann, 2011) – sounds almost identical to the "new" NEXTUP model.

Postulating a different function for dreaming separate from the function of sleep-dependent memory consolidation does not explain why some studies found a correlation between dream content and memory performance after sleep. The study presented in the book (p. 102ff) using a maze task within a nap design (Wamsley et al., 2010) should be viewed with caution as the persons who recalled a maze-related dream were worse than average in the learning phase and comparable to the group mean in the retest, i.e., the gain is larger but in the end they were not better than the others. Maybe they dreamed about the maze because they didn't perform so well.

Interestingly, the same pattern (increased gain for participants reporting task-related dreams due to low baseline performance) was also found in a subsequent over-night study conducted by the same authors (Wamsley & Stickgold, 2019). Another research group using a word-picture association task found that participants with task-related NREM dreams performed better in the morning (Schoch et al., 2019). Using a paradigm even closer to dreams, that is, recalling a film clip, REM dream incorporation were related to memory performance in the morning (Klepel & Schredl, 2019), indicating that the role of dreams in sleep-dependent memory consolidation might indeed depend on the paradigm used; tasks that parallel episodic memory (storing the waking-life experiences of the dreamer) might be more promising than word-pair associations or procedural tasks like maze learning or mirror tracing.

The authors took up the idea suggested by Domhoff (2011) that the default mode network might be the neurological substrate of dreaming (p. 120ff). I find this interesting because daydreaming/mindwandering that is also related to the default mode network might have functions similar to the dreaming that occurs during sleep. Unfortunately, there are so far no studies linking default mode network activation patterns to the dream experience itself – mainly because it is so difficult to sleep in an MRI scanner for a longer time period.

The most important question ("Gretchen-Frage" in German, based on Goethe's work "Faust") was somehow left out by the authors. Is it possible to test the function of unremembered dreams? If a dream is remembered and told, the person might think about the dream and, thus, have beneficial insights. A large variety of studies have shown that actively working with dreams in individual sessions, in group sessions, or in therapeutic settings is beneficial (Edwards et al., 2015; Hill & Knox, 2010; Pesant & Zadra, 2004). Let me illustrate this line of thinking by referring to the findings of Rosalind Cartwright who found that divorced women who dreamed about their ex-husbands were better adapted a year after the divorce (Cartwright, 1996). The first explanation might be that the divorce was worked through in the dream and, therefore, the woman benefited. However, it could also be that the women with husband dreams where thinking about the dream and this second step – not the dream itself – was responsible for the improvement. As dreams have to be told in order to know whether the person dreamed about the issue at hand, these two effects cannot

be separated. That is, we might never be able to study the function of unremembered dreams. In that sense, NEXTUP is one theoretical framework among several others like the Social Simulation Theory (Tuominen et al., 2019), Threat Simulation Theory (Revonsuo, 2000), emotion regulation theories (Kramer, 2007), or problem solving (Wright & Koulack, 1987) that makes intuitively some sense but cannot be tested empirically – not unlike Freud’s theories which were criticized by the authors in Chapter 3.

To summarize, it’s my hope that the NEXTUP theory presented in the book encourages researchers, especially young researchers, to pursue the many different topics addressed in the book, dream content analysis, nightmares, lucid dreaming, etc. On the other hand, I have my doubts about the “novelty” of the suggested theory and it leaves many more questions unanswered than answering the still elusive function(s) of dreaming, the subjective experiences during sleep. My bet would be on a theory about dream function focusing on strong and expected associations between waking-life topics and dream content based on emotions and/or metaphorical depictions of emotions and basic behavioral patterns.

References

- Antrobus, J. S. (1991). Dreaming: cognitive processes during cortical activation and high afferent thresholds. *Psychological Review*, 98, 96-121. <https://doi.org/10.1037/0033-295x.98.1.96>
- Aserinsky, E., & Kleitman, N. (1953). Regularly occurring periods of eye motility and concomitant phenomena during sleep. *Science*, 118, 273-274. <https://doi.org/10.1126/science.118.3062.273>
- Barrett, D. (2001). *The committee of sleep: How artists, scientists, and athletes use dreams for creative problem-solving - and how you can too*. Crown.
- Cartwright, R. D. (1996). Dreams and the adaption to divorce. In D. Barrett (Ed.), *Trauma and dreams* (pp. 179-185, 262-263). Harvard University Press.
- Chen, Z., & Wilson, M. A. (2017). Deciphering Neural Codes of Memory during Sleep. *Trends in Neurosciences*, 40(5), 260-275. <https://doi.org/10.1016/j.tins.2017.03.005>
- Diekelmann, S., Wilhelm, I., & Born, J. (2009). The whats and whens of sleep-dependent memory consolidation. *Sleep Medicine Reviews*, 13, 309-321. <https://doi.org/10.1016/j.smrv.2008.08.002>
- Domhoff, G. W. (2011). The neural substrate for dreaming: Is it a subsystem of the default network? *Consciousness and Cognition*, 20, 1163-1174. <https://doi.org/10.1016/j.concog.2011.03.001>
- Edwards, C. L., Malinowski, J., Ruby, P. M., Bennett, P., McGee, S. L., & Blagrove, M. (2015). Comparing personal insight gains due to consideration of a recent dream and consideration of a recent event using the Ullman and Schredl dream group methods. *Frontiers in Psychology*, 6. <https://doi.org/10.3389/fpsyg.2015.00831>
- Freud, S. (1900/1991). *The interpretation of dreams* (Org.: Die Traumdeutung). Penguin Books.
- Haar Horowitz, A., Cunningham, T. J., Maes, P., & Stickgold, R. (2020). Dormio: A targeted dream incubation device. *Consciousness and Cognition*, 83, 102938. <https://doi.org/10.1016/j.concog.2020.102938>
- Hall, C. S., & Van de Castle, R. L. (1966). *The content analysis of dreams*. Appleton-Century-Crofts.
- Hartmann, E. (2000). We do not dream of the 3 R’s: implications for the nature of dream mentation. *Dreaming*, 10, 103-110. <https://doi.org/10.1023/A:1009400805830>
- Hartmann, E. (2011). *The nature and functions of dreaming*. Oxford University Press.
- Hill, C. E., & Knox, S. (2010). The use of dreams in modern psychotherapy. *International Review of Neurobiology*, 92, 291-317. [https://doi.org/10.1016/S0074-7742-\(10\)92013-8](https://doi.org/10.1016/S0074-7742-(10)92013-8)
- Hobson, J. A. (2009). REM sleep and dreaming: towards a theory of protoconsciousness. *Nature Reviews Neuroscience*, 10(11), 803-813. <https://doi.org/10.1038/nrn2716>
- Hobson, J. A. (2011). *Dream life - An experimental memoir*. MIT Press.
- Hornung, O. P., Regen, F., Danker-Hopfe, H., Schredl, M., & Heuser, I. (2007). The relationship between REM sleep and memory consolidation in old age and effects of cholinergic medication. *Biological Psychiatry*, 61, 750-757. <https://doi.org/10.1016/j.biopsych.2006.08.034>
- Jouvet, M. (1979). What does a cat dream about? *Trends in Neurosciences*, 2, 280-282. [https://doi.org/10.1016/0166-2236\(79\)90110-3](https://doi.org/10.1016/0166-2236(79)90110-3)
- Karni, A., Tanne, D., Rubinstein, B. S., Askenasy, J. J., & Sagi, D. (1994). Dependence of REM sleep of overnight improvement of a perceptual skill. *Science*, 265, 679-682. <https://doi.org/10.1126/science.8036518>
- Klepel, F., & Schredl, M. (2019). Correlation of task-related dream content with memory performance of a film task – A pilot study. *International Journal of Dream Research*, 12(1), 112-118. <https://doi.org/10.11588/ijodr.2019.1.59320>
- König, N., Heizmann, L. M., Göritz, A. S., & Schredl, M. (2017). Colors in dreams and the introduction of color TV in Germany: An online study. *International Journal of Dream Research*, 10, 59-64. <https://doi.org/10.11588/ijodr.2017.1.34577>
- Konkoly, K. R., Appel, K., Chabani, E., Mangiaruga, A., Gott, J., Mallett, R., Caughran, B., Witkowski, S., Whitmore, N. W., Mazurek, C. Y., Berent, J. B., Weber, F. D., Türker, B., Leu-Semenescu, S., Maranci, J. B., Pipa, G., Arnulf, I., Oudiette, D., Dresler, M., & Paller, K. A. (2021). Real-time dialogue between experimenters and dreamers during REM sleep. *Current Biology*. <https://doi.org/10.1016/j.cub.2021.01.026>
- Kramer, M. (2007). *The dream experience: a systematic exploration*. Routledge.
- Malinowski, J. E., & Horton, C. L. (2014). Evidence for the preferential incorporation of emotional waking-life experiences into dreams. *Dreaming*, 24(1), 18-31. <https://doi.org/10.1037/a0036017>
- Maury, A. (1861). *Le sommeil et les rêves*. Didier.
- Nadorff, M. R., Nadorff, D. K., & Germain, A. (2015). Nightmares: Under-Reported, Undetected, and Therefore Untreated. *Journal of Clinical Sleep Medicine*, 11(7), 747-750. <https://doi.org/10.5664/jcsm.4850>
- Ohlmeyer, P., Brilmayer, H., & Hüllstrung, H. (1944). Periodische Vorgänge im Schlaf. *Pflügers Archiv für die Gesamte Physiologie des Menschen und der Tiere*, 248, 559-560.
- Pagel, J. F., Blagrove, M., Levin, R., States, B. O., Stickgold, R., & White, S. (2001). Definitions of dream: a paradigm for comparing field descriptive specific studies of dream. *Dreaming*, 11, 195-202. <https://doi.org/10.1023/A:1012240307661>
- Pesant, N., & Zadra, A. L. (2004). Working with dreams in therapy: what do we know and what should we do? *Clinical Psychology Review*, 24, 489-512. <https://doi.org/10.2466/pr0.1995.76.3c.1288>
- Plihal, W., & Born, J. (1997). Effects of early and late nocturnal sleep on declarative and procedural memory. *Journal of Cognitive Neuroscience*, 9, 534-547. <https://doi.org/10.1162/jocn.1997.9.4.534>

- Revonsuo, A. (2000). The reinterpretation of dreams: an evolutionary hypothesis of the function of dreaming. *Behavioral and Brain Sciences*, 23, 877-901. <https://doi.org/10.1017/s0140525x00004015>
- Revonsuo, A., Tuominen, J., & Valli, K. (2015). The Avatars in the Machine. In T. K. Metzinger & J. M. Windt (Eds.), *Open MIND* (pp. 1-28). MIND Group. <https://doi.org/10.15502/9783958570375>
- Saint-Denys, H. d. (1982). *Dreams and how to guide them* (Original: 1867). Duckworth.
- Schoch, S. F., Cordi, M. J., Schredl, M., & Rasch, B. (2019). The effect of dream report collection and dream incorporation on memory consolidation during sleep. *Journal of Sleep Research*, 28(1), e12754. <https://doi.org/10.1111/jsr.12754>
- Schredl, M. (2003). Continuity between waking and dreaming: a proposal for a mathematical model. *Sleep and Hypnosis*, 5, 38-52.
- Schredl, M. (2006). Factors affecting the continuity between waking and dreaming: emotional intensity and emotional tone of the waking-life event. *Sleep and Hypnosis*, 8, 1-5.
- Schredl, M. (2009). Frequency of precognitive dreams: Association with dream recall and personality variables. *Journal of the Society for Psychical Research*, 73, 81-90.
- Schredl, M. (2010). History of dream research: The dissertation "Entstehung der Träume (Origin of dreams)" of Wilhelm Weygandt published in 1893. *International Journal of Dream Research*, 3, 95-97. <https://doi.org/10.11588/ijodr.2010.1.507>
- Schredl, M. (2011a). Frequency and nature of flying dreams in a long dream series. *International Journal of Dream Research*, 4, 31-34. <https://doi.org/10.11588/ijodr.2011.1.9077>
- Schredl, M. (2011b). Frequency and nature of pain in a long dream series. *Sleep and Hypnosis*, 13, 1-6.
- Schredl, M. (2012). Review of 'The nature and functions of dreaming'. *Dreaming*, 22(2), 150-155. <https://doi.org/10.1037/a0026274>
- Schredl, M. (2013). Seeking professional help for nightmares: A representative study. *European Journal of Psychiatry*, 27, 259-264. <https://doi.org/10.4321/S0213-61632013000400004>
- Schredl, M. (2015). The continuity between waking and dreaming: Empirical research and clinical implications. In M. Kramer & M. Glucksman (Eds.), *Dream research - Contributions to clinical practice* (pp. 27-37). Routledge.
- Schredl, M. (2018). *Researching Dreams: The Fundamentals*. Palgrave Macmillan.
- Schredl, M. (2019). Typical dream themes. In K. Valli & R. J. Hoss (Eds.), *Dreams: Understanding biology, psychology, and culture - Volume 1* (pp. 180-188). Greenwood.
- Schredl, M. (2020). "What Goes Up Must Come Down"—Elevators in a Long Dream Series. *Imagination, Cognition and Personality*, 40(2), 143-153. <https://doi.org/10.1177/0276236620926486>
- Schredl, M., Dyck, S., & Kühnel, A. (2020). Lucid Dreaming and the Feeling of Being Refreshed in the Morning: A Diary Study. *Clocks & Sleep*, 2(1), 54-60. <https://doi.org/10.3390/clockssleep2010007>
- Schredl, M., & Erlacher, D. (2007). Self-reported effects of dreams on waking-life creativity: An empirical study. *Journal of Psychology*, 141, 35-46. <https://doi.org/10.3200/JRPL.141.1.35-46>
- Schredl, M., & Erlacher, D. (2010). Is sleep-dependent memory consolidation of a visuo-motor task related to dream content? *International Journal of Dream Research*, 3, 74-79. <https://doi.org/10.11588/ijodr.2010.1.486>
- Schredl, M., Hoffmann, L., Sommer, J. U., & Stuck, B. A. (2014). Olfactory stimulation during sleep can reactivate odor-associated images. *Chemosensory Perception*, 7, 140-146. <https://doi.org/10.1007/s12078-014-9173-4>
- Schredl, M., & Hofmann, F. (2003). Continuity between waking activities and dream activities. *Consciousness and Cognition*, 12, 298-308. [https://doi.org/10.1016/S1053-8100\(02\)00072-7](https://doi.org/10.1016/S1053-8100(02)00072-7)
- Schredl, M., Weber, B., Leins, M.-L., & Heuser, I. (2001). Donepezil-induced REM sleep augmentation enhances memory performance in elderly, healthy persons. *Experimental Gerontology*, 36, 353-361. [https://doi.org/10.1016/s0531-5565\(00\)00206-0](https://doi.org/10.1016/s0531-5565(00)00206-0)
- Silberer, H. (1909). Bericht über eine Methodik, gewisse symbolische Halluzinations-Erscheinungen hervorzurufen und zu beobachten. *Jahrbuch für Psychoanalytische und Psychopathologische Forschungen*, 1, 513-525.
- Stefanakakis, H., Zadra, A. L., & Donderi, D. (1990). A correlational analysis of dream content variables with measures of self-reported well-being. *Association for the Study of Dreams Newsletter*, 7(4), 1-3,16.
- Stickgold, R., Rittenhouse, C., & Hobson, J. A. (1991). Dream coherence: Is beauty in the eye of the beholder? *Sleep Research*, 20, 150.
- Tassi, P., & Muzet, A. (2000). Sleep inertia. *Sleep Medicine Reviews*, 4, 341-353. <https://doi.org/10.1053/smr.2000.0098>
- Thünker, J., Norpoth, M., Aspern, M. v., Özcan, T., & Pietrowsky, R. (2014). Nightmares: Knowledge and attitudes in health care providers and nightmare sufferers. *Journal of Public Health and Epidemiology*, 6, 223-228. <https://doi.org/10.5897/JPHE2013.0565>
- Tuominen, J., Revonsuo, A., & Valli, K. (2019). The social simulation theory. In K. Valli & R. J. Hoss (Eds.), *Dreams: Understanding biology, psychology, and culture - Volume 1* (pp. 132-137). Greenwood.
- Ullman, M., Krippner, S., & Vaughan, A. (1989). *Dream telepathy: Experiments in nocturnal ESP* (Second edition ed.). McFarland.
- Van de Castle, R. L. (1994). *Our dreaming mind*. Ballentine.
- Wamsley, E. J., & Stickgold, R. (2019). Dreaming of a learning task is associated with enhanced memory consolidation: Replication in an overnight sleep study. *Journal of Sleep Research*, 28(1), 1-8. <https://doi.org/10.1111/jsr.12749>
- Wamsley, E. J., Tucker, M., Payne, J. D., Benavides, J. A., & Stickgold, R. (2010). Dreaming of a learning task is associated with enhanced sleep-dependent memory consolidation. *Current Biology*, 20, 850-855. <https://doi.org/10.1016/j.cub.2010.03.027>
- Weygandt, W. (1893). *Entstehung der Träume*. Gröbel & Sommerlatte.
- Wilson, M. A., & McNaughton, B. L. (1994). Reactivation of hippocampal ensemble memories during sleep. *Science*, 265, 676-679. <https://doi.org/10.1126/science.8036517>
- Wright, J., & Koulack, D. (1987). Dreams and contemporary stress: a disruption-avoidance-adaptation model. *Sleep*, 10, 172-179. <https://doi.org/10.1093/sleep/10.2.172>