Lucid Dreaming

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Chapter 52

Lucid Dreaming

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Chapter Highlights

- During lucid dreaming, the dreamer is fully aware of his or her current dream state. This metacognitive insight often leads to full access to memory and increased volitional control over the dream narrative.
- Lucid dreaming is a rare natural phenomenon; however, several strategies are available to induce dream lucidity or increase the frequency of this sleep state.
- Lucid dreaming is associated with increased neural activity in several neocortical regions, particularly lateral prefrontal, frontopolar, and medial parietal cortices. On the electroencephalogram, 40-Hz gamma power over dorsolateral prefrontal areas is increased during lucid dreaming, and 40-Hz transcranial alternating current stimulation of this region induces dream lucidity.
- Lucid dreaming has a potential clinical application in the therapy of nightmares. In keeping with the view that dreaming can serve as a model for psychosis, lucid dreaming may potentially be of value for the therapy of metacognitive deficits in psychosis.

Conscious experience varies strikingly across the sleep-wake cycle. During wakefulness, humans are alert, aware of external and internal stimuli, able to reflect on their perceptions, emotions, and thoughts, and capable of acting volitionally according to their intentions. Most of these properties of waking consciousness fade during the process of falling asleep; however, they partly reappear during sleep mentation. Conscious experience during sleep is manifold. If not absent as in dreamless sleep, it can include abstract thought fragments, intense emotions, and sensory imagery, up to fully immersive visuomotor hallucinations with a complex interactive dream plot.[1] From the perspective of the dreamer, this virtual reality often feels indistinguishable from waking life. Dream experiences, however, typically show many cognitive peculiarities, with delusional thought, diminished volition, and a complete lack of insight into the true state of mind even in the face of a bizarre dream plot. In this regard, dreaming resembles the psychosis of mental diseases such as schizophrenia, characterized by hallucinations, loosening of associations, incongruity of personal experience, and a loss of self-reflective capacity.[2,3]

In contrast with normal dreaming, the rare phenomenon of lucid dreaming is characterized by the reappearance of many wake-like cognitive capabilities. Minimally defined by the criterion that the sleeper is aware of the current dream state as such,[4] lucid dreaming often leads to full insight into the delusional nature of the dream environment, access to short- and long-term memory, and sometimes even volitional control over the dream narrative.[5] Despite this wake-like cognitive capability, lucid rapid eye movement (REM) sleep comprises all defining markers of REM sleep[4] and all basal dream features such as visuomotor hallucinations[1]—in fact, prototypical aspects of dream phenomenology such as bizarreness might even be more pronounced in lucid dreams.[6] Lucid dreaming is not an all-or-nothing phenomenon but can occur in different degrees.[7,8] Questionnaires such as the Metacognitive, Affective, Cognitive Experience (MACE) questionnaire[9] and the Lucidity and Consciousness in Dreams scale[10] aim to assess this continuum ranging from single-minded sleep mentation over prelucid reflections to full-blown lucid control dreams.

Despite being described in ancient scripture and reported in early modern research literature, lucid dreaming faced considerable skepticism in mainstream sleep research during most of the twentieth century. In the late 1970s, the first systematic validation of lucid dreaming as an objective phenomenon occurring during otherwise normal REM sleep was achieved. In accordance with the scanning hypothesis, according to which rapid eye movements during REM sleep are related to gaze direction during dreaming,[11] lucid dreamers were asked to move their eyes in a left-right-left-right fashion during dreaming as soon as they became aware of their dreaming state.[4] Through this technique, which has since become the gold standard in lucid dream research, lucid dream reports could be objectively verified by eye movement patterns as recorded in the electrooculogram. By providing objective temporal markers of dream content, this method has allowed, for example, investigations into neural correlates of dreamed behaviors[12-14] and comparisons of the passage of time as experienced during dreaming with objective measurements in the real world.[15] Nevertheless, the rarity of lucid dreams and the difficulties of observing them under laboratory conditions hamper research with considerable sample sizes, rendering many results from lucid dreaming studies preliminary. In

addition, lucid dreams documented in the laboratory tend to be much shorter than at home, which further restricts the possibilities of lucid dream research.[16,17]

PREVALENCE AND INDUCTION METHODS

Generally, lucid dreaming is quite rare. Only one half of the general population know the phenomenon from personal experience, approximately 20% have lucid dreams on a monthly basis, and only a minority of approximately 1% have lucid dreams several times a week.[18,19] Some differences across different populations and cultures seem to exist—for example, German students reported a much higher lucid dream frequency than Japanese students,[20,12] and even when representative population samples are surveyed, Germans report more lucid dreams than Austrians.[19,21] Also, age-related differences in lucid dreaming prevalence have been recognized, with young children and adolescents reporting lucid dreams more frequently than adults.[22,17]

Quite often, lucid dreaming spontaneously emerges from nightmares, recurrent dreams, or some peculiarities within a dream. However, lucid dreaming also can be intentionally induced by applying various induction or relaxation techniques, by engaging with topics of dreaming and lucid dreaming, and with use of other deliberate training strategies.[23,24] Sleep-specific circumstances, such as short awakening in the morning or an afternoon nap, as well as stress also can initiate the first lucid dream experience.[17]

Since the onset of lucid dream research, possible induction techniques have always been a pertinent concern. A plethora of strategies to induce lucid dreams have been suggested in the literature, which can be loosely classified into three broad categories: cognitive techniques, external stimulation, and miscellaneous.[25] The first category encompasses all cognitive activities that are carried out to increase the likelihood of achieving lucidity in a dream state. For this category, a large number of different methods have been suggested that can be further divided into methods whereby lucidity is initiated from within a dream, so that the person becomes lucid during a dream (*dream-initiated lucid dreaming*), and methods whereby lucidity is initiated from wakefulness, so that the person retains conscious awareness when falling asleep (*wake-initiated lucid dreaming*). The rationale behind the second category is that an external stimulus presented to a sleeping person can be incorporated into the dream (e.g., spraying water on the sleeping person's face may promote the incorporation of sudden rainfalls in the dream) and that the incorporated stimuli serve as a cue to remind the dreamer about being in the dream state (e.g., someone squirting water signals the dreamer that he or she is dreaming) and thereby triggers dream lucidity.[26] The third category includes miscellaneous aids to gain lucidity, such as drugs (e.g., Donepezil) but also specific practices involving sleep-wake patterns—for example, waking up in early-morning hours and then, after a certain period, going back to bed to take a nap, known as *wake-back-to-bed* (WBTB).[27] WBTB is not a technique per se, because it was empirically tested only in combination with other techniques (*mnemonic induction of lucid dreams* [MILD]) and may boost their efficacy.

Most lucidity induction strategies described in the literature are based on personal and anecdotal accounts. A recent systematic review of evidence found 27 studies that experimentally tested the efficacy of lucidity induction techniques,[25] of which 5 were conducted as sleep laboratory studies and the other 22 were done as field experiments, in some cases with low methodologic quality. None of the induction techniques was verified to induce lucid dreams reliably, consistently, and with a high success rate; some methods, however, proved to be promising—for example, the MILD/WBTB combination. More recently, noninvasive brain stimulation methods yielded encouraging results. Although transcranial direct current stimulation of the dorsolateral prefrontal cortex during REM sleep showed rather modest success in inducing dream lucidity as assessed by the eye signaling technique,[27] transcranial alternating current stimulation in the low gamma range (25 Hz and 40 Hz) led to a robust increase in retrospectively reported dream lucidity as measured by the Lucidity and Consciousness in Dreams questionnaire.[28]

NEUROBIOLOGY

Dream-like mental activity can be observed during all sleep stages; REM sleep dreams, however, are particularly vivid and intense. The specific phenomenologic characteristics of dreaming frequently have been associated with neural activation patterns observed during REM sleep. For example, higher visual areas show strong metabolic activity during REM sleep,[29] which is in line with visuospatial hallucinations as the hallmark of typical dreaming.[1] The amygdala, medial prefrontal cortex, and anterior cingulate cortex also show increased activity during REM sleep.[30,31] All of these brain areas have been implicated in emotional processing, nicely mirroring the intense emotions experienced in many dreams. By contrast, the dorsolateral prefrontal cortex, frontopolar cortex, and parietal areas including the supramarginal cortex and precuneus show low metabolic rates during normal REM sleep.[30,31] In particular, prefrontal deactivations have been postulated to underlie cognitive deficiencies typical of ordinary dreaming such as impaired critical thinking, diminished metacognitive ability, and restricted volitional control.[32]

Although lucid REM sleep dreaming is characterized by the full range of coarse electroencephalographic features of REM sleep according to the classical Rechtschaffen and Kales (1968)[33] or new American Association of Sleep Medicine (AASM)[34] sleep stage scoring, it does incorporate some subtle physiologic changes relative to nonlucid REM sleep, such as higher eye movement density and increases in respiration, heart rate, and skin potential.[16] In addition, brain activity during lucid REM sleep shows distinctive changes from that during nonlucid REM sleep. Early electroelectrogram (EEG) studies observed higher alpha activity,[35,37] and increased beta-1 activity (13 to 19 Hz) over parietal regions during lucid dreaming.[36] A more recent high-density EEG study demonstrated that lucid dreaming is associated with higher activity in the gamma band—the between-states-difference peaking at approximately 40 Hz—and overall EEG coherence compared with nonlucid REM sleep.[37] Both power in the 40-Hz band and coherence levels were observed to be strongest over the dorsolateral prefrontal cortex (Figure 52-1), which has been associated with metacognitive evaluation.[38]

In a combined functional magnetic resonance imaging (fMRI)-EEG approach, activations in a network of purely neocortical regions including the dorsolateral and frontopolar prefrontal cortex were observed during lucid dreaming as

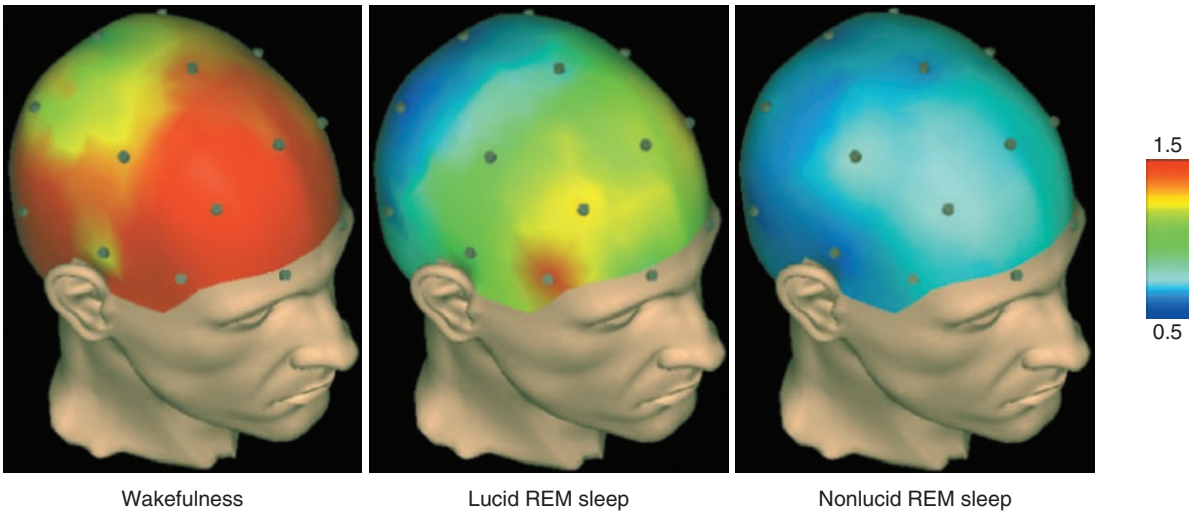

Figure 52-1 Quantitative EEG Data for Lucid Dreaming. Shown is gamma 40-Hz standardized current source density power during wakefulness, lucid REM sleep, and nonlucid REM sleep. The dorsolateral prefrontal cortex during lucid dreaming shows similar 40-Hz power to that during wakefulness. EEG, Electroencephalogram. (From Voss U, Holzmann R, Tuin I, Hobson JA. Lucid dreaming: a state of consciousness with features of both waking and non-lucid dreaming. *Sleep* 2009;32:119–200, with permission of the American Academy of Sleep Medicine from Voss et al. 2008; permission conveyed through Copyright Clearance Center, Inc.)

compared with nonlucid REM sleep background (Figure 52-2),[39] thus confirming earlier EEG data. Of note, recent anatomic analyses have demonstrated larger gray matter volume in the frontopolar cortex in dreamers with high self-reported dream lucidity.[40] The frontopolar cortex has been related to the processing of internal states, such as self-evaluation of thoughts and feelings,[41] metacognitive ability,[42] and supervisory modes,[43] which are impaired in normal dreaming but reinstated in lucid dreaming. Strong activation increases during lucid dreaming also were observed in parietal regions including the precuneus, inferior parietal lobules, and supramarginal gyrus.[44] Prefrontal-parietal interactions are involved in many higher-level cognitive processes such as intelligence or working memory,[45] whereas the precuneus has been implicated in self-referential processing such as first-person perspective taking and experience of agency.[46] These findings are in line with the notion that dream lucidity provides increased availability of self-related information, leading to a much higher degree of coherence and stability of the phenomenologic self during lucid dreaming.[47] Taken together, the frontoparietal activation patterns observed during lucid REM sleep nicely mirror the reinstatement of cognitive capabilities experienced during lucid dreaming. Activation increases during lucid dreaming also were found in some occipital and inferior-medial temporal regions.[44] These cortical areas are part of the ventral stream of visual processing, which is involved in several aspects of conscious awareness in visual perception.[48] Although such activations initially may seem puzzling—nonlucid dreams also are characterized by vivid dream imagery—they are consistent with reports of lucid dreamers stating that lucidity is associated with an exceptional brightness and visual clarity of the dream scenery.[49]

In recent years, network analyses of neuroimaging data have been introduced into sleep research.[50,51] Particular interest has been directed at the *default mode network*,[52] which during wakefulness shows increased activity in the absence of processing related to external tasks. Because this activity increase appears to be related to stimulus-independent thought such as internal awareness and daydreaming during wakefulness,[53,54] the default mode network has been proposed to be associated with nonlucid dreaming during sleep.[55,56] A second network shows activation anticorrelated with the default mode system in resting state fMRI analyses: the *dorsal attention system,* which is mainly involved in externally directed perceptual processes.[57] A third network, dubbed the *frontoparietal control system,* has been postulated to integrate information coming from both the default mode and the dorsal attention network by switching between competing internally and externally directed processes.[58,59,60] Phenomenologically, this might be interpreted as a monitoring of and control over mind-wandering and perception by metacognitive processes.[61] Owing to this role as a kind of meta-network, the frontoparietal control system might be seen as an ideal candidate subserving metacognitive aspects of consciousness that are the hallmark of lucid dreaming.[51] Brain regions activated during lucid dreaming indeed comprise substantial parts of the frontoparietal control network.[44]

LUCID DREAMING AS HIGHER-ORDER CONSCIOUSNESS

The contrast between lucid and nonlucid dreaming has been suggested to mirror the conceptual contrast between basal (primary) and higher-order (secondary) aspects of consciousness.[62,63] Although all basal features of consciousness, such as perceptions and emotions, are present in normal dreaming, metacognitive reflections and the insight into the current state of consciousness are, by definition, bound to dream lucidity. Because some reflective thoughts have been reported in nonlucid dreaming, and also because active reflections frequently are absent during daydreaming and other phases of wakefulness, it has been argued that metacognitive activity differs only quantitatively and not qualitatively between dreaming and waking consciousness.[64] This absence, however, is only a

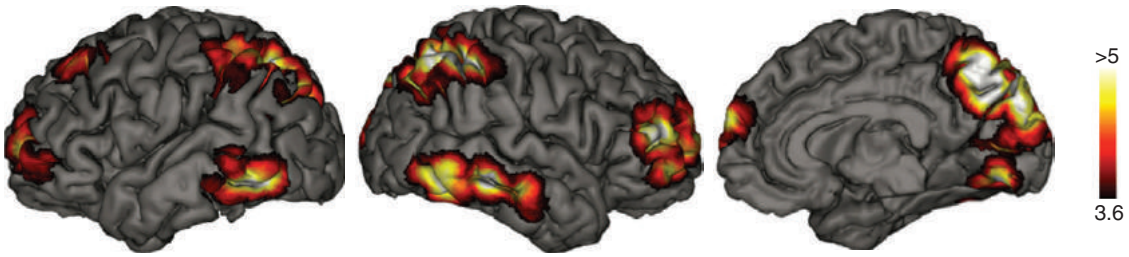

Figure 52-2 Functional MRI Data for Lucid Dreaming. During lucid REM sleep, strong activation is seen for dorsolateral prefrontal and frontopolar regions including the inferior, middle, and superior frontal gyri; parietal regions including the precuneus, inferior parietal lobule, and supramarginal gyrus; and temporal regions including the inferior and middle temporal gyri, as compared with nonlucid REM sleep. The *color bar* represents T-values. MRI, Magnetic resonance imaging. (From Dresler M, Wehrle R, Spoormaker VI, et al. Neural correlates of dream lucidity obtained from contrasting lucid versus non-lucid REM sleep: a combined EEG/fMRI case study. *Sleep* 2012;35:1017–20, with permission of the American Academy of Sleep Medicine; permission conveyed through Copyright Clearance Center, Inc.)

"local," not global feature of such phases. It is hardly imaginable, at least in nonpathologic cases, that the daydreaming subject misinterprets the daydream for reality, with full recognition of his or her current state prevailing. In the dreaming state, by contrast, this misperceived "reality" is completely normal—unless the dreamer eventually achieves lucidity by means of such prelucid reflection.[7]

Lucid dreaming may even be critical to achieve full understanding of the neural correlates of higher-order consciousness, because in contrast with coma-wake, anesthesia-wake, or sleep-wake comparisons, no major shift occurs in the vigilance state as defined by formal neurophysiologic criteria. Lucid REM sleep still is REM sleep proper, according to the classical Rechtschaffen and Kales (1968) or newer AASM[34] sleep scoring criteria. When compared with wakefulness, pathologic or pharmaceutically induced loss of consciousness also reduces the brain's basal metabolism, as does deep sleep. Lucid dreaming therefore provides the only known phenomenon that can contrast basal consciousness with full-blown higher-order consciousness within the same arousal level, allowing for comparison of cerebral activity by means of EEG, positron emission tomography, or fMRI without differences in the basal activity state.[51]

Higher-order aspects of consciousness are traditionally thought to be most pronounced in humans.[65,66] If the contrast between ordinary and lucid dreaming mirrors that between basal and higher-order consciousness, data on the neural correlates of dream lucidity might shed new light on this debate. Indeed, it turns out that cerebral regions showing increased activity during lucid dreaming also show extensive volumetric expansion in humans as compared with nonhuman primates.[67,68] In particular, the frontopolar cortex is significantly larger in humans than in other primate species[69] and has even been suggested to be a distinctly human brain structure.[70,71]

CLINICAL APPLICATIONS

Lucid dreaming has been suggested as a therapeutic approach for several clinical conditions, including nightmares, posttraumatic stress disorder, and schizophrenia. Lucid dreaming frequency is moderately correlated with nightmare frequency,[20] and people with frequent lucid dreams have incidentally reported that their nightmares have triggered lucidity. Theoretically, dream lucidity seems a logical solution to the main problem of nightmares, which encompasses a real emotional response to a nonexistent threat.[72] Becoming lucid in a nightmare should therefore take the sting out of it, and once the person realizes the threat is not real, it should disappear—along with the emotional response. Neurocognitive models of disturbed dreaming emphasize a hyperresponsivity of the amygdala in nightmare generation, coupled with a failure of medial prefrontal regions to dampen this activation.[73] Lateral prefrontal regions have been shown to be capable of influencing amygdala function through connections to the medial prefrontal cortex.[74] The neurobiology of lucid dreaming with increased lateral prefrontal activation therefore fits well with potential therapeutic effects of lucid dreaming on nightmares.[14]

Thus far, the theory holds—but does it work as readily in practice? Patients with narcolepsy who frequently suffer from nightmares report that dream lucidity intervention indeed provides relief during nightmares,[75] and a few case studies[76] and one small controlled pilot study[76] have indicated that lucid dreaming therapy was effective in reducing nightmare frequency. In the controlled pilot study, lucid dreaming therapy was superior to a waiting list regarding nightmare frequency but did not have an effect on secondary anxiety and sleep measures; its efficacy was much higher in individual patients than in a group therapy setting, suggesting confounding therapist effects.[77] A larger online self-help study did not find any additional effect of lucid dreaming therapy as an add-on to other effective cognitive-behavioral techniques such as imagery rehearsal therapy,[78] although low power and high dropout rates (>50%) limited the scope of the conclusions.

Lucid dreaming therapy raised some unexpected issues. An important consideration was that people with frequent nightmares may report becoming lucid but then find themselves unable to change the nightmare,[76] presumably because the expectations about the storyline may be too strongly engrained into the brain.[79] Moreover, realizing that one is dreaming does not automatically erase the threat and accompanying (intense) emotions, which could be expected to take some time after complete threat removal. As in all lucid dreams, lucidity in nightmares is not precisely an all-or-none phenomenon but rather a staged process, and a prelucid or half-lucid stage may not suffice to fully tackle a seemingly real threat. Moreover, many subjects with frequent nightmares reported a spontaneous change in their nightmares even without obtaining

lucidity.[77] This finding suggests that control over the nightmare, not lucidity, may be the therapeutic factor in successful nightmare treatment. Last but not least, even if the promising initial findings (which are only partly corroborated in controlled pilot studies) are sustained, the effects of lucid dreaming therapy tend to be stronger on nightmare aspects (frequency, intensity) than on general sleep quality or mental health characteristics. By contrast, the effects of imagery rehearsal have been much broader in scope.[80]

However, one disadvantage of the nightmare treatments that are currently best supported by experimental evidence, such as imagery rehearsal,[81] exposure therapy,[82] and combinations of both,[83] is that they also require a repetitive nightmare or theme to work with. If nightmares are too different from night to night, no story lines are available to rescript, as in imagery rehearsal, nor are repetitive images to systematically desensitize, as in exposure. Here, lucid dreaming therapy has the advantage that although having a repetitive nightmare or theme is beneficial (to allow recognition of the dream state in a future nightmare), it is not a sine qua non, because people can train themselves to become lucid without having nightmares.[72] Moreover, appropriate training can help patients link lucidity with feeling anxiety and fear in therapy and thereby prepare themselves for the next time they feel threatened—as it is likely to occur during a future nightmare. In this manner, lucid dreaming therapy can be useful for people with idiopathic nightmares with very different contents.

One important caveat is that lucid dreaming therapy may not be optimal for treating posttraumatic nightmares, besides being less evidence-based than imagery rehearsal. Because many posttraumatic nightmares may constitute a replication of an original event or parts of an original event,[84] changing the nightmare "on-line" during its occurrence may be much harder to achieve than changing it "off-line" in mentation, and even this issue typically raises questions concerning guilt and "undoing the past." Lucidity may thus have the adverse consequence that patients with posttraumatic stress disorder relive their original traumatic event with full consciousness but without the possibility to change anything.[76] Such an occurrence would be retraumatizing rather than empowering, and although solutions to this inability to change the nightmares have been proposed (e.g., starting by changing small background objects in color and then proceeding from there in small steps), it appears better to avoid experimenting with such inflammable material and to first try the treatments that may work in a majority of cases.

Besides nightmares, lucid dreaming also has been suggested as a therapeutic strategy in the treatment of schizophrenia.[3,28] The idea that normal dreaming can serve as a model for psychosis has a long and honorable tradition; however, it is notoriously speculative. One of the most interesting aspects of the dreaming-psychosis model is the issue of insight. Between 50% and 80% of patients diagnosed with schizophrenia have poor insight into the presence of their disorder,[85] probably owing to ineffective self-reflection processes.[86] Because such deficits are thought to lead to more relapses and rehospitalizations and poorer therapy success in general,[87] the concept of insight is becoming an increasingly important area of investigation in schizophrenia research.[88] On the dreaming side of the model, lack of insight into the current state characterizes almost any dream experience—with the obvious exception of lucid dreaming. This suggests that dream lucidity may be a good model for insight in the dreaming-psychosis model. Of interest, historical approaches to psychosis used the term "lucidity" to denote the patient's awareness of his or her illness.[89] Although the specific composition of the multiple facets of insight in psychosis is still under discussion,[90,91] two crucial dimensions are classically considered to be (1) the affected person's recognition that he or she has a mental illness and (2) the ability to recognize unusual mental events (delusions and hallucinations) as pathologic.[92] Hence, in the dreaming-psychosis model, lucidity during dreaming represents what patients in psychosis lack: full insight into the delusional nature of the current state of consciousness.

In neurobiologic studies, in particular, prefrontal, medial parietal, and inferior temporal cortical regions that are linked to insight problems in psychosis show striking overlap with brain regions associated with dream lucidity.[5] It has been demonstrated that prefrontal cortex function in schizophrenic patients can be improved through cognitive training.[93] Metacognitive training approaches are of particular interest, because skilled lucid dreamers typically gained their frequent insight into the dreaming state by metacognitive training, in particular by developing autosuggestions and the habit of frequently contemplating about their state of consciousness.[24,25] By teaching schizophrenia patients such training regimens, enhancing insight-related prefrontal and medial parietal functions might well lead to enhanced insight capabilities during acute psychosis. In addition, recent advances in dream lucidity induction by electrical brain stimulation methods[94,28] may show generalization effects to insight processes during psychotic wakefulness, or they may potentially serve as direct tools to improve insight during acute psychosis. Of note, a recent case study provides evidence that brain stimulation might indeed transiently attenuate insight problems in psychosis.[95] Lucid dreaming as a model for the successful treatment of psychotic symptoms also may be helpful for developing and testing new antipsychotic medication. If a given pharmacologic agent increases the frequency of lucid dreams in healthy subjects, it can be considered as a promising candidate to enhance insight in psychotic patients as well.[68] Lucid dreaming, therefore, transforms the dreaming-psychosis model from an interesting idea with a long history into a testable scientific hypothesis and a promising new therapeutic approach.

NONCLINICAL APPLICATIONS

Lucid dreaming also is used for several nonclinical purposes. A recognized strategy is to maximize certain behaviors or patterns within the dream state. Among the most popular intended dream behaviors are flying, communication with dream characters, and sexual encounters during dreaming, with lucid dreaming frequency appearing to predict how successful such intentions are recalled and executed in lucid dreams.[17] Besides such purely recreational applications within dreams, use of lucid dreaming also has been reported by many persons to influence aspects of waking life.[96] Two examples for which at least some scientific data are available are creative problem solving and practicing motor skills.

Anecdotal reports on scientific discovery, inventive originality, and artistic productivity suggest that creativity can be triggered or enhanced by sleeping and dreaming. In addition, theoretical considerations and experimental studies suggest that dreams can improve waking-life creativity.[44] Theoretically,

sleep has been suggested to provide an ideal state for creative incubation. The internally generated dream narrative, in the absence of external sensory data, leads to a much more radical renunciation from unsuccessful problem-solving attempts, leading to coactivations of cognitive data that are highly remote in waking life, and both dreaming and creativity have been characterized with primary process thinking, flat associative hierarchies, and defocused attention. In contrast with the more random flow of nonlucid dream narratives, dream lucidity allows for a more goal-oriented use of these creativity-related dream characteristics. Surveys among lucid dreamers and experimental studies demonstrate that lucid dreaming can indeed be used to improve creative thinking and problem solving.[97,96]

Motor practice during lucid dreaming is a novel type of mental rehearsal in which the person uses the dream state to consciously practice specific tasks without waking up.[98] It can be compared to mental practice, which is well established in sports theory and sports practice.[99] For both mental and dream rehearsal, movements are simulated with an imagined body on a purely cognitive level, while the physical body remains still. One advantage that lucid dreaming has over both mental practice and modern virtual reality simulators is that it offers the potential for practice with all kinesthetic sensations of the dream body in an environment that is experienced with as much vividness and realism as would be encountered in waking experience. In addition, the lucid dreamer, being limited only by imagination and attentional stability, has far greater potential for control over his or her own body, actions, and environment than in mental rehearsal, virtual reality environments, or waking life. In contrast with the vast amount of research on mental practice, however, empiric data on practice in lucid dreams are rather sparse.

In several anecdotal reports, amateur and professional athletes have described using lucid dreaming to improve their waking performance, such as in long distance running, tennis, skating, alpine skiing, or martial arts.[100,72] In a more systematic questionnaire study, 840 German athletes from a variety of sports were surveyed about their experiences with lucid dreams.[101] Although lucid dreaming in athletes was similar in prevalence to that in the general population,[19] the percentage of lucid dreams relative to all recalled dreams was found to be nearly doubled in athletes. Approximately 1 in 10 athletes who had lucid dreams (5% of the total sample) used lucid dreaming to practice sports skills, with most of them reporting improved performance.

Few studies have tested possible effects of practice in lucid dreams in controlled experiments. In a qualitative study, subjects were instructed to perform different complex sports skills familiar to them in waking life, such as skiing or gymnastics, in their lucid dreams.[102] Participants reported that they had no difficulties performing these sports skills in their lucid dreams and that their movements improved both in the dream and the waking state. In a quasiexperimental pre-/postdesign study, participants were asked to practice a coin-tossing task in their lucid dreams.[103] Results showed a significant increase in hitting the target from pretest to posttest evaluations for the group that practiced the coin-tossing task in lucid dreams, but no increase was found for the control group. More recently, these results could be replicated with a different motor task (sequential finger tapping). Improvements after lucid dream practice seem to be similar to or slightly less in degree than those obtained with actual physical practice, and similar to or slightly better than those with mental practice in wakefulness.[104]

CONCLUSIONS AND FUTURE DIRECTIONS

Up until the late 1970s, lucid dreaming met much skepticism or was completely ignored by mainstream sleep research, and even in the late 1990s, studying lucid dreaming was not considered to be experimentally advantageous for the neuroscience of consciousness.[105] Since then, an increasing number of studies have elucidated the neurobiologic basis of lucid dreaming and demonstrated its value for clinical and nonclinical applications. Nevertheless, owing to the rarity of the phenomenon, the study of lucid dreaming is still in its infancy, with many preliminary data demanding further confirmation and many details of the neural mechanisms underlying lucid dreaming and its therapeutic effects awaiting thorough investigation. In particular, reliable lucidity induction strategies are needed to boost lucid dream therapy and the relevant research.

CLINICAL PEARL

Lucid dreaming has been proposed as a natural therapy for nightmares, because the insight into the illusional nature of the dreamed threat could prevent the emotional response to it. Lucid dreaming as a therapy for nightmares has indeed some clinical support. It might be particularly suited for addressing nonrecurring nightmares but less so for managing posttraumatic nightmares. Because lucid insight into dreaming and insight into psychosis appear to largely share the same brain basis, lucid dreaming also may potentially be of value in schizophrenia therapy or in the development of novel antipsychotics.

SUMMARY

In contrast with the metacognitive impairments of normal dream mentation, lucid dreaming is characterized by awareness of the current state of mind, often leading to considerable volitional control of the dream narrative. Lucid dreaming is a rare skill; however, it can be learned and reinforced with training using a variety of induction strategies ranging from autosuggestion to transcranial current stimulation. Lucid dreaming as a research topic has faced much skepticism during most of the past century; in recent years, however, interest is acquiring increasing momentum. Lucid dreaming is associated with specific changes in neural activity when compared to nonlucid dreaming, with lateral prefrontal, frontopolar, and medial parietal activation as proposed neural correlates of the increased metacognitive capacity that defines dream lucidity. Lucid dreaming has clinical and nonclinical applications, ranging from nightmare therapy to mental motor skills training and creative problem solving. Reliable induction methods are strongly needed to further explore the potential of lucid dreaming and for its scientific study.

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