# Lucid dreams from reactivating mindfulness during REM sleep: A pilot study

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*Summary*. People typically become aware that a dream was "just a dream" only after awakening. Alternatively, people can become aware that they are dreaming during the dream. These lucid dreams are thought to involve increased prefrontal cortex activity relative to non-lucid dreams, and they are associated with volitional control over dream content. Lucid dreams could be valuable for many purposes, such as part of therapy for nightmares. Yet, research on such applications has been limited by the long-standing challenge of inducing lucid dreams. Recent studies made progress in showing that memory reactivation during an early-morning nap can induce lucid dreams. Here, we propose that reactivating mindfulness during REM sleep can also be an effective strategy for inducing lucid dreams. A brief literature review and preliminary results support this notion. In this pilot study, participants ($N$ = 5) underwent a wake-back-to-bed procedure with standard polysomnography to track sleep stages and verify lucid dreams with electro-ocular eye signaling. After approximately 5 hours of sleep, participants were awakened to complete a breath-counting task while ambient music cues played in the background. When participants returned to sleep and reached REM sleep, cues were replayed to reactivate the task context. This procedure induced signal-verified lucid dreams in two participants. This rate of induction success approached that of recent full-scale investigations, though additional evidence will be needed to substantiate these initial results. Nevertheless, the present findings suggest that mindfulness-associated sensory stimulation in REM sleep has high potential value for promoting lucid dreaming.

*Keywords:* Sleep, dreams, lucidity, induction, mindfulness, targeted memory reactivation

## 1. Introduction

In lucid dreams, unlike nonlucid dreams, individuals gain awareness that they are dreaming while still asleep (Baird et al., 2019). By one estimate, 55% of the general population has experienced at least one lucid dream and 23% claim to experience lucid dreaming at least once a month (Saunders et al., 2016). Although the scientific literature on lucid dreaming is limited due to the challenges of inducing lucid dreams (LaBerge et al., 1981; Hearne, 1978; Tan & Fan, 2022; Van Eeden, 1913), the extant evidence suggests that lucid dreams can be used to enhance creativity, promote motor learning, and treat nightmares (Appel et al., 2018). Furthermore, lucid dreams allow for novel studies of human consciousness.

One strategy for inducing lucid dreams is known as the wake-back-to-bed (WBTB) method. With WBTB, a participant sleeps for ~5 hours, then stays awake for ~30 minutes, and then returns to sleep (S. LaBerge et al., 1994; Tan & Fan, 2022). Dreams that occur during this early-morning nap tend to have an enhanced chance of including a lucid dream (Tan & Fan, 2022). Given that lucid dreams occur more frequently following sleep disruption (Gott et al., 2020), the WBTB method takes advantage of this by deliberately disrupting sleep. Certain cognitive tasks can also be used prior to returning to sleep to boost lucid-dreaming frequency. For example, more lucid dreams were reported by participants who reflected on dreaming during the wake period than those who read unrelated material (Erlacher & Stumbrys, 2020). In another study, dreams were more likely to be lucid when WBTB was combined with pharmacological manipulation (galantamine) and meditation than when WBTB was used alone (Sparrow et al., 2018).

A promising new approach is to reactivate memories during sleep to induce a lucid dream. The procedure, known as Targeted Lucidity Reactivation (TLR) is a variant of the targeted memory reactivation (TMR) procedure (Carr et al., 2023). In this study, before sleep, participants spent several minutes practicing critical self-awareness and reflecting on the uniqueness of their current experience, while novel sounds were presented. Next, when participants were asleep and observed to be in REM sleep, the same sounds were presented. Given previous studies using TMR to reactivate memories (Paller et al., 2021), these sounds were thought to reactivate the associated pre-sleep memories so as to help individuals discriminate dreaming from waking experiences (Carr et al., 2023). In half of the participants,

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the cue sounds were recognized during dreams to trigger lucidity.

How does one come to recognize the dream state in real time? A leading hypothesis is that lucid dreams occur when higher-order cognition leads to the realization that certain dream elements are not consistent with waking life (Adams & Bourke, 2020). Higher-order cognition in this context encompasses components such as cognitive control, and perhaps metacognitive attention to mindfulness, probably associated with prefrontal cortical activity (Friedman & Robbins, 2022). Relatedly, working memory and other executive function tasks have repeatedly been linked with prefrontal cortex activation, and patients with prefrontal damage commonly fail to evaluate or appreciate incongruous information (Knight et al., 1995). Also, Stumbrys and colleagues (2015) observed a strong correlation between lucid-dreaming frequency and trait mindfulness scores on the Freiburg Mindfulness Inventory.

The goal of the current pilot study was to test the efficacy of a lucidity-induction protocol combining WBTB, brief mindfulness meditation, and TMR. This protocol was based largely on the success of recent methods that combined TMR with lucidity-focused mindfulness (Carr et al., 2023; Konkoly et al., 2021). Given that TMR can be effective at reactivating specific memories (Hu et al., 2020), we used an early-morning awakening, during which participants performed a task of attention/mindfulness, followed by REM-sleep TMR with task-related cues. We hypothesized that this procedure would help participants recognize when they are dreaming.

## 2. Method

### 2.1. Participants

Volunteer participants (*N* = 5) were recruited through local flyers and social media advertisements to participate in a sleep study related to lucid dreaming. They had varying levels of lucid-dream experience, ranging from a lucid-dreaming frequency of <1 per year to >1 per week, with one participant reporting 2-4 per year and two participants reporting about one per year. Participants were between the ages of 18 and 44 years. Four identified as female and one as male. They gave informed consent (approved by the Institutional Review Board of Northwestern University) and were compensated at $12.50/hr.

### 2.2. Polysomnography

Electrophysiological recordings were made with a Neuroscan SynAmps system in a sound-attenuating Faraday cage. Polysomnography (PSG) setup included contacts referenced to the right mastoid for electroencephalography (Fz, Cz, Oz), electrooculography (vertical left eye, horizontal right eye) and electromyography (chin). Respiration was recorded using a nasal cannula and Sleepmate respiration belt.

### 2.3. Wake-back-to-bed

Participants arrived at the lab approximately 1 hour before their typical bedtime. After PSG setup, a brief survey, and LRLR-signal training (described below), participants went to bed. After roughly 4-5 hours of sleep, participants were awoken for a series of computerized tasks and returned to bed for a morning nap (see Figure 1A).

### 2.4. Breath-Counting Tasks

Participants completed the Breath Counting Task (BCT), which yields a behavioral measure of accuracy that has shown positive relationships with measures taken to index trait mindfulness (Levinson et al., 2014). Participants were asked to "be aware of the movement of the breath" and to count their breathing cycles for 10 minutes. Specifically, they were instructed to press the left arrow on breaths 1-8, the right arrow on breath 9, and the spacebar if they lost count. One breath cycle was 9 breaths. Accuracy on the BCT was calculated as the percentage of total cycles where the right arrow was pressed only on breath 0 (Levinson et al., 2014). Participants completed the BCT immediately before the nap and again after the nap. The BCT data was collected after the nap based on the goals of a different experiment and those results are not included here. A white fixation cross on a gray background was displayed during the task, and ambient music (excerpt from Brian Eno's LUX 3, https://youtu.be/rXXH5JSJXGI) played at a comfortable intensity.

### 2.5. Targeted Memory Reactivation

PSG was monitored in real-time for sleep staging according to AASM standards (Iber et al., 2007). Upon entering REM sleep, 30-second music excerpts from the BCT (i.e., cues) were played. These cues were played at brief intervals (a random 1-5 minute silent pause between 30-s music segments) until REM sleep ended or an eye signal for lucidity was observed.

### 2.6. Lucidity Verification

Lucid dreams can be verified objectively. For example, making use of EOG recordings, a lucid dreamer can perform a predetermined eye-movement sequence when they become lucid (Baird et al., 2019; LaBerge et al., 1981; Hearne, 1978). We thus asked participants to signal when they realized they were dreaming by giving a left-right-left-right-center (LRLR) signal. To produce the signal, they were instructed to look "in the dream all the way to the left then all the way to the right two times consecutively then back to center without pausing" (Baird et al., 2019). Participants were awoken after producing the signal, and then a dream report was elicited. Subjective evidence for a lucid dream can be obtained through a post-sleep report of their dream experience of lucidity. A more objective criterion is a LRLR signal during a dream, which constitutes evidence for a signal-verified lucid dream.

### 2.7. Statistical Analysis.

To assess whether the present induction method produced lucid dreaming, we used descriptive statistics to compare our lucid condition to results from a recent study (Carr et al., 2023).

## 3. Results

Two of the five participants (40%) experienced a signal-verified lucid dream after spending one night in the laboratory (see Figure 1B). Their LRLR signals were clearly discernible on EOG channels (see Figure 1C). Post-sleep dream reports corroborated lucid dreaming in these two participants. For example, one participant reported: *"I was dreaming that my*

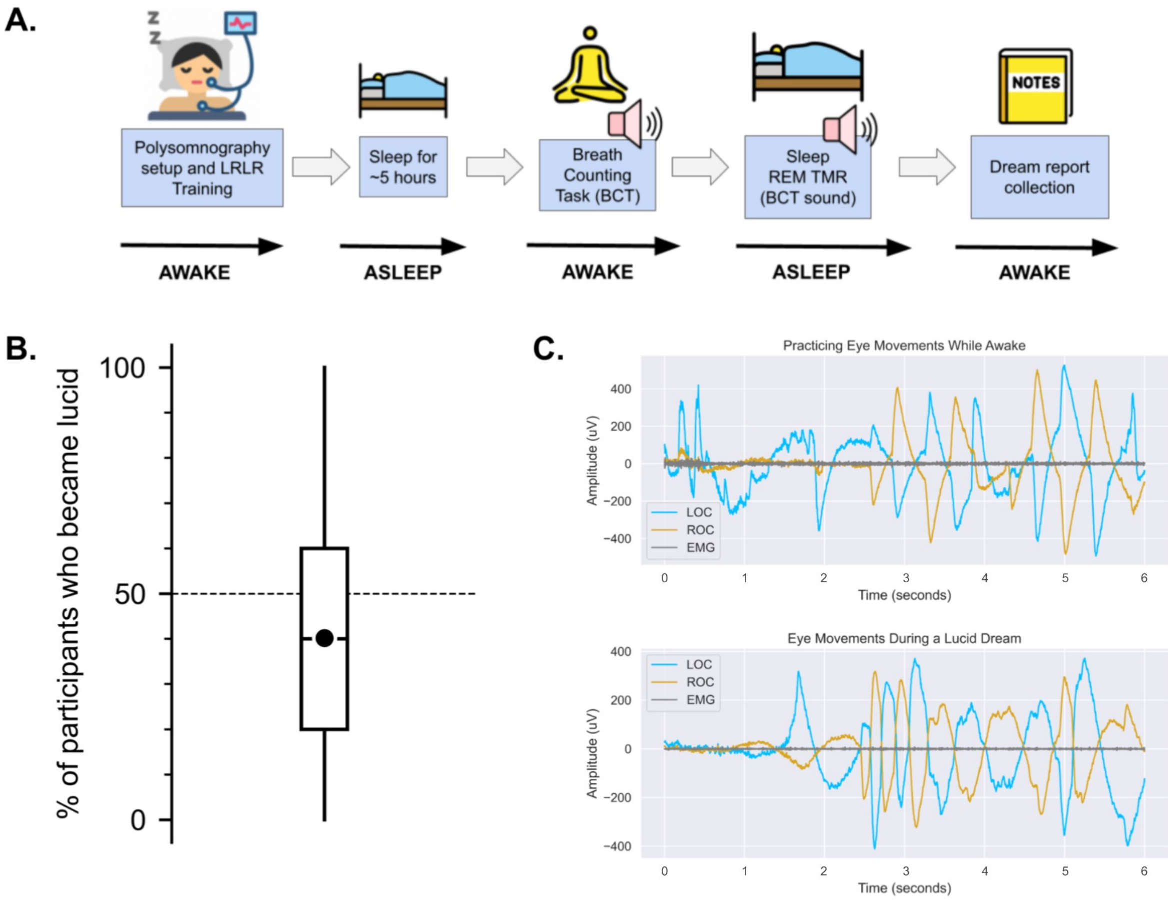


*Figure 1*. Lucid dream induction procedure and results. (A) Participants slept overnight in the lab while being monitored with PSG. After being awoken, participants completed a behavioral mindfulness task while listening to music. Task cues were then played during REM sleep. (B) Two out of five participants became lucid and provided LRLR eye-movement verification along with post-sleep dream reports of lucidity. Box plot represents the distribution of success rates after a bootstrap resampling procedure. Dashed line represents induction success from a similar protocol (Carr et al., 2023). (C) Participants learned to move their eyes in a specific left-right-left-right pattern while awake, and then moved their eyes in the same way while dreaming if they became lucid.

*dog that passed away got in the bed with me here, and I remembered to move my eyes. I was aware [of the dream], and I remembered to move my eyes... left, you know, and then right."* This success rate (40%) is comparable to that in a similar protocol used by Carr and colleagues (2023), who found that 50% of their 14 participants had a signal-verified lucid dream. To attain a measure of confidence in our success rate, Figure 1B shows the full distribution from resampling (with replacement) all five participants and recalculating the success rate 2,000 times.

During the WBTB awake period, BCT accuracy ranged from 33% to 89%. Median accuracy was 83% and mean accuracy was 70% (*SD* = 24%). The two participants who became lucid had accuracies of 89% and 60%.

## 4. Discussion

In this small pilot study, we explored the possibility of inducing lucid dreams through a mixed-methods procedure combining WBTB, TMR, and brief meditation. We observed a reasonably high success rate (2 out of 5). Both lucid dreams in this study were signal-verified using EOG to capture intentional signals while dreaming, offering strong objective support for the occurrence of lucid dreams.

Conclusions from this study must be tempered by a major limitation, which is that results were based on a very small sample that may not be representative. Also, there was no control condition, such that an estimate of lucid-dreaming probability in the absence of the manipulation was lacking. Prior evidence suggests that the probability would be very small (Saunders et al., 2016). Yet, given the small sample size, it remains possible that other factors led to 40% of participants becoming lucid rather than as a direct result of the manipulation. Further research is needed with a larger sample size. Additionally, it is known that lucid dreams occur more frequently when there is an intention to experience them before falling asleep, and many procedures with WBTB could work similarly in terms of effectiveness (Stumbrys et al., 2012). Given the theoretical rationale for the procedure and these promising pilot results, however, we suggest that future work with this approach would be valuable.

Prior WBTB studies succeeded in inducing lucid dreaming in roughly 25-50% of participants (Tan & Fan, 2022). Indeed, perhaps no single method would work for everyone. A combination of techniques, as in the current protocol, could be very promising. WBTB is hypothesized to be effective due to the temporary sleep disruption but appears to be more effective when used in conjunction with other techniques.

A benefit of our procedure is the inclusion of a pre-sleep mindfulness task with measurable performance variables. Future work could investigate how accuracy or engagement with this task might predict subsequent TLR-induced lucidity. With more testing, this procedure and related induction procedures could be tested as treatments for sleep disorders such as recurring nightmares and insomnia (Ouchene et al., 2023). Inducing lucid dreams reliably has been a barrier for progress in this field. With further optimization, the present sort of strategy for inducing lucid dreams could also be used to advance understanding of other aspects of sleep, dreaming, and consciousness.

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