Intentional Lucid Dreaming with a Transformative Learning Agenda

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Article

Keywords: lucid dreaming, rapid eye movement sleep, REM sleep, contemplative practices, dream yoga

Posted Date: February 3rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8745420/v1

Additional Declarations: There is **NO** Competing Interest.

Intentional Lucid Dreaming with a Transformative Learning Agenda

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Abstract

To reduce maladaptive behaviors, cognitive-behavioral and mindfulness-based interventions can be engaged during wakefulness. Such strategies may also be engaged during sleep, providing a unique and powerful pathway to positive behavioral change. Here we describe an initial scientific investigation of Dream Yoga, a type of contemplative practice that includes a set of prescribed tasks enacted after an individual recognizes that they are dreaming while concurrently staying asleep (lucid dreaming). We used polysomnography and two-way communication during dreams in six individuals with extensive Dream-Yoga training. Practitioners purportedly gain insights by developing refined abilities to influence what happens in their dreams. Recordings from 19 overnight sessions documented respiratory signals made during rapid-eye movement sleep in the context of Dream-Yoga exercises. Signals were then described in post-sleep microphenomenological interviews examining these dream experiences in detail. We thus confirmed the viability of intentional dreaming aimed at transforming one's waking behavior and well-being.

Keywords: lucid dreaming, rapid eye movement sleep, REM sleep, contemplative practices, dream yoga

Methods for systematically training the mind through contemplative practices are integral to the global human heritage going back millennia. Improvements in well-being achieved through procedures linked with mindfulness, as derived from historical contemplative traditions, are also documented in a growing body of research in psychiatry and neuroscience[1-5]. Mindfulness-based approaches have been successfully applied to alleviate diverse symptoms in various clinical populations[6,7]. Despite extensive research on mindfulness and related strategies of cognitive-behavioral therapy, there is a negligible scientific literature on contemplative practices that are performed during sleep. Some of these practices are performed during lucid dreaming[8], which is defined as recognizing a dream while remaining asleep, and which can afford opportunities for exerting some control over what happens in a dream. Focused scientific investigation is needed to substantiate claims derived from these contemplative methods and to rigorously document how dreaming is used intentionally to achieve transformative and potentially therapeutic results.

The term *Contemplative Sleep Practices* (CSPs) refers to the general category of structured methods to cultivate awareness, intentionality, and insight during sleep. Here we emphasize CSPs engaged during dreaming or during transitional periods between wake and sleep. In many cultural contexts, dreaming is regarded not merely as a feature of sleep but as a mode of experience complementary to ordinary wakefulness that can shape how waking reality is understood. In some Mesoamerican cultures i.e. the Toltecs in Mexico for instance, dreams are viewed as a liminal space between two equally real worlds, offering access to a reality beyond waking perception[9,10]. In Sufi mysticism, dreams are understood as conduits for divine knowledge, offering guidance through symbolic imagery and mystical states[11]. In Judaism, lucid dreaming has also been described in the context of obtaining a revelatory state[12]. Sleep-based contemplative practices appeared in Tibetan-Buddhist texts from the 11th century onwards, describing how advanced practitioners may acquire various psychological benefits [13-15].

CSPs from Tibetan Buddhism within a class known as Vajrayāna practices are particularly well-suited for behavioral and neuroscientific investigation for several reasons. Most notably, a systematic conceptual framework has been abundantly documented from the first-person perspective, covering intentional dreaming and discrete exercises to perform in a lucid dream[14,16]. These practices are collectively referred to as Dream Yoga (Tibetan: *rmi lam rnal 'byor*). A core idea within the Dream-Yoga framework is that waking and dreaming are constructed experiences, shaped by habitual patterns of perception, cognition, and embodiment. Furthermore, these ancient contemplative practices have survived over many centuries and are currently performed in many parts of the world.

Current thinking in cognitive neuroscience offers some interesting parallels. It would not be outlandish, for example, to note that experiences of waking and dreaming are constructed based on neural mechanisms. Further, a predictive-processing framework postulates perception as an active inferential process in which predictions about the world are continually generated, drawing on both sensory input and knowledge acquired through experience. This constructive nature of perception makes experience inherently fallible and prone to systematic biases[17,18], meaning that experience can be considered a result of unconscious inference as opposed to being an objective read-out of reality.

Dream-Yoga practices go further by leveraging this constructed nature of waking and dreaming. Practitioners gradually learn to intentionally work with constructs of experience within their dreams. Experts in Dream-Yoga refine their skills of attaining and maintaining the lucid-dreaming state in order to explore various dream experiences. In the general population, it is rare for individuals to experience lucid dreams frequently and by some estimates about half of the population do not recall ever having such experiences[19]. Yet, advanced practitioners of Dream Yoga claim to stabilize their awareness of the dream state such that they can repeatedly engage in deliberate dream activities.

Behavioral strategies have been described for increasing the likelihood of experiencing and remembering a lucid dream[20-22]. Individuals may seek lucid dreams for pleasure, to practice skills, to broader their creativity, to have experiences that are impossible in the waking state, and so on[23]. Unlike these common approaches to lucid dreaming, Dream Yoga is embedded within a broader contemplative agenda to reveal and transform the habitual tendencies that shape one's understanding, and update beliefs of the self and the world[13-16]. Accordingly, practicing dream yoga may offer a valuable opportunity to modify deeply conditioned and maladaptive patterns of behavior[13-16,24].

Recent methodological breakthroughs in sleep science have transformed the field of dream research, which previously relied largely on post-sleep dream reports for evidence about dream experiences[25]. Researchers can now monitor brain and body states during dreaming to establish real-time communication with dreamers who can understand questions and respond accurately using eye movements and subtle facial muscle contractions[26]. These signals allow researchers to mark specific dream events, to record concurrent neural activity, and to substantiate dream experiences reported after waking. For example, a dreamer's post-sleep report may describe a series of sounds they heard and signals they produced, which can be mapped onto events coded in recordings made during sleep.

We used these strategies to observe the time-course of sensory events and volitional responses during Rapid Eye Movement (REM) sleep verified with standard polysomnography. Our investigations also included microphenomenological methods to explore first-person accounts of dreams[27,28,29]. Although people often lack accurate insight into their own cognition[30], extensive meditation experience may help people more-accurately describe the subtleties of their experience[31]. Whereas historical texts on Dream Yoga provide a framework for conceptualizing a practitioner's dream experiences[8,13,32], our approach complements this effort by combining neuroscience methods with a systematic analysis of dream experiences[33].

Several open questions about Dream Yoga need to be addressed. First, do the experiences of advanced practitioners occur during a waking state, a liminal state between wake and sleep, a standard sleep stage such as REM sleep or non-REM sleep, or perhaps a novel state yet to be characterized? Second, do advanced practitioners show a typical progression of sleep stages or does their training lead to unusual sleep patterns? For example, unique hybrid states could be generated given the possibilities of local sleep[34]. A study of practitioners with advanced training, even if they show signs of enhanced cognitive or emotional abilities, cannot clearly attribute their abilities to any specific practice amidst all their other life experiences. We included some such measures, such as tests of cognitive flexibility, but conclusions

about the benefits of these practices will require longitudinal studies. Nevertheless, by rigorously documenting the viability of these dream-based practices and describing practitioners' experiences before, during, and after their dreams, future studies will have a foundation for addressing such questions.

Results

Lucid Dreaming and Volitional Signals in Expert Practitioners

Polysomnographic recordings were obtained from six adults with extensive training in Dream Yoga and exceptional lucid-dreaming abilities. These participants experienced many lucid dreams and regularly succeeded in performing specific Dream-Yoga exercises in their dreams. Prior to visiting the sleep lab, they followed our instructions at home for learning to signal about their experiences while dreaming, based on methods we used in our prior studies[35,36]. To signal the onset of a lucid dream, participants performed a Left-Right-Left-Right (LRLR) eye-movement sequence, looking all the way to the left, then to the right, twice[37 32]. To signal the start of a contemplative task, they executed two rapid nasal inhalations and exhalations (sniffs).

Each individual visited the sleep lab for 3 or 4 consecutive overnight sessions. Before going to bed, participants chose the exercise they intended to perform in a dream and rehearsed the signals they were to make. In some nights, we included the method known as Targeted Lucidity Reactivation (TLR) in order to induce lucid dreaming[26,36,38].

For the first component of TLR, specific stimuli were associated with a *lucid mindset*, which we define as attending carefully to one's experiences with a critical intention to discern and evaluate relevant features that might differentiate dreaming from waking experiences. The premise of TLR is that a lucid mindset can increase the chances of noticing such features in a dream. In addition, a conditioning procedure was used such that certain stimuli would reliably prompt a lucid mindset. Stimuli were a sound together with light flashes (one participant preferred using only the sound).

For the second component of TLR, these stimuli were presented during REM sleep as determined based on online monitoring of polysomnographic data by experimenters. To avoid awakening, sound intensity began at the participant's detection threshold and was gradually increased. We also presented auditory cues that had been associated with the Dream-Yoga exercise that the participant planned to perform (e.g., water sound as a reminder to walk on water).

A wake-back-to-bed protocol began approximately 4 hours after each participant fell asleep. Participants were awakened and remained awake for approximately 30 minutes before returning to sleep. During this period, they engaged in practices aligned with their CSP, such as cultivating intentions for upcoming dreams. A critical dimension of Dream Yoga is to generate strong pre-sleep intentions, which include aiming to have a lucid dream and engage in specific practices[13]. Practitioners generally strengthen these intentions by emphasizing their altruistic desire to promote compassion broadly.

Across 19 overnight sessions, nine lucid dreams were reported. Of these, six were verified by volitional signals, in that the dream reports collected after awakening included veridical descriptions of the polysomnographic signals produced by the participant during periods of REM sleep. In these signal-verified lucid dreams (SVLD), participants performed Dream-Yoga exercises as described below.

Impossible Actions: Moving Through Solid Objects

Lucid dreams can be fleeting, but skilled practitioners become proficient at avoiding a return to nonlucid dreaming or waking up. When the practitioner can maintain the lucid-dreaming state, a series of training regimes are engaged. By completing various exercises, the practitioner works on their ability to influence their dreams with specific intentions. Some of these exercises defy the normal laws of physics. For example, the practitioner can attempt to walk through walls, put their hands through solid objects, or walk on water. Because such actions are impossible while awake, and because of our ingrained or habitual knowledge of those impossibilities, they may commonly be experienced as impossible in the dream too — but they are nevertheless possible.

Why do practitioners engage in dream exercises that involve impossible actions? These exercises can be considered as steps in a process of loosening expectations about the world that have been acquired over many years. These expectations represent assumptions about waking reality that carry over into assumptions about dream reality. Although these assumptions are adaptive in many circumstances, there is also a sense in which unquestioned assumptions may form maladaptive constraints. Figuratively speaking, maybe the walls of our perceptions or conceptions could beneficially be regarded as permeable. Of course, the goal is not to return to the waking state willing to try to walk through walls. Rather, these practices are stepping stones to the potential loosening of some higher-order assumptions. By challenging standard conceptions of reality, casting alternative light on our experiences, one might free up resources to reduce self-centeredness and reveal options for healthier behavior, as discussed further below.

We observed Participant 4 experience three lucid dreams on three different nights in the sleep lab, each verified with real-time LRLR signals and concurrent determination of REM sleep according to standard criteria. On the first overnight session, he dreamt of sitting up in bed in the lab with his palms resting on a wooden table. He recognized the lab setting, which for him constituted a *dream sign*—defined as a dream experience that triggers the insight that one is dreaming. At this moment, he produced a deliberate LRLR eye signal, as shown in **Figure 1**.

In the dream report, Participant 4 described remembering the exercise he intended to perform in the dream, and he recounted the sense of duty he felt to continue with the agreed protocol (“I want to be a good lab rat”). He performed two sniffs to mark the start of the exercise, which was to pass his hands through a solid object. He started by “putting palm prints in the wood” and continued to insert his right index finger and then left into the wood. Feeling concerned about damaging the table, he leapt to the ground, landing in a sphinx-like position. He continued crouching at the foot of the bed, aware that “nobody can see me down here… I can do everything I want,” while dragging both hands through the floor and wall of the lab. His lucidity remained stable with a clear first-person embodiment and point of

view. At some point, he heard background voices that sounded like TV-chatter, which he found annoying. Thinking the voices could wake him from the dream, he shouted the Italian word *"silenzio!"* He deliberated on whether to pursue a second Dream-Yoga exercise but chose to execute four sniffs to indicate the end of the walking-through-walls exercise (**Figure 1,** right panel). This signal occurred in a period that was scored as wakefulness, though the participant perceived it to be during the dream state.

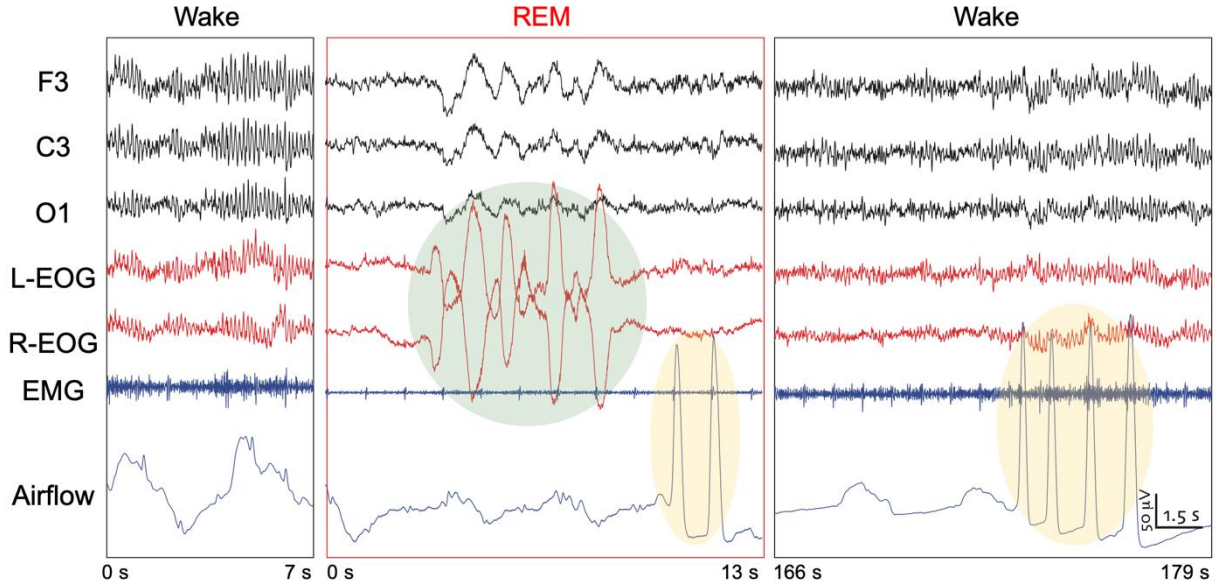

Figure 1. Polysomnographic recordings from Participant 4 documenting the Dream-Yoga exercise of moving through solid objects. Recordings depict data from 3 scalp EEG channels (F3, C3, and O1), two electro-oculographic channels (left and right, L-EOG and R-EOG), a chin electromyographic channel (EMG), and airflow from a nasal cannula. To allow juxtaposition with REM sleep, the left panel shows a wake period prior to sleep, with high EEG alpha and high muscle activity indicative of wakefulness and a normal breathing pattern. About 500 min after sleep began, in the third REM period, he produced the signal of lucidity, multiple LR eye movements highlighted in the green circle. Seven seconds later, the dreamer produced two sniffs (yellow oval) to indicate the initiation of the exercise. After 2.7 min, four sniffs were performed to mark the end of the exercise. The 2-sniff signal was clearly during a REM period, with minimal muscle activity. The 4-sniff signal was during a period of wakefulness, 23 s after a prominent increase in alpha and theta EEG activity. No cues were presented on this night.

In another dreamer, Participant 6, we also observed attempts to move though solid objects. During the first night, she reported a dream characterized by intermittent transitions between lucid and non-lucid states. Initially the dream experience was a two-dimensional image (she noted in the dream report that, "it was early in the dream formation"). After attaining lucidity, she waited for the environment to become three-dimensional and to "solidify." She walked through an enlarged lab room to a vast warehouse-like space. To stabilize the dream environment, she intentionally used her hands to squeeze her arms and called out for a lucidity boost. She then performed the LRLR eye signal (**Figure 2**), followed by two sniffs to mark the start of the exercise.

She then carried out a series of Dream-Yoga exercises, successfully walking through a wall, hands first, and then again along with the thought, "the dream body, the wall, are made of mind; there is no physical object." Subsequently, the dreamer encountered difficulties while attempting to pass through a pile of luggage. Her hands went through but her head bumped against them. She overcame resistance by mentally reaffirming the dream's fundamental openness.

Participant 6 then shifted to the Dream-Yoga exercise of transforming an object. She attempted to enlarge a backpack twice but was unsuccessful. The intensity of these attempts seemed to destabilize the dream, as colors faded and the dream flattened back to a two-dimensional image followed by darkness. In the darkness, the dreamer tried to remain lucid and precipitate another dream. Further stabilization through grounding techniques, such as physically interacting with objects (e.g., grabbing a bag), were unsuccessful, and she eventually felt "pulled back" into her sleeping body.

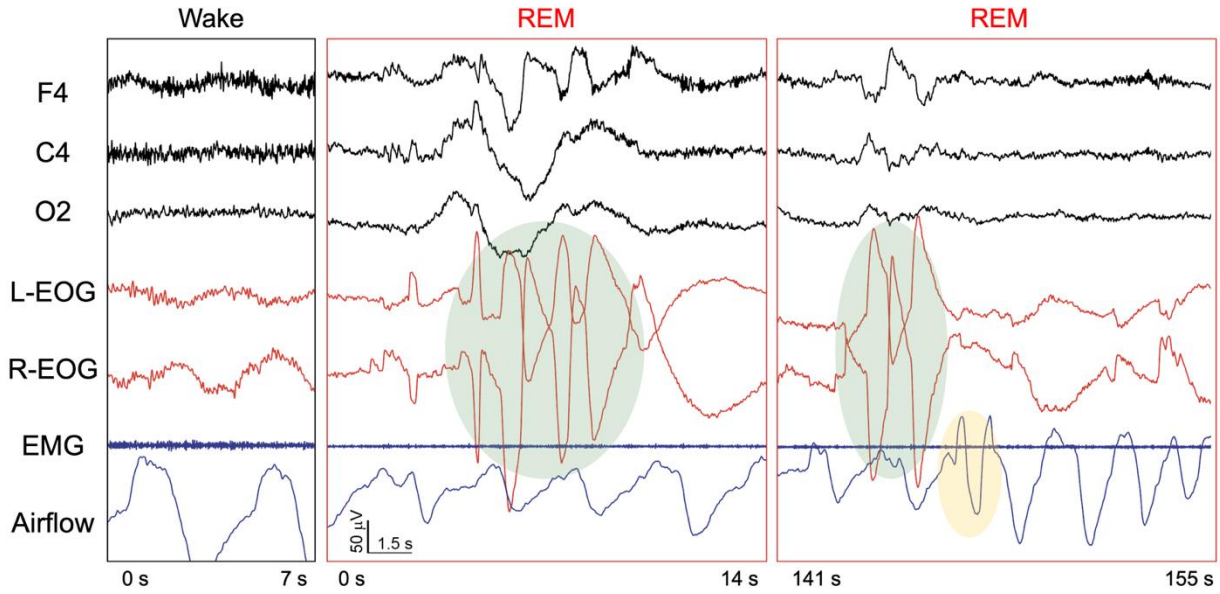

Figure 2. Polysomnographic recordings from Participant 6 documenting the Dream-Yoga exercise of moving through solid objects (same channels as in Figure 1). Left panel shows a period of wake with high EEG alpha and muscle activity. In a REM period approximately 442 mins after bedtime, she produced two volitional LRLR signals to indicate lucidity and produced two volitional LRLR signals (green ovals), 134 seconds apart from each other. Following the second LRLR signal, the participant performed two sniffs (yellow oval) to indicate initiating the dream exercise. The 4-closing sniff signal was not performed, and no cues were presented during this period.

Impossible Actions: Flying

Another facet of a Dream-Yoga practice is to expand proprioceptive awareness in novel ways. These experiences, like feeling one's body floating or flying around, defy the normal waking experience of gravity and challenge the fixity of one's body sense. By violating the extent to which one's body is subject to physical laws, practitioners may loosen their attachment to the perceived status of the self in waking reality, and they may begin to transcend their default sense of a permanent, unchanging self. A contemplative goal of advanced CSPs is thus to recognize how both dreaming and waking experiences are constructed, how our experiences are not as limited and constricted as they can appear.

Participant 5 experienced a signal-verified lucid dream in REM sleep during her second overnight session. She recalled the beginning of the dream when she found herself standing in a room that

resembled the sleep lab but was altered. There were brick-colored walls, gray cement floor, no bed, and a few white feathers. While picking up and observing the beauty and strangeness of one feather, she heard children and an old-style phone ring “everywhere in space.” She noticed the auditory resemblance to her chosen cue sound, which included child-like voices. The timing of one cue sound is shown in **Figure 3** in relation to physiological data collected at that time. Given that multiple cue sounds were presented, there is some ambiguity about the timing of her dream-report experiences relative to specific cues. After attaining lucidity, her attention then shifted to the preselected Dream-Yoga exercise, flying, during which she reported making two sets of sniffs. She also noticed a door with no handle, so grabbed a foot-pull to open it, and then observed “black emptiness” beyond. To stabilize the dream, she twirled her arms slowly before turning to walk down a hallway. She reported doing the eye signal with eyes closed (not evident in recordings), opening her eyes, and taking a few heavy steps into a horizontal flight (“superwoman-like” at low altitude), gradually gaining speed. She briefly considered flying through the roof but chose to stay in the hallway while focusing on not losing lucidity. As the hallway started to fragment and dissolve into blackness, she experienced a sense of urgency and stopped flying, transitioning to a standing position from which she performed sniff signals again, and then she reported experiencing an immediate awakening at the moment. Some of her sniff signals were evident in REM recordings (**Figure 3**).

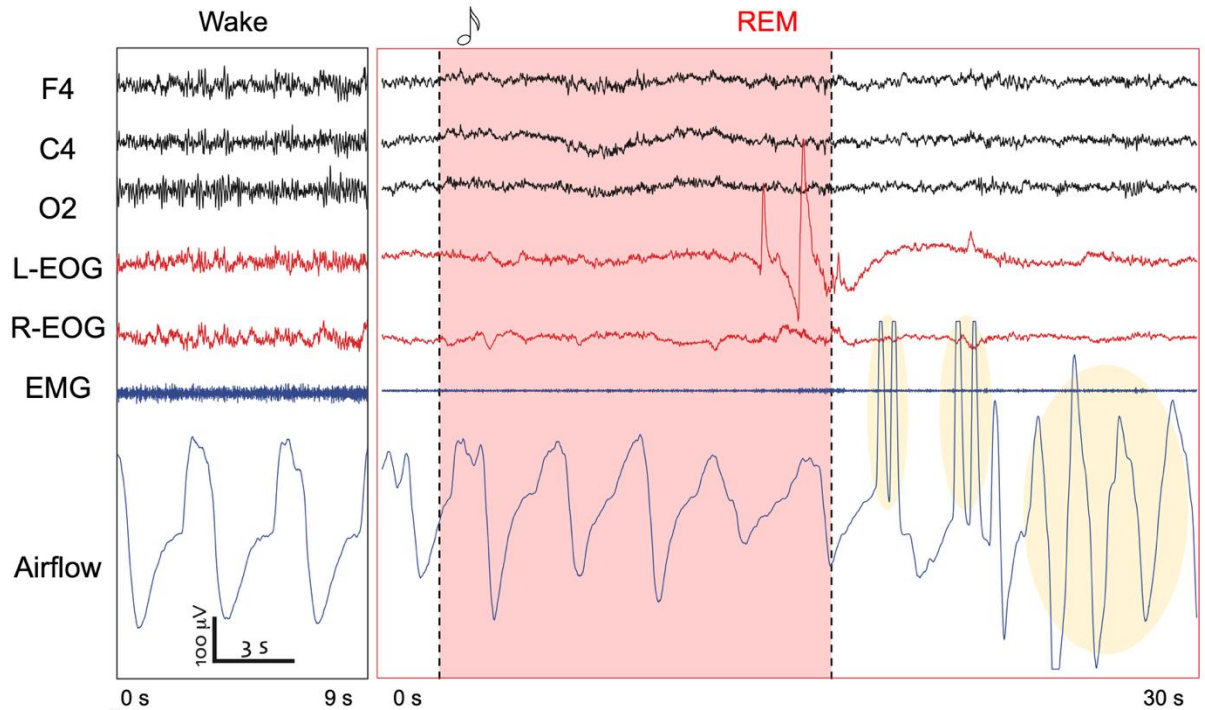

Figure 3. Polysomnographic recordings from Participant 5 during a flying exercise (same channels as in Figure 1). Left panel shows a period of wakefulness with high EEG alpha and muscle activity. Then in a REM period, multiple sound cues were presented (indicated by red shading with dashed lines at onset and offset). The sounds comprised low-pitched chanting. After awakening, the dreamer reported performing eye-movement signals when she achieved lucidity. None were detected during

sleep, except for a sharp ambiguous signal in the L-EOG, near the end of the sound presentation, but she did produce two nasal sniffs followed by four additional sniffs (yellow ovals). The participant woke up 73 seconds later.

During her third overnight session, Participant 5 reported a lucid dream in REM sleep in which she found herself standing on a grassy hill overlooking an ocean. The ocean was a personal dream sign for her, precipitating the insight of lucidity and then a focus on the agreed-upon exercise, to fly. She ran downhill, twirling her arms, and then jumped. Instead of flying, she experienced slowly floating upward into the sky (Mary-Poppins-style). As she described further in her dream report, she floated up for about 10 seconds and then remembered the experimental context, so performed the LRLR signal. Concerned the signal might have been too slow, she made some sniff signals. Polysomnographic recordings showed only partial correspondence, as signals were more ambiguous than in other nights (**Figure 4**). The dreamer described an extensive set of flying experiences next. She transitioned to horizontal flight at medium speed over the ocean and islands amid clouds. Following a sense of curiosity, she thought, "I wonder what it would be like if I fly into space," so she went vertical again and ascended. At some point, she became concerned about not being able to breathe in space, but this concern abated when the knowledge that she was in a lucid dream relaxed her and broadened her attention as her dream body dissolved. With a sense of amazement and awe, she perceived the sky shift from blue to whitish-gray to black with stars in all directions. Then she felt a drop in temperature as the Star Wars theme music swelled, prompting laughter, joy, and a playful sense of compassion. Then she heard a bell sound as Tinker Bell appeared abruptly in front of her, followed by a peaceful and gradual awakening.

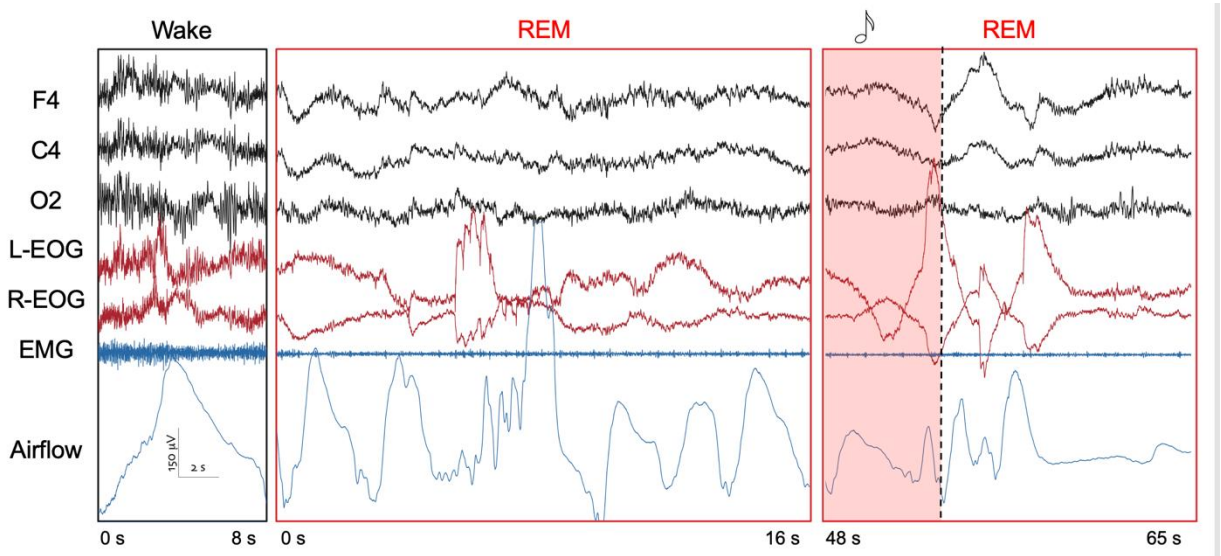

Figure 4. Polysomnographic recordings from Participant 5 documenting a Dream-Yoga flying exercise during REM sleep (middle and right panel) contrasted with a wake period (left panel) with high EEG alpha and high muscle activity (same channels as in Figure 1). Several sound cues were presented (red shading, soundtrack comprised mostly of harp music), the dreamer reported becoming lucid, producing LRLR eye movements and sniff signal, however, signals were ambiguous.

On his second overnight session, **Participant 4** planned to perform the Dream-Yoga exercise of walking through walls. During a period of REM sleep, approximately 3 hours after the wake-back-to-bed procedure, he was cued with a beeping sound associated with the lucid mindset. After awakening, he did not describe hearing the sound in the dream. The first recalled moment of the dream was a non-lucid experience of lying outdoors on the ground, embracing his high-school sweetheart while enjoying warm, affectionate bodily closeness. They both heard a teacher's voice from behind and above, so he decided to float up to investigate. He soon recognized the impossibility of floating ("hey, wait a second, I can't do this… I'm dreaming!"), so quickly produced a LRLR signal (**Figure 5**). Floating further, he approached the teacher, who now appeared as a large Tibetan Buddha statue covered with snow. He remained lucid, but did not recall the experimental context, and instead spent some time delicately dusting the snow off the face of the statue with great devotion, while admiring the radiance of the statue. He then flew down to join his high-school sweetheart along with a second woman, who embraced him affectionately. At this point, some aspects of the dream dissolved, including the two dream characters. Then, he remembered the experiment and shifted his attention to performing the four-sniff signal, indicating completion of an exercise. He explained in his dream report that he chose to give the four-sniff signal, even though he didn't complete the exercise of walking through walls, intending to explain the deviation to a flying exercise afterward. At this point, he was already awake, and the experimenter prompted him to give a dream report.

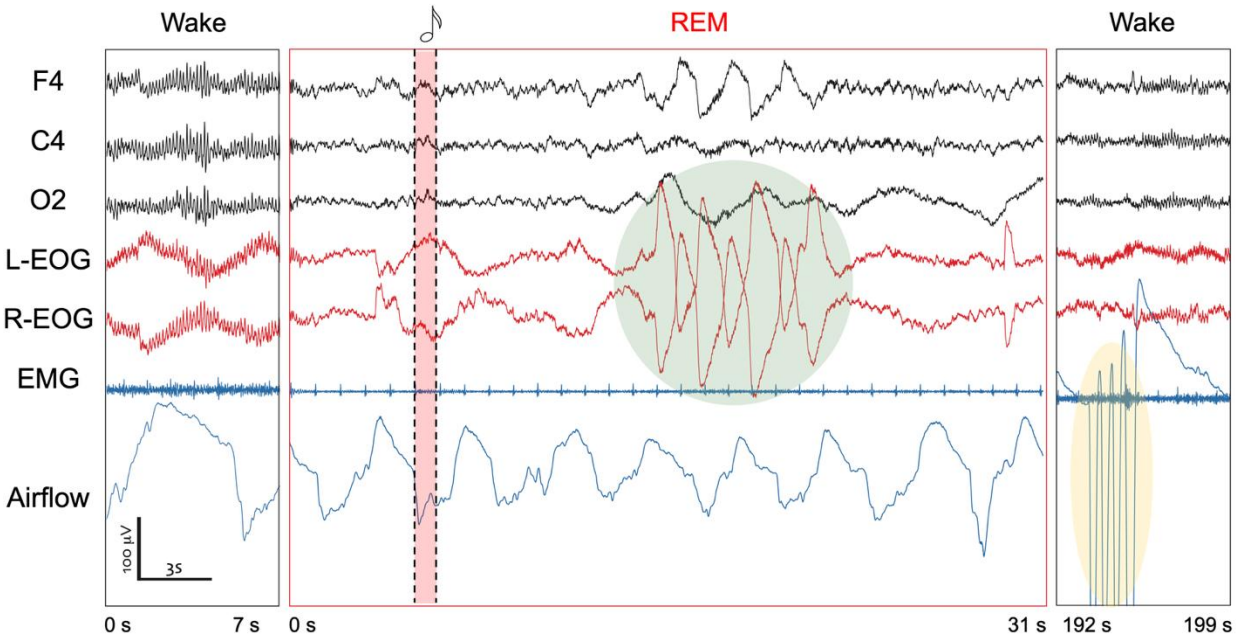

Figure 5. Polysomnographic recordings from Participant 4 documenting a Dream-Yoga exercise of flying during REM sleep (middle), contrasted with prior data from wake (left panel) showing high EEG alpha and high muscle activity (same channels as in Figure 1). During REM sleep, brief task cues were played (3 beeps indicated in dashed lines and red shading), and 7 seconds later the participant produced a LRLR signal (green circle) to indicate lucidity. The participant signaled the end of the exercise with four sniffs (yellow oval) during a period of wakefulness 193 seconds after the lucid signal.

Dream Yoga for Mental Stability and Nonreactivity

Along with the many methods dream-yoga practitioners use to establish and maintain dream lucidity, they also work on developing additional mental qualities. In one important example, the practitioner moves through the dream environment while attempting to sustain stable, nonreactive, non-judgemental awareness. During this exercise, which can be called *nonreactive witnessing*, there is no attempt to alter dream content. Rather, one cultivates this mode of awareness in relation to whatever happens in the dream. This exercise can be particularly challenging because of the pervasive tendency to react to, grasp, seek out, or avoid certain aspects of one's experience. By engaging in this exercise, however, practitioners seek to develop high-level skills in remaining stable, nonreactive, and nonjudgemental. Furthermore, this skill is thought to facilitate a practitioner's progress with advanced dream-yoga practices such as transforming into another individual and developing prosocial qualities such as boundless compassion (could cite Chenrezig paper here).

A signal-verified lucid dream in REM sleep was observed in **Participant 3** during her second session. Her dream report began with vague feelings of warmth and heaviness, with no other content or detail. Then, she recalled the moment in the dream when she became aware of moving her eyes laterally, then realizing that she was dreaming. She then deliberately completed the LRLR eye signal (**Figure 6**). A visual scene emerged in which she engaged with the dream as a witness-observer rather than trying to direct or interact with the dream. She described the experience as "a lucid dream within a non-lucid one" with a muffled quality. She maintained a detached perspective from above (autoscopy), witnessing her body walking slowly and deliberately through a softly lit white space. She identified partially with the walking body but mostly with the observer. She awoke while noticing her own unintentional eye movements but uncertain about the immediately prior dream segments. Two sniffs were recorded just prior to awakening.

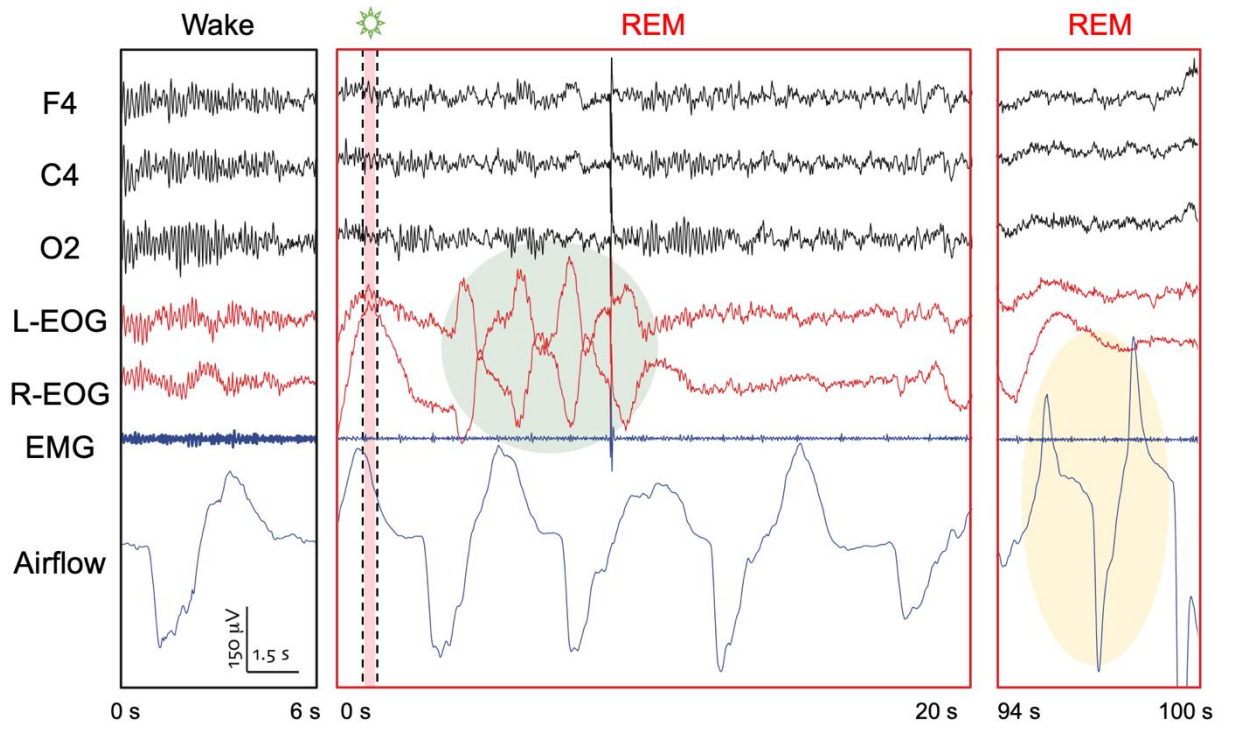

Figure 6. Polysomnographic recordings from Participant 3 documenting nonreactive witnessing as a dream-yoga exercise during a REM period (middle and right panel) contrasted with wake (left panel) with high EEG alpha and high muscle activity (same channels as in Figure 1). During a REM period 286 min after bedtime, a series of light cues were flashed (red rectangle). The participant performed LRLR eye signals three seconds after the cue, to signal lucidity (green oval). She also reported producing a two-sniff signal, which was observed 90 seconds later (yellow oval), followed immediately by an awakening.

Satisfactory Sleep Quality in Expert Practitioners

Because Dream-Yoga practitioners make use of sleep interruption, their practices could negatively impact their sleep quality. However, their subjective sleep quality, as assessed with the Pittsburgh Sleep Quality Index (PSQI), did not support this prediction (**Figure 7ab**). Overall, dream-yoga practitioners showed higher perceived sleep quality (2.00 ± 0.26) compared to a normative sample[39] (866 US college students, 5.64 ± 0.09, $t_{(5)}$ = -14.09, p= 0.032, *Cohen's d* = -1.30). Practitioners reported better quality (lower scores) across nearly all PSQI components. Sleep quality (0.17 ± 0.17) and efficiency (0 ± 0) were significantly better in Dream Yoga practitioners compared to normative data (1.06 ± 0.02, and 0.52 ± 0.02, respectively) with a large effect size (W= 0, p= 0.031, Cohen's *d* = –1.46 and W= 0, p= 0.031, Cohen's *d* = –1.29, respectively). Three participants reported waking up in the middle of the night more than once per week for their practices. Nevertheless, the group's mean disturbance score (0.67 ± 0.21) was significantly lower than normative scores (1.16 ± 0.01; W= 0, p= 0.031, Cohen' *d* = –1.00). Dream-Yoga preparatory practices can affect sleep latency, but participants reported taking 15-30 min to fall asleep, similar to normative data from the PSQI latency dimension (0.83 ± 0.30 and 1.05 ± 0.03, respectively). Daytime dysfunction scores (0.16 ± 0.16) were lower than for the normative data (1.15 ±

0.02; W= 0, p= 0.031, Cohen's *d* = –1.29). Five participants reported sleeping more than 7 hours per night, except one who reported sleeping 6–7 hours.

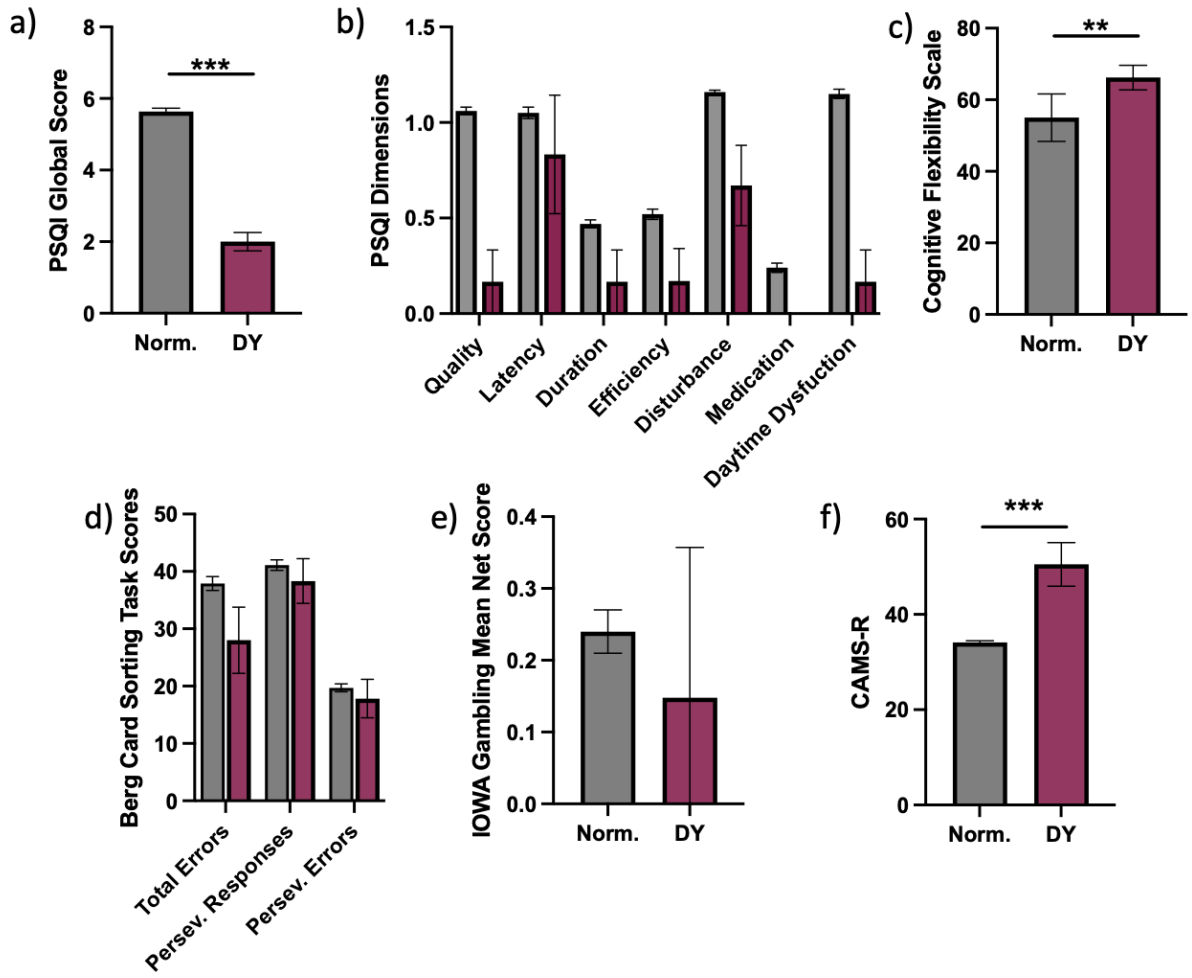

Figure 7. **Comparison of questionnaire and task results between dream-yoga practitioners and normative samples. (a)** Mean global Pittsburgh Sleep Quality Index (PSQI) scores for dream-yoga practitioners (DY; magenta) and a normative population (Norm.; gray)[39]. Error bars represent standard error. Lower scores reflect better sleep quality. PSQI categories: scores of 0–5 indicate good sleep quality, 6–14 moderate sleep difficulty, 11–15 mild, and 16–21 severe sleep difficulty. **(b)** Mean scores for each PSQI dimension across groups. **(c)** Cognitive Flexibility Scale scores were significantly higher in Dream-Yoga practitioners compared to that in normative participants[40]. **(d)** On the Berg Card Sorting Task, Dream-Yoga practitioners showed nonsignificant differences with a normative group[41]. **(e)** On the Iowa Gambling Task, Dream-Yoga participants showed comparable mean net scores to the normative group[42], with greater variability across individuals. **(f)** DY practitioners scored significantly higher Cognitive and Affective Mindfulness Scale-Revised (CAMSR) when compared to the normative sample[43]. Bars represent group means ± SEM;. *** p ≤0.001 **p ≤0.001

Do Expert Dream Yoga Practitioners Exhibit Enhanced Cognitive Flexibility?

The Dream-Yoga practitioners we studied exhibited a high level of familiarity with the lucid-dreaming state, a remarkable proficiency with influencing events that transpired in their dreams, and a great capacity to adapt to whatever happened. Despite the unpredictably changing nature of their dreams, they were able to adapt to the unpredictable nature of the dream and were able to maintain their focus on completing goals they had set in advance for the dream. We hypothesize that this capacity might be closely related to cognitive flexibility, which has been defined as the capacity in the waking state to modify one's behavior in response to shifting environmental demands[44,45]. According to these views, this capacity involves disengaging from a prior task, reorganizing mental strategies, and effectively applying a new set of responses to meet current goals. Cognitive flexibility has been described by some authors as less influenced by genetic inheritance and more susceptible to environmental factors, including training and education[46]. In the present context, cognitive flexibility also covers the ability to navigate diverse dream scenarios and landscapes, switching them at will, and responding adaptively within the dream context when a desired outcome is not forthcoming.

To assess participants' cognitive flexibility, we used the Cognitive Flexibility Scale, a self-reported questionnaire to measure the ability to adapt to a new situation or environment[40]. As shown in **Figure 7c**, the mean score on this scale showed that Dream-Yoga practitioners were superior (66.20 ± 1.53) compared to normative data from 275 participants[22] (55 ± 0.40, $t_{(4)}$= 7.32, p=0.001, *Cohen's d* = 1.6). This finding tentatively suggests an enhanced ability in our participants to shift perspectives and respond flexibly.

Behavioral tasks may capture related aspects of cognitive flexibility, so we included two standard tasks, a computerized version of the Berg Card Sorting Test (BCST) and the Iowa Gambling Task. The total errors (28 ± 5.7), perseverative responses (38.3 ± 3.8), and perseverative errors (17.8 ± 3.3) on the BCST were statistically comparable to normative data collected from 207 participants (37.9 ± 1.22, 41.1 ± 0.92 and 19.7 ± 0.69, respectively)[41] (**Figure 7d**). The mean net score of the Iowa gambling task were very similar in the Dream Yoga practitioners (0.14 ± 0.2) when compared to normative data of 50 young adults[42] (0.24 ± 0.03) (**Figure 7e**) [47].

Because Dream Yoga involves daytime contemplative practices, including meditative techniques of observation and visualization, we sought to assess traits relevant to these practices by evaluating attention and acceptance/nonjudgment using the Cognitive and Affective Mindfulness Scale–Revised (CAMS-R). This questionnaire was developed to measure dispositional mindfulness or an individual's tendency to be mindful in daily life. Dream-Yoga participants mean score was 50.5 ± 1.8 out of a possible 60, which was significantly higher than data from a normative sample of 298 students[43] (34.1 ± 5.5, $t_{(5)}$ = 8.74, p = 0.003, **Figure 7f**).

Discussion

Extending the boundaries of our current scientific understanding of dreaming, we completed an initial investigation of advanced practitioners performing a Contemplative Sleep Practice (CSP). We combined polysomnographic recordings, real-time communication, and microphenomenological interviews to characterize these practices, with physiological measures providing verification of lucid-dream signalling during REM sleep. Dream Yoga originated within Tibetan-Buddhist philosophical frameworks and has been described in an extensive literature wherein training procedures and results were discussed in great detail[8,13-16]. According to these accounts, advanced practitioners can be trained to recognize and manipulate dream environments through sustained effort in the context of multifaceted contemplative training. Documented behavioral and physiological observations add substantially to these accounts.

Our principal findings characterize contemplative practices of Dream Yoga in a select group of advanced practitioners who intentionally engaged with their dreams with a transformative learning agenda. We obtained detailed dream reports together with recordings of physiological signals during unambiguous periods of REM sleep. Those periods included when we presented auditory cues to participants and when received specific signals from them. Time stamps of stimuli and signals in the recordings were then compared with details from post-awakening dream recall, such that we could describe many ways in which the physiological data converged with and substantiated the behavioral dream reports.

Given the unusual nature of the dream experiences conveyed by the practitioners, their sleep might be expected to be qualitatively quite abnormal. However, most aspects of sleep physiology were not obviously different from those seen in other individuals. Experiences of multiple dream-yoga exercises occurred during periods of REM sleep that were not noticeably distinctive from recordings of REM sleep in the general population. Measures of subjective sleep quality were also quite normal, despite the inherent sleep fragmentation of Dream-Yoga practices. In this sense, sleep physiology was not unusual in the expert practitioners, despite their unusual experiences. Nonetheless, dreaming in these individuals was not passive and out of control; rather, complex goal-directed behavior with a transformative learning agenda can occur within oneiric consciousness.

This investigation emerged from a novel interdisciplinary framework that integrated traditional contemplative approaches with neurophysiological and first-person methods. Microphenomenological interviews provided rich, nuanced insights into participants' experiences, capturing fine-grained cognitive dynamics of intention, awareness, and control within the dream state. This approach complements conventional neurophysiological techniques to produce a comprehensive picture of the subjective and objective dimensions of CSPs. By triangulating EEG data, real-time signaling, and in-depth phenomenological reports, this study offers a rare multimodal window into the lived experience of advanced contemplative dream practitioners.

Dream-Yoga practitioners train to recognize the dream state, sustain lucid awareness amidst its volatility, and counter entrenched beliefs. They influence or direct ever-changing dream content, which demands metacognitive expertise and flexibility. We hypothesize that their CSP training may strengthen

their capacity to shift between mental frames, including self-representations. This capacity may be reflected in increased cognitive flexibility, which relies on the dynamic interplay of multiple neurocognitive systems, such as cognitive shifting, inhibition, working memory, attention, salience detection, among other systems[48]. To gain a comprehensive profile of this capacity, a multidimensional array of tasks may be needed [44,48]. In this study, this capacity was indexed using the cognitive flexibility scale, in combination with two neuropsychological tasks. While these measures capture complementary aspects of cognitive flexibility, the relatively small sample size and the limited breadth of the assessment battery constrain the strength and generalizability of the conclusions. Accordingly, the findings should be interpreted with appropriate caution. Future work employing larger samples, richer task batteries, and longitudinal designs will be essential to determine whether and how these practices produce sustained changes in cognitive flexibility over time.

In addition to their relatively normal sleep quality, Dream-Yoga practitioners scored significantly higher on the CAMS-R, indicating greater dispositional mindfulness. These results raise two plausible and non-mutually exclusive interpretations. One possibility is that long-term CSP engagement may alter the way sleep is experienced and evaluated, such that sleep fragmentation is no longer perceived as disruptive. Through sustained training in awareness, attentional regulation, and emotional acceptance, practitioners may develop a more flexible and less reactive relationship to nocturnal awakenings, thereby preserving—or even enhancing—subjective sleep quality while simultaneously cultivating trait-level mindfulness.

An alternative explanation is a selection effect: individuals with higher baseline dispositional mindfulness, greater attentional stability, and stronger intentional commitment may be more likely to engage with, persist in, and benefit from Dream Yoga practice. Because these practices require discipline, devotion, and sustained motivation, it is possible that individuals with elevated trait mindfulness are overrepresented among long-term practitioners, which could account for both higher mindfulness scores and preserved sleep quality. Distinguishing between these interpretations will require longitudinal and prospective designs capable of disentangling training-related changes from pre-existing individual differences

Dream Yoga enables practitioners to directly engage with the constructed nature of experience in a dream and to reshape habitual perceptual and cognitive schemas. Because cognitive flexibility is fundamental to psychological resilience[49], practices that cultivate this capacity may hold strong translational potential. From the standpoint of predictive processing, perception is shaped by the brain's ongoing efforts to minimize prediction error by updating prior beliefs. In Dream Yoga, learning to alter one's beliefs within the dream, such as believing one can walk through walls, trains this kind of flexible updating. These processes can be extended to reduce maladaptive patterns such as rumination and rigid self-referential thinking, which are implicated in multiple mental health conditions including depression and anxiety. In a Dream-Yoga practice, fears and phobias, volitionally conjured by the practitioners or represented in nightmares, can be faced and processed in the safe and virtual environment of a lucid dream. Thus, Dream Yoga-based contemplative interventions may offer a novel and scientifically

underexplored pathway to improve mental health by potentially targeting different cognitive mechanisms.

However, there are important limitations. Our sample was small and selective, precluding causal inference. The normative comparison groups differed in demographic and cultural context, which may confound interpretation. Signal detection reliability varied across nights, in this study, we encountered a case of mismatch between subjective experience and physiological trace, limiting signal detectability. These issues emphasize the need for longitudinal designs with active control groups and field-based data collection to generalize these findings.

Documented lucid episodes, verified by concomitant physiological markers establish the feasibility of investigating conducting rigorous laboratory-based research on CSP during sleep, but also the possibility of isolating neural correlates of discrete contemplative tasks. Future research should extend this work by characterizing the electrophysiological signatures of intentional dream engagement, leveraging mobile EEG in culturally contextualized settings, and exploring whether these practices can be systematically learned by novice populations. Understanding the extent to which contemplative sleep practices modulate cognitive and neural processes could inform novel interventions targeting cognitive inflexibility and maladaptive predictive models implicated in psychiatric disorders such as depression and PTSD.

In summary, this research lays foundational groundwork for a multidisciplinary science of intentional dreaming, integrating contemplative knowledge systems with empirical neuroscience, and expanding the landscape of human cognitive training beyond waking states.

Methods

Participants

Screening was conducted with 20 candidates who were identified as potential experts through word-of-mouth. Interviews were conducted to assess expertise in contemplative practices and types of prior contemplative training. Each interview was conducted individually via videoconference and lasted approximately 45 minutes. A semi-structured interview guide was followed to ensure consistency while allowing flexibility for follow-up questions, including the following core items.

- At what age did you begin lucid-dreaming practices?
- In which traditions of Dream Yoga were you instructed, and which are you currently practicing?
- How frequently do you practice lucid dreaming?
- Which specific Dream-Yoga practices are you most familiar with?
- What is the frequency of similar practices in your regular routine?
- Are you able to intentionally induce sleep during the day?
- How have dream experiences influenced your waking life?

We selected six advanced practitioners (4 females, 2 males, average of 43 ± 14 years of age). They were invited to our sleep research laboratory located on the Northwestern University campus in Evanston, Illinois, for 3 or 4 consecutive nights. During the weeks leading up to their visit to the sleep lab, they were asked to practice the LRLR and sniffing signals during their lucid dreams and to complete standardized questionnaires. One additional practitioner, a monk in India, was invited to participate in the study. Given his remote location, a study team travelled to collect data. The data are not presented in this report given the lack of screening and microphenomenological interviews. The study was approved by Institutional Review Boards at all three institutions and informed consent was obtained.

Questionnaires

Two weeks prior to the lab visit, participants completed a battery of self-report questionnaires to assess sleep quality, lucid-dreaming frequency and confidence, and cognitive flexibility. Questionnaires were administered online via encrypted forms (Qualtrics).

The Frequency and Intensity of Lucid Dreaming (FILD) questionnaire was administered along with custom questions about frequency of lucid dreams and of deliberate attempts to induce lucidity over the past month. Questions assessed typical dream recall, the number of lucid dreams per week, the frequency of deliberate induction attempts, and subjective ratings of lucidity confidence. Participants were also asked to estimate the typical duration of their lucid dreams, described in terms of dream scenes or narrative segments (FILD Mean Score: 6 ± 0.89). Four participants reported successfully attempting and achieving lucidity two or more times per week. The other two participants reported attempting and succeeding between one to four times per month. Participants reported high confidence in their lucidity for the vast majority of their lucid dreams. Five participants reported confidence in 80%-100% of their lucid dreams, and one participant reported confidence in 60%-70% of their lucid dreams. The duration of lucid dreams was typically described as spanning 3 ± 0.89 dream scenes (see supplemental material for further details).

Using the Lucid Dreaming Skills Questionnaire (LUSK), a 10-item self-report measure designed to assess skills such as dream awareness, control over dream content, and intentional action within dreams, we compared Dream-Yoga participants to a normative sample of 675 German individuals reported by Shredl and colleagues[50]. The normative sample had a mean score of 1.51 ± 0.88, whereas Dream-Yoga participants scored significantly higher, with a mean of 28.80 ± 6.78. Higher LUSK scores reflect greater proficiency in various aspects of lucid dreaming, including recognizing the dream state, maintaining lucidity, exerting control over dream content, and performing intentional actions while dreaming (**Figure S1)**.

Polysomnographic recordings

Participants slept for three consecutive nights with full polysomnography (except one participant who slept for one additional night), including electroencephalography (EEG), electromyography (EMG), electrooculography (EOG), and electrocardiography (ECG). EEG was recorded from 18 electrodes placed according to the international 10–20 system (F3, F4, C3, C4, O1, O2, T5, T6, and both mastoids (right mastoid reference). There were also two submental EMG channels on the chin, two EOG channels (horizontal and vertical), and one ECG channel. Airflow was measured via a nasal cannula connected to a nasal airflow pressure transducer (BiNAPS). Data were collected using a Neuroscan SynAmps system with a 1000-Hz sampling rate and bandpass at 0.1–100 Hz for EEG and EOG, 10-100 Hz for EMG, and 0.05–50 Hz for airflow.

Contemplative Sleep Procedures and Interactive Dreaming

On the first night, participants were asked to sleep normally and were encouraged to follow their usual nightly practices. This initial night served as an adaptation night and four out of six participants were not cued or disturbed in any way. Two participants had a lucid dream in the adaptation night and woke naturally to report the dream.

On some nights, Targeted Lucidity Reactivation (TLR) was used to increase lucid dreaming[26,38]. As described above, participants associated a specific sound or light cue with a lucid state of mind prior to sleep. TLR stimuli were presented overnight to return participants to this lucid state of mind. Sound cues were chosen by participants. Before sleep, we adjusted sound intensity to determine each participant's threshold for detection. Sound levels were titrated to each participant's comfort level and kept low to avoid awakening. Sounds were played from a speaker located on the ceiling of the sleep chamber. Visual cues were brief pulses of light presented via a soft LED near the bed. If a participant did not spontaneously produce the lucid signal, lucid cues (auditory and visual, or just auditory) were presented during REM periods to help promote lucidity.

Dream Reports

Dream reports were recorded after participants were either awakened at the conclusion of a REM period or after an arousal. The experimenter whispered the participant's name softly to wake them up. The following questions were asked.

1. Please describe your experience, including any dreams, sensations, feelings, thoughts, or emotions from the last few moments or since we last spoke.

2. (If relevant) Please try to recount in sequence in as much detail as possible how you became lucid, signals you completed, and everything you remember about the tasks you completed.

3. Did you notice any cues while you were asleep?

4. (If relevant) Please describe which cues you noticed, how many times, and how you experienced them.

5. (If lucid) During your dream, how aware were you that you were dreaming? (Scale: 0 = not at all, 4 = very much so).

6. (If lucid) During your dream, how much were you able to control your actions or what happened? (Scale: 0 = not at all, 4 = very much so).

7. Do you remember anything else?

After answering the questions, participants returned to bed so that cues could be presented during the subsequent REM period.

Microphenomenological Interviews

Participants took part in a one-on-one micro-phenomenological interview after each overnight session. The interview was conducted by an experimenter with extensive experience in such interviews. The interview took place via a private video call during the day following the overnight session. Each interview lasted approximately 1.5 hours. Interviews followed a structured micro-phenomenological protocol[28,29] adapted to the dream-research context to elicit detailed reports[33]. The protocol aims to guide participants in an unbiased way through the recollection process of the dream, focusing on

particular examples of Dream-Yoga practices, perceiving stimuli during a dream, and producing volitional signals. Instructions from the interviewer encourage participants to focus on their immediate, lived experience rather than preconceived notions or interpretations. This technique may reveal subtle or overlooked aspects of an experience that otherwise can be difficult to articulate[28,29].

EEG Data Processing

Electrophysiological data were preprocessed with additional bandpass filters using ERPLAB[51]. EEG data were filtered from 0.3 to 35 Hz and EOG data from 0.3 to 15 Hz. To reduce artifacts, an IIR Butterworth bandpass filter was applied to improve the signal-to-noise ratio while preserving frequency dynamics relevant for sleep scoring. In cases where certain channels showed persistent noise, typically due to movement artifacts or poor electrode contact, targeted filtering was applied to those specific channels to suppress contamination without affecting other channels. Sleep staging was performed manually using SleepSMG, an open-source graphical interface for EEG-based sleep analysis. Manual scoring followed AASM guidelines, with scorers (KK, SGTP, & DM) assigning a sleep stage to each 30-s epoch. Disagreements were resolved through discussion until consensus was reached.

Behavioral Tasks

We used an online version of the Wisconsin Card Sorting Test called the Berg Card Sorting Task [52]. Participants sorted 128 stimulus cards by matching them to one of four target cards according to color, shape, or number, with correct/incorrect feedback but without explicit instruction about the current rule. After achieving a set of 10 correct responses, the sorting rule changed, requiring participants to flexibly learn the new rule. Decision-making under uncertainty was assessed using the Iowa Gambling Test, where participants aimed to maximize earnings by choosing cards from decks that varied in rewards and losses. Psychology Experiment Building Language open-source software was used for these tests.

Statistical Analyzes

Statistical analyses were conducted using Python (SciPy and NumPy libraries). Normality was assessed using Shapiro–Wilk tests. One-sample t-tests were used for normally distributed data. The Wilcoxon-signed rank test was used for non-normally distributed data. When multiple comparisons were conducted, p-values were adjusted using the Holm–Bonferroni procedure, controlling the family-wise error rate at $\alpha = 0.05$. Effect sizes were calculated using Cohen's d, with the pooled standard deviation computed as a weighted average of variances from the sample and the normative group. This approach accounts for differences in group sizes and provides a more accurate estimate of effect magnitude. All measurements were expressed as mean ± SEM and $p \leqslant 0.05$ was considered significant in all statistical tests.

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