"IS THIS A DREAM?" – EVOLUTIONARY, NEUROBIOLOGICAL AND PSYCHOPATHOLOGICAL PERSPECTIVES ON LUCID DREAMING

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"IS THIS A DREAM?" – EVOLUTIONARY, NEUROBIOLOGICAL AND PSYCHOPATHOLOGICAL PERSPECTIVES ON LUCID DREAMING

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Editorial: "Is this a Dream?" – Evolutionary, Neurobiological and Psychopathological Perspectives on Lucid Dreaming

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Editorial on the Research Topic

"Is this a Dream?" – Evolutionary, Neurobiological and Psychopathological Perspectives on Lucid Dreaming

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Lucid dreaming (LD) is a peculiar state of dream consciousness occurring mostly during rapid eye movement (REM) sleep where individuals are aware of they are dreaming and even may control the oneiric content, while remaining asleep (Baird et al., 2019). Whereas this phenomenon has been described in many religions and by philosophers thousands of years ago (Van Eeden, 1913), scientific research on LD began last century (LaBerge et al., 1981). Recent epidemiologic studies demonstrate spontaneous LD to occur at least once in life in 51–55% of the human population, with their incidence being correlated positively with dream recall frequency and negatively with advancing age (Schredl and Erlacher, 2011; Saunders et al., 2016). Notably however, a higher incidence of LD is frequently associated with sleep disorders, psychiatric and neurological conditions, and also with elevated cognitive traits including meta-cognitive abilities and creativity (Blagrove and Hartnell, 2000; Blagrove and Pace-Schott, 2010; Filevich et al., 2015; Voss et al., 2018; Scarpelli et al., 2019; Siclari et al., 2020).

Since neurophysiologic and modern mindfulness-based techniques for induction of LD have been introduced (LaBerge et al., 1981; Tholey, 1988), it was proposed that practicing LD could boost cognitive and psychological functions, thus being implicated in treatment of psychiatric disorders and recurrent nightmares (Stumbrys et al., 2012; Mota-Rolim and Araujo, 2013). Indeed, neurophysiologic studies show that LD in REM sleep might provide the dreamers with a unique opportunity to navigate volitionally the oneiric content, possibly through induction of a sleep-wake-hybrid state (Voss et al., 2009) or by activating those brain structures and neural networks that underlie executive functions in wake and that are normally suppressed during sleep (Dresler et al., 2015; Baird et al., 2018). However, the actual psychological worth and neurobiological correlates of LD and their effects on daytime functioning still remain less well-understood.

In this Research Topic, we aimed to organize a discussion forum on current trends in LD research to foster future collaborations and enhance our understanding of LD and human consciousness. We welcomed seventeen submissions of which sixteen were published: six original research studies, two reviews, seven opinions, and one perspective article, which targeted different, yet partially overlapping aspects of LD research.

We begin with the historical review by Mota-Rolim et al. which offers a valuable summary of evidences from past cross-cultural religious sources that strongly support the view of LD as a natural feature of human conscious experience in sleep which influences the highest levels of conceptual thinking. The authors advocate for consideration of the accumulated in past empirical experiences with LD in contemporary research to further explore LD frequency and characteristics among modern non-religious societies. Investigating further the frequency and characteristics of LD in religious and non-religious communities could make a good sense in evaluating changes in locus of control (LOC), the degree to which people believe that they, as opposed to external forces, have control over the outcome of events in their lives (Rotter, 1966) in association with dreaming and with LD, in particular (Blagrove and Hartnell, 2000). A recent study demonstrated high prevalence of supernatural agent in dream imagery among Hindu Nepalese informants (Nordin and Bjälkebring, 2019).

In contrast, studies on LD in non-religious participants suggest LD characteristics to be associated with higher cognitive and memory functions including meta-cognitive abilities and creativity and also with various personality traits (Blagrove and Pace-Schott, 2010). Two original studies published in our topic clearly show such interesting associations. Firstly, the large community-based study in Chinese students demonstrates significantly lower bizarreness density (BD) in subjects with LD than in participants without LD, while meta-cognition traits (self-reflection and insight) are negatively associated with BD in both LD and non-LD (Yu and Shen). Secondly, the online-based survey among 455 English responders who had previously experienced LD points to complex relationships across LD characteristics (frequency and extent of sustained awareness and control), REM sleep dissociative states (sleep paralysis and nightmares), proneness to reality deficits, and paranormal experiences and beliefs. The study shows paranormal experiences to correlate positively with LD features and parasomnia-related dissociative states, while paranormal beliefs are only associated with sleep paralysis and nightmares (Drinkwater et al.). Collectively, these two studies infer, firstly, LD to be associated with less bizarreness and higher meta-cognition in a state-dependent manner, and secondly, proneness to reality deficits to be associated with LD and sleep dissociative states trait-dependently.

Next, the opinion of Drinkwater et al. discuss possibilities for socially aversive traits, machiavellianism, narcissism and psychopathy, known as dark triad to affect dreams and LD features. They analyze the studies available and highlight substantial research limitations pointing to the need of future investigations in this area. Further, the opinion of Horton provides interesting and meaningful information about the role of LD for emotional processing, while discussing correlates of LD incidence with various psychopathologies. Definitions of key concepts in research on LD and non-LD regarding cognition, control of dream content, and conscious states are deeply emphasized.

Some contributions consider the current applicability, benefits and limitations of cultivating LD. The opinion of Vallat and Ruby rises serious concerns that LD and training procedures to increase their frequency may be harmful to the normal sleep and daytime functioning, while impacting negatively on sleep regulatory mechanisms. The authors argue, firstly, that methodologies used for LD induction alter sleep integrity, and secondly, that brain state during LD is neither that of wake, nor that of REM sleep but is rather a hybrid state which is naturally infrequent or unlikely. In the same line of discussion, the opinion of Soffer-Dudek outlines some potential benefits from LD, while considering risks at fragmented sleep that deliberate induction of LD may produce, which adverse effects are frequently disregarded. The author argues that continuous deliberate LD induction also may produce detrimental psychotic and dissociative mental sates through blurring of boundaries between reality and dreaming. The opinion of Mota-Rolim provides discussion on whether it is physiologically possible to move the eyes consciously and voluntarily during a pure REM sleep episode, as required for the pre-agreed eye movements (PAEM) technique, which is used to objectively indicate a LD. Results that gave rise to the "scanning hypothesis" were critically reviewed. The author concludes that since the PAEM constitutes the most used method to scientifically study LD, a consensus on how to apply this technique in a standardized way is still clearly warranted.

The original research by Ribeiro et al. describes and compares dream experience frequencies (dream, lucid dreams, awareness, and control) in association with sleep quality among students and in a general population sample. It is found that the frequency of all dream experiences could not predict negative impact on the quality of sleep. Aspy conducted an original research among 355 participants to evaluate the effectiveness of five different techniques for induction of LD. Major findings indicated that all techniques were effective regardless of baseline LD frequency or prior experience with LD. No adverse effects on sleep quality were found. Erlacher and Stumbrys conducted an insightful sleep laboratory controlled experiment using four different wake-up-back-to-bed (WBTB) conditions and a mnemonic technique (MILD) to explore reliably the effectiveness of this technique. The overall pattern of obtained results shows that through applying a combination of WBTB and MILD, detectable LD can be effectively induced in people who are not selected for their LD abilities. Regarding the neurophysiological approaches for inducing LD, the opinion of Mota-Rolim et al. describes portable devices for induction of LD, their scientific backgrounds and their reliability. The authors found that there are 10 portable devices in LD induction technologies, but only one has been empirically tested with published results and two provided minimal technical information on how their algorithm detects REM sleep online. In addition, association of the portable devices with cognitive and pharmacological techniques and their potential to improve the reliability of LD induction high-technologies were considered.

Regarding the clinical applicability of LD therapy (LDT), the manuscript of Macêdo et al. reviews existing literature of the effectiveness of LDT for treatment of nightmares. The authors conclude that although induction of LD may be a feasible aid in the treatment of patients with nightmares through minimizing their frequency, intensity and psychological distress, the available studies are still scarce and do not provide consistent results. Several study limitations should be considered in future clinical trials. Similarly, the case-controlled study by Holzinger et al. investigates the effectiveness LDT for coping with nightmares and sleep problems in patients suffering from posttraumatic stress disorder (PTSD). The authors found no effect of the LDT on the investigated sleep variables and no a correlation between reduction of nightmare severity and changes in PTSD-profile. However, levels of anxiety and depression decreased significantly in the course of therapy. The opinion of van Heugten-van der Kloet and Lynn discuss the enhanced insight and meta-consciousness through LD as possible psychological approach in coping with dissociation and psychotic illnesses, in order to reduce negative emotions in patients suffering from psychiatric disorders. They also acknowledge the high costs and the frequently observed ineffectiveness of this approach and advocate for opening novel research programs focusing on the relations among dissociation, the sense of self, and sleep and dreaming.

Finally, the perspective study by Holzinger and Mayer describes and models neurophysiological evidence for the seven awareness criteria of LD proposed by Tholey (1988). Each of the awareness criteria was analyzed separately with regard to its underlying neural circuits. It is hypothesized that not one, but several regions are involved in the state of lucid dreaming. Altogether, these contributions provide important psychological, neurophysiological, methodological, and clinical implications in future LD research.

AUTHOR CONTRIBUTIONS

SM-R, KA, and RK drafted the manuscript and are accountable for all aspects of the work.

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OPINION
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Portable Devices to Induce Lucid Dreams—Are They Reliable?

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INTRODUCTION

One of the main current challenges in lucid dreaming (LD) research is to develop a simple and reliable way to induce it (Stumbrys et al., 2012). This is because, for most people, LD is very pleasurable but also very rare (LaBerge and Rheingold, 1990; Mota-Rolim et al., 2013). Along with its recreational nature, LD also has potential clinical applications, such as the treatment of recurrent nightmares in post-traumatic stress disorder (Aurora et al., 2010; Mota-Rolim and Araujo, 2013; Morgenthaler et al., 2018). This has attracted the attention of high-tech companies, which have been launching portable LD induction devices commercially available to the general public.

This equipment captures electroencephalographic (EEG) activity for the online detection of rapid eye movement (REM) sleep, the sleep stage associated with typical dreaming (Aserinsky and Kleitman, 1953; Dement and Kleitman, 1957; for review, see Hobson et al., 2000). To induce lucidity, most devices provide visual, auditory, and/or tactile stimuli as sensory cues, which can become incubated into the dream content to alert dreamers that they are dreaming but without waking them up (LaBerge et al., 1981a; LaBerge and Levitan, 1995). Other devices provide transcranial alternating current stimulation (tACS) of the frontal cortex (Voss et al., 2014). Here we review 10 such devices: DreamLight, NovaDreamer, Aurora, Remee, REM-Dreamer, ZMax, Neuroon, iBand, LucidCatcher, and Aladdin (**Figure 1**).

THE PIONEERS: DREAMLIGHT AND NOVADREAMER

In the early 1980s, neuroscientists tried to induce LD by verbal suggestion (LaBerge et al., 1981a), musical tones (Kueny, 1985), tactile stimuli (Rich, 1985), and olfactory stimuli (LaBerge et al. unpublished data). In 1987, Stephen LaBerge conducted the first study on inducing LD by light stimulation during REM sleep: of 28 volunteers, 17 (61%) reported having experienced at least one LD episode (LaBerge, 1987).

With the success of light stimulation, LaBerge and Levitan (LaBerge and Levitan, 1995) tested for the first time a portable computerized biofeedback device, named DreamLight. Lights were used during REM sleep in 14 subjects for 4–24 nights. As a way to control for the placebo effect, lights were delivered on alternate nights, without the volunteers' knowledge. Eleven subjects (78%) reported 32 LD episodes: 22 happened on nights with the light cues and 10 on nights without them. Besides, the volunteers reported seeing the cues in their dreams significantly more often on light-cue nights compared to non-light-cue nights (73 vs. 9, respectively).

Following these experiments, LaBerge and co-workers from the Lucidity Institute released the first commercialized product to induce LD: the sleeping mask NovaDreamer. This device detects

REM sleep automatically and delivers flashing lights to incubate these stimuli into the dream, as a cue to induce lucidity. The mask was available in the market until 2004, when its production was discontinued. In 2009, the Lucidity Institute reported working on a new NovaDreamer, which would be released in 2016, but since then, no update has been announced.

THE MODERN DEVICES

Products That Are Available in the Market

Aurora was the first headband launched on a crowdfunding platform. Its campaign started in December 2013, asking for US$ 90,000, and in 40 days, they raised almost US$ 240,000. Aurora has electrodes for EEG oscillation detection and accelerometers that track body movements. According to their site: "Our experiments with real-time sleep stage detection have proven very accurate with 90% of our experimental subjects"; however, the developers do not provide enough scientific information on how their algorithm calculates accuracy, nor make the data supporting this claim accessible. They also admit some limitations of the method and posted as a disclaimer that the "REM-detection algorithm is not yet perfect." To date, the system is not available for immediate purchase but can be ordered. The Aurora platform is open-source and thus allows users to contribute in developing the system.

Remee is the cheapest sleeping mask and the only one that does not use online sleep stage detection. According to their site: "Using a series of smart timers, light patterns are displayed throughout the night…" This means that lights can appear during REM sleep or during the other sleep stages: sleep onset (N1), superficial sleep (N2), and deep sleep (N3). It is known that LD happens predominantly during REM sleep (LaBerge et al., 1981b, 1986) and less often during N1 and N2 sleep stages (LaBerge, 1980a,b, 1990; LaBerge et al., 1981a; Dane and Van de Caslte, 1984; Stumbrys and Erlacher, 2012; Mota-Rolim et al., 2015). However, if lights appear during N3, they will most probably fail to induce LD, since there are no reports of LD during this sleep stage. Besides, this mask may potentially impair sleep quality by disturbing the slow waves that occur during N3, which are related to the homeostatic restoration function of sleep (Benington and Heller, 1995).

The REM-Dreamer device (**Figure 1A**) has two features among all masks. First, it can induce lucidity by recording and playing voice messages, such as the user saying "I am dreaming," for instance, which can incubate into dreams (LaBerge et al., 1981a). Second, it allows communication between the dreamer and the machine. This feature is based on the ideas that (1) subjective eye movements during dreaming correlate with objective eye movements (that is, real eyeball rotations), as postulated by the "scanning hypothesis" (Roffwarg et al., 1962; for review, see Arnulf, 2011; LaBerge et al., 2018a,b); and (2) it is possible to voluntarily move the eyes to indicate dream lucidity (Hearne, 1978; LaBerge, 1980a,b). Thus, when the dreamer perceives the cues, the dreamer can move the eyes in such a predetermined manner that the device would sense this movement and stop generating the stimuli. The sleeping mask utilizes infrared sensors to detect when the user is in REM sleep; however, not enough technical information is available on how the algorithm implements this.

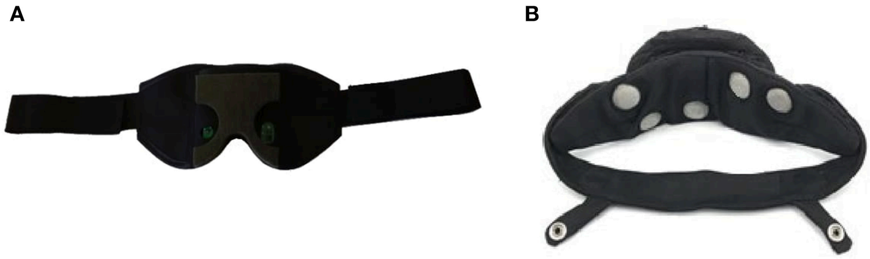
Hypnodyne's ZMax became available for sale in 2018 and is the most expensive device nowadays. ZMax is a sleep-monitoring headband that delivers light, vibrotactile, and auditory stimuli, and also allows audio-recording of dream experiences. ZMax is currently being tested in various universities and scientific institutions around the world. The device monitors sleep through two frontal sensors, which capture brain activity and ocular movements. In contrast to other devices that use dry EEG sensors, ZMax uses proprietary disposable solid hydrogel electrodes. In addition, it includes sensors for heart rate (acquired through a photoplethysmogram; PPG), temperature, ambient light, sound, and body movements. ZMax features offline autoscoring and online REM sleep detection algorithms, whose technical information is available and comprehensive. The accuracy of ZMax relies in part on individual EEG phenotype detection. To do this, REM sleep classification is initially delayed for 2 h, a period that will usually include at least the first sleep cycle. When this time has elapsed, the system analyzes the sleep data collected thus far and extracts a brief phenotype description of the individual. The result is saved in a subject-specific file, which can be loaded for subsequent trials, before data collection. Importantly, ZMax's online algorithms, whether for REM sleep detection or for stimulus protocols, require a computer to be connected through a wireless connection dongle because the algorithmic computations occur on the computer and are transmitted back to ZMax. Despite ZMax not being open-source, it allows for the scripting of several functions in JavaScript for custom stimuli. ZMax can also be interfaced with various other programming languages (MATLAB, Python, PHP, C++, Java, etc.) through an exposed TCP/IP[1] data socket.

Products That Are Under Development

Neuroon includes a mobile app dream diary, which is a good method to increase dreams and LD recall (LaBerge and Rheingold, 1990). It is open-source and also was launched in a crowdfunding platform: they asked for US$100,000 in pledges in June 2017, and 1 month later, they achieved almost $360,000. Besides measuring EEG activity, Neuroon has a pulse oximeter (PPG) and sensors for temperature and ocular movements, which would allow for online detection of REM sleep. The technical documentation of Neuroon is accessible; however, despite claiming the use of established techniques to induce LD (i.e., visual and tactile stimulation; Paul et al., 2014), the product is yet to be scientifically tested. More recently, the company behind Neuroon has filed for bankruptcy, and its future is thus uncertain.

iBand is the device that got the most crowdfunding support. They started their campaign in September 2016, asking for €50,000, and in 44 days received around €64,500. This headband has sensors that measure brain rhythms, body movement, temperature, and heart rate, and claims to analyze them through

[1]The TCP/IP socket is given according to the local network infrastructure policy for each installed device, and this could be static or dynamic. The required extended TCP/IP address information is not appropriated, as it depends on installation factors for each device.



	Sensor	Stim	Open Source	REM detect	Tech Info	Sci Test	Price (USD)	Sale Status
DreamLight	-	L	-	-	-	+	-	Not available
NovaDreamer	EM	L+S	-	+	-	-	450	Second hand
Aurora	EEG A	L+S	+	+	-	-	175	Pre-order
Remee	-	L	-	-	-	-	65	Purchase
REM-Dreamer	EM	L+S	-	+	-	-	170	Purchase
Zmax	EEG, A EM,P,T	L+S V	+/-	+	+	-	900	Purchase
iBand	EEG, A P, T	L+S	-	+	-	-	200	Delayed
Neuroon	EEG, T EM,P	L+V	+	+	+	-	300	Delayed
Aladdin	EEG	tACS	-	+	-	-	300	Delayed
LucidCatcher	EEG EM	tACS	-	+	-	-	350	Delayed

FIGURE 1 | Up: Internal views of **(A)** REM-Dreamer sleeping mask and **(B)** LucidCatcher headband (images reproduced with permission from ELI Company and Luciding Inc). Down: Table comparing the devices. Stim, Stimulus; REM detect, online REM sleep detection; tech info, technological information; sci test, scientifically tested; L, light; S, sound; V, vibration; EM, eye movement; A, accelerometer; T, temperature; P, pulse oximeter; tACS, transcranial alternating current stimulation. Neuroon, iBand, Aurora, and Aladdin electrodes are placed on Fp1/Fp2 referenced to FpZ; ZMax electrodes are placed on AF7/AF8 referenced to FpZ; and LucidCatcher electrodes are placed on Fp1/Fp2 referenced to TP9/TP10.

an "auto-learning software algorithm." However, its platform is not open-source, and the technical details of this algorithm are not available.

LucidCatcher (**Figure 1B**) and Aladdin are the only headbands that promise to induce LD using tACS of the frontal region. Since frontal gamma power (∼40 Hz) increases during LD (Mota-Rolim et al., 2008, 2010; Voss et al., 2009), Voss et al. (2014) used a low current to induce gamma activity on the frontal region during REM sleep and successfully increased self-awareness subjective scores during dreaming. Despite the claim that the Voss et al. (2014) study "was replicated by Aladdin in an IRB-approved clinical study," we could not find these data nor any related scientific publication. Importantly, there has not been a published reproduction of Voss et al. (2014) to date. It should also be noted that intracranial recordings have recently questioned whether transcranial electric stimulation can directly affect neuronal circuits, since traditional transcranial electric stimulation techniques require 4–6 mA to directly affect neuronal circuits (Vöröslakos et al., 2018), at least 16 times more than in the Voss et al. (2014) protocol. Therefore, it can be argued that the Voss et al. (2014) results were likely due to indirect mechanisms, i.e., the sensation of the electrotactile stimulus may have brought participants closer to waking up. This would increase cortical activation, particularly in key brain areas involved in LD (Mota-Rolim et al., 2008, 2010; Voss et al., 2009; Dresler et al., 2012; for review, see Baird et al., 2019), and therefore may have led to heightened dream consciousness.

CONCLUSIONS AND PERSPECTIVES

Most devices that were launched on crowdfunding platforms, mainly Aurora, iBand, and Neuroon, were able to raise much more resources than they asked for, which indicates that the public is interested in LD induction technologies. To date and to the authors' knowledge, the only research-ready equipment available in the market is ZMax; other devices, such as Neuroon, Aladdin, and LucidCatcher have had their release dates continually delayed. Only Neuroon and ZMax provide minimal technical information on how their algorithm detects REM sleep online, but none makes the data fully available. Most importantly, only DreamLight has been empirically tested with published results (**Figure 1**, table); thus, we conclude that better-controlled validation studies are necessary to prove the effectiveness of LD induction devices.

More scientific studies on other techniques to induce LD are also clearly warranted, and in particular, more reproducible studies in which LD can be induced. In a systematic review, Stumbrys et al. (2012) investigated 35 studies, which employed (a) cognitive techniques—such as autosuggestion, reality testing, and alpha feedback, for example ($n = 26$); (b) external stimulation—such as light, acoustic, and vibrotactile ($n = 11$); and (c) application of donepezil, which is an acetylcholinesterase inhibitor ($n = 1$). The authors observed that the methodological quality of the works analyzed was relatively low, and none of the induction techniques reported in these studies induced LD reliably and consistently. More research is needed to increase our understanding of external sensory stimulus processing during sleep and the conditions and the stimulus properties required for reliable dream content incubation, while preventing awakenings (Appel et al., 2018).

Promising results were obtained by two recent studies that applied galantamine (another acetylcholinesterase inhibitor), in combination with cognitive techniques, such as sleep interruption plus mnemonic induction of lucid dreams (MILDs; LaBerge et al., 2018a,b) or sleep interruption plus meditation and dream reliving (MDR; Sparrow et al., 2018). The association of the portable devices with cognitive and pharmacological techniques has great potential to improve the reliability of LD induction techniques.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Is It a Good Idea to Cultivate Lucid Dreaming?

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INTRODUCTION

Lucid dreaming (LD) is the process of being aware that one is dreaming while dreaming. In some cases, the dreamer may even gain control over a part of the dream plot and scenery. The scientific investigation of LD (experience already mentioned in Antiquity) did not start before the nineteenth century *(de Saint-Denys, 1867)*, and the use of objective methods to study LD only emerged a few decades ago (e.g., LaBerge, 1979, 1980, 1988; LaBerge and Rheingold, 1991; Levitan and LaBerge, 1994). Recently, LD gained visibility: surveys showed that 1/4 of all participants ($N = 1{,}380$) had heard of LD, that LD research is no longer seen as esoteric, and that the public has a generally positive view on LD (Lüth et al., 2018; Neuhäusler et al., 2018).

With the emergence of a digital lifestyle in rich countries and hyper-realistic video games, it became obvious to an ever-increasing amount of people that LD is the ultimate form of immersive experience. Indeed, it offers a (free) unique and fantastic world in which everything may become possible or controllable and feels real without putting the dreamer at risk. These characteristics (fantastic sensory and emotional experience) make LD indubitably highly desirable (e.g., Stumbrys et al., 2014).

There is however a problem preventing most of the population from enjoying LD: spontaneous LD is not frequent. About 50% of individuals have experienced at least one lucid dream in their lifetime, and only 11% report having two or more lucid dreams per month (Schredl and Erlacher, 2011; Saunders et al., 2016; Vallat et al., 2018).

It is not surprising, in this context, that numerous training methods and devices aiming at increasing LD frequency and the level of control within the dream have been developed and commercialized in recent years. The various LD induction methods can be classified in three categories: (1) cognitive techniques, (2) external stimulation during sleep and, (3) intake of specific substances (Stumbrys et al., 2012; Dyck et al., 2017; Bazzari, 2018; LaBerge et al., 2018). Reviews highlighted that none of these induction techniques were verified to induce LD reliably and consistently. However, for lack of anything better, individuals who want to increase their LD frequency may use one of these methods.

SLEEP DISRUPTION RISK DUE TO LD INDUCTION METHODS

Several of the LD induction methods deliberately (or incidentally) alter sleep architecture or duration. In the cognitive technique category, this is especially true of the widely-used mnemonic induction of lucid dreams technique (MILD; Levitan and LaBerge, 1994; Neuhäusler et al., 2018). The MILD is indeed more efficient if the trainee awakens during the night, stays awake for 30–120 min and then goes back to sleep (Stumbrys et al., 2012). This observation led to the development of the Wake-up-back-to-Bed technique, a LD induction method based solely on forced awakenings and periods of wake during the night. Those methods disturb sleep by increasing its fragmentation, modifying its architecture and decreasing its duration. Likewise, the dream

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re-entry method recommends counting while falling asleep after a short awakening, which may prevent trainees from actually falling asleep (Stumbrys et al., 2012).

Regarding the stimulation methods category, the principle is to deliver stimuli during sleep to trigger lucidity. Such stimulation is intrinsically associated with the risk of awakening (or arousing) the participants, and thus of decreasing sleep depth, disrupting sleep architecture and/or shortening sleep duration. The combination of the MILD techniques with external stimulation has also been tested because it was considered promising to induce LD (LaBerge, 1988; Levitan and LaBerge, 1994). In this case the risk of sleep disruption of the two techniques is cumulative.

Several substances have also been used to stimulate LD (via intracerebral acetylcholine increase), often in combination with the MILD technique (e.g., LaBerge et al., 2018; Baird et al., 2019). In this case, in addition to the previously mentioned risk, there is also the risk of disturbing the balance between the serotonergic and cholinergic systems which are jointly involved in regulating sleep. Disturbing this balance may impact sleep structure integrity (i.e., increased sleep fragmentation, time awake during the night, and sleep paralysis) and have adverse effects on health (Stumbrys et al., 2012; Biard et al., 2015, 2016).

Considering the gigantic amount of scientific evidence linking poor-quality or insufficient sleep to adverse health outcomes (including shorter life expectancy), and especially of sleep fragmentation in altered physical and cognitive health (e.g., Stepanski, 2002; Bonnet and Arand, 2003; Mullington et al., 2009; Mary et al., 2013; Walker, 2017, 2019; Ahuja et al., 2018; Barnes and Watson, 2019; Brauer et al., 2019; Pichard et al., 2019), one may seriously question the health consequences of regularly practicing LD induction methods.

THE MODIFIED CEREBRAL STATE DURING LD

The experimental investigation of LD is challenging given the difficulty to get LD in the lab. Indeed, LD is rare and unpredictable even for frequent lucid dreamers, especially in an unfamiliar experimental setting. Nonetheless, by applying the method of LD objective detection (pre-determined ocular signaling, LaBerge and Rheingold, 1991) to EEG and fMRI, some determined neuroscientists have managed to get a glimpse of the cerebral correlates of LD. In a pioneering EEG study, Voss et al. (2009) succeeded in recording the brain activity of three dreamers while they were experiencing a lucid dream. They observed an increased activity in the gamma frequency band in the frontal lobe in lucid rapid eye movement (REM) sleep as compared to non-lucid REM sleep and concluded that LD constitutes a hybrid state of consciousness in-between sleep and wake (Hobson, 2009), with definable and measurable differences from waking and from REM sleep, particularly in frontal areas. This is coherent with the fact that most LD induction methods promote an increase of the arousal level during sleep, and suggest that anything susceptible to awaken the subject gradually, including nightmares, might favor or induce LD (e.g., Schredl and Erlacher, 2004). In line with this idea, a case fMRI study showed that lucid REM sleep was associated with a reactivation of areas that are normally deactivated during REM sleep, such as bilateral precuneus, parietal lobules, and prefrontal and occipito-temporal cortices (Dresler et al., 2012). These regions are involved in higher cognitive functions such as self-awareness and executive functions, and their reactivation during LD could account for the resurgence of a certain level of self-awareness and voluntary control (Hobson, 2009; Zink and Pietrowsky, 2015). In support to this hypothesis, an increased level of self-reflective awareness during dreaming was induced by fronto-temporal transcranial alternating current stimulation (tACS) (Bray, 2014; Voss et al., 2014). This study encouraged people to use tACS to induce LD, which again raises questions about safety notably of chronically using a method that affect cortical electrical activity (there are currently no clinical information on chronic or repeated use of tACS).

Abbreviations: EEG, electroencephalography; fMRI, functional magnetic resonance imaging; LD, lucid dreaming.

SLEEP DISRUPTION RISK DUE TO AN INCREASE OF LD FREQUENCY

In the case of a spontaneous increased LD frequency without any use of LD induction methods, one may still wonder what is the impact of "replacing" a regular sleep stage by a hybrid sleep stage on general health and notably on the function of sleep, given the well-known involvement of good sleep in good health and especially of REM sleep in emotional regulation and memory consolidation (e.g., Rauchs et al., 2005; Walker and van der Helm, 2009; Perogamvros and Schwartz, 2013; Plailly et al., 2019). Since there are now evidences that the brain is not functioning in the same way during lucid and non-lucid REM sleep (Voss et al., 2009, 2014; Dresler et al., 2012), one cannot exclude that an increase of lucid REM to the detriment of non-lucid REM may alter or diminish the outcome of regulation processes known to be at play during non-lucid sleep (Walker and van der Helm, 2009; Perogamvros and Schwartz, 2013; Ahuja et al., 2018; Lewis et al., 2018; Tempesta et al., 2018).

DISCUSSION

There are several reasons to fear an adverse effect on sleep and health of a regular use of LD induction methods or of an increased LD frequency, since (1) LD induction methods alter sleep integrity and (2) the brain state during LD is neither that of wake nor that of REM sleep, but rather a hybrid one that is naturally infrequent. Such concerns regarding the possible danger of LD training for sleep integrity are acknowledged on the web. On Google Search's top listing[1] (at the time of writing) for "lucid dreaming," one can read *"Another concern is that engaging in lucid dreaming requires focus and effort, which might mean that the sleeper does not*

[1]https://www.medicalnewstoday.com/articles/323077.php#12

get enough rest." Yet, such acknowledgment are mostly absent from the current scientific literature, and only a handful of studies have investigated the potential downsides of LD. The few existing experimental works are not visible and confirm the feared prediction by showing a significant relationship between LD frequency and poor sleep quality (Schadow et al., 2018; $N = 1824$). Similarly, Mota et al. (2016) showed that LD practice may further empower deliria and hallucinations in a psychotic population.

Our goal is therefore to draw attention to the fact that, as of today, we do not have a well-educated and clear idea of the consequence that training and cultivating LD may have on sleep integrity and more generally on health. This is even more important to highlight that there is a tendency in scientific and lay publications toward encouraging LD and not mentioning the possible side effects of LD training methods (e.g., Hobson, 2009; Mota-Rolim and Araujo, 2013; Stumbrys et al., 2016; Dyck et al., 2017). For example, Dyck et al. (2017) encourage to increase LD induction methods duration without mentioning possible adverse effect on sleep "*Future studies should extend the training period and increase participants' motivation by using social media technology in order to evaluate what techniques might be beneficial in a home setting for a group of participants not specifically selected for high interest in lucid dreaming.*" One can further read in Mota-Rolim and Araujo (2013): "*LD may allow for motor imagery during dreaming with possible improvement of physical rehabilitation,*" and in Stumbrys et al. (2016): "*Lucid dreaming practice provides a more realistic simulation of the waking environment than mental practice and could be alternatively used when an athlete is injured, unable to practice physically or actions are dangerous [...] While only a limited number of athletes have lucid dreams on a frequent basis, there is a wide range of techniques that can be used for lucid dream induction.*" In these two latter publications LD is encouraged to achieve what could be done as effectively by motor imagery during wake (i.e., improved motor performance, as shown by the authors in Stumbrys et al., 2016), and without mentioning the possible side effects of LD practice on sleep. LD is also recommended in several publications (e.g., Mota-Rolim and Araujo, 2013; Morgenthaler et al., 2018; Sparrow et al., 2018) as a possible way to diminish nightmare frequency, even though several behavioral techniques preserving sleep are working very efficiently for this matter (e.g., Krakow and Zadra, 2006; Casement and Swanson, 2012; Putois et al., 2019; Imagery Rehearsal Therapy).

Our opinion is thus that one needs to be cautious and responsible regarding recommendations to practice LD training methods and a state (LD) whose consequences on health are unknown and understudied. To improve the safety of experimental use of LD in research or as a recreational activity, future studies would need to investigate the above-discussed downsides of LD induction methods practice and of LD frequency increase, and characterize them.

CONCLUSION

In this opinion paper, we draw the attention to the possible adverse effect of LD on sleep and health. There are several reasons leading to fear that LD, and especially training to increase LD frequency, may be detrimental to normal sleep and notably to the sleep-related regulation processes. Our aim is to encourage future studies to recognize the lack of knowledge regarding possible side effects of LD induction methods or LD frequency increase, as well as to investigate such side effects to better characterize what they are and in which context they appear.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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My Dream, My Rules: Can Lucid Dreaming Treat Nightmares?

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Nightmares are defined as repeated occurrences of extremely dysphoric and well-remembered dreams that usually involve subjective threats to survival, security, or physical integrity. Generally, they occur during rapid eye movement sleep (REMS) and lead to awakenings with distress and insufficient overnight sleep. Nightmares may occur spontaneously (idiopathic) or as recurrent nightmares. Recurrent nightmares cause significant distress and impairment in occupational and social functioning, as have been commonly observed in post-traumatic stress disorder, depression and anxiety. By contrast, during lucid dreaming (LD), subjects get insight they are dreaming and may even control the content of their dreams. These features may open a way to help those who suffer from nightmare disorder through re-significations of the dream scene, i.e., knowing that they are dreaming and having control over their dream content. Thus, lucid dreamers might be able to render nightmares normal dreams, thereby assuring a restoring sleep. The aim of the present study is to review the existing literature of the use of LD as an auxiliary tool for treatment of nightmares. We conducted a careful literature search for eligible studies on the use of LD treatment for nightmares. We observed that whereas LD may be a feasible aid in the treatment of patients with nightmares through minimizing their frequency, intensity and psychological distress, the available literature is still scarce and does not provide consistent results. We conclude therefore that more research is clearly warranted for a better estimation of the effective conductance and therapeutic outcome of LD treatment in clinical practice.

Keywords: lucid dreaming, nightmare, rapid eye movement sleep, post-traumatic stress disorder, depression, anxiety

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INTRODUCTION

According to the International Classification of Sleep Disorders, 3rd Edition (American Academy of Sleep Medicine, 2014), nightmare disorder represents repeated occurrences of extended, extremely dysphoric, and well-remembered dreams that usually involve threats to survival, security, or physical integrity. Nightmares generally occur during rapid eye movement sleep (REMS) and often result in awakening and worsened sleep quality. On awakening from nightmares, subjects rapidly become oriented and alert, but with emotional and physical signs of stress, such as fear, tachycardia, tachypnea, sweating, and daytime impairment in emotion regulation, cognition, and in many social areas of functioning (Levin and Nielsen, 2007; American Academy of Sleep Medicine, 2014; Scarpelli et al., 2019). Nightmares may occur occasionally in almost half of adults, but they may become recurrent, that is, repeated, especially in post-traumatic stress disorder (PTSD) (Hartmann, 1984; Aurora et al., 2010; Morgenthaler et al., 2018), anxiety (Haynes and Mooney, 1975; Levin, 1998; Nielsen et al., 2000; Zadra and Donderi, 2000; Tanskanen et al., 2001) and depression (Germain and Nielsen, 2003; Agargun et al., 2007).

An important etiological distinction made is the difference between idiopathic and posttraumatic nightmares. Idiopathic nightmares are those with unknown etiology and unrelated to other disorders (American Academy of Sleep Medicine, 2014; Robert and Zadra, 2014). Their content is unspecific and includes interpersonal conflict, failure, helplessness, apprehension, being chased, accident, evil force, disaster, and environmental abnormality (Mota-Rolim et al., 2013). According to the "threat simulation theory," nightmares serve adaptation to stressful events in life (Revonsuo, 2000). However, recent observations point to maladaptive effects of nightmares on sleep and daytime neurobehavioral functions (Levin and Nielsen, 2007; American Academy of Sleep Medicine, 2014; Scarpelli et al., 2019). In contrast, posttraumatic nightmares refer to dreaming disturbances that are part of the stress reaction following exposure to a traumatic event, either during the acute stress response, or over the course of PTSD. Whereas approximately 2–8% of the general population suffers from idiopathic nightmares, nightmares are a core feature of PTSD, with up to 80% of individuals with PTSD reporting disturbing and suicidal dreams with some degree of resemblance to the actual traumatic event (Hasler and Germain, 2009; American Academy of Sleep Medicine, 2014).

Regarding anxiety disorder, it has been found that whereas stress increases frequencies of negative emotions in dreams and nightmares occurrence (Lauer et al., 1987; de Koninck and Brunette, 1991; Köthe and Pietrowsky, 2001), nightmares in turn increase anxiety (Schredl, 2003; Scarpelli et al., 2019). Levin and Fireman (2002) found that in a long run, the reported distress associated with nightmare experience impacted more negatively on quality of life than their frequency did. This finding appears to significantly challenge the "threat simulation theory" (Revonsuo, 2000). It is important to note that whereas nightmare frequency is the number of occurrences of the nightmare, nightmare distress refers to the negative feelings upon awakening following nightmare (Belicki, 1992; Blagrove et al., 2004). In depressed patients, there is a relationship between nightmares and suicides (Agargun et al., 1998; Agargun and Cartwright, 2003; Bernert et al., 2005; Sjöström et al., 2007). The bad feeling soon after awaking from nightmares persists during the rest of the day, being associated with a melancholy and increased suicide risk (Agargun et al., 2007).

The etiology of nightmares is still elusive (Gieselmann et al., 2019). According to the neurocognitive theory, dreams are not mainly generated by the brainstem REMS control, but rather by complex forebrain mechanisms independently of the REMS state (Solms, 2000). According to the impaired fear extinction model (Germain et al., 2008; Nielsen and Levin, 2007), a process of recombining fearful memories with novel and dissociated contexts is continuously activated in nightmare disorder. As stipulated by the affect network dysfunction model (Nielsen and Levin, 2007), individuals high in affect load and affect distress are particularly prone to such impaired fear extinction. In addition, this model is proposed in the trait susceptibility theory of nightmares, which suggests that individuals with frequent nightmares display an increased depth of processing of both negative and positive semantic stimuli (Carr et al., 2016). Finally, all the above factors may contribute to the condensing of recurrent nightmare elements into a nightmare script (Spoormaker, 2008).

Idiopathic nightmares and those related to PTSD, anxiety, depression and other disorders can be treated with lucid dreaming therapy (LDT). Lucid dreams (LD) are those in which the subjects are aware that they are dreaming during the dream, and even may control the oneiric plot (LaBerge, 1980; Mota-Rolim and Araujo, 2013; Baird et al., 2019). This possibility opens a way to help the bearers of nightmares from what is known as re-signification of the dream scene: Being lucid in a nightmare, one can stop fearing the threats by knowing that it is only a dream, and that it could never bring real physical damage. Another tactic would be to face the source of fear, such as monsters, for example (Saint-Denys, 1982), or talk to these monsters in an attempt to find out if they have any specific reason for being there (Tholey, 1988). According to Mota-Rolim and Araujo (2013), individuals can also wake up during the nightmare, try to neutralize it, or even make it enjoyable. Here we would like to answer three basic questions: (1) Is LDT effective for treating nightmares? (2) What are the mechanisms by which LDT works? (3) What are the most used procedures, and the limitations of the LDT?

MATERIALS AND METHODS

We searched for original research articles in scientific databases, such as PubMed, Medline, PsycINFO, Web of Science, and Scopus using the keywords "lucid dream(s)" or "lucid dreaming" and "nightmare(s)" or "recurrent nightmare." Our inclusion criteria were: (1) original research articles; (2) written in English; (3) investigated LDT for nightmares. Our exclusion criteria were: (1) original findings replicated in books, book chapters and reviews; (2) purposed on for issues different from clinical use of LDT for recurring nightmares (**Figure 1**). Data was extracted by three researchers and then reviewed by three (including one that extracted data as well).

RESULTS

We found 10 original research articles dealing with LDT as a therapeutic approach for nightmares (**Table 1**). Five case report studies demonstrated beneficial effects of LDT on nightmares and related distress (Halliday, 1982; Brylowski, 1990;

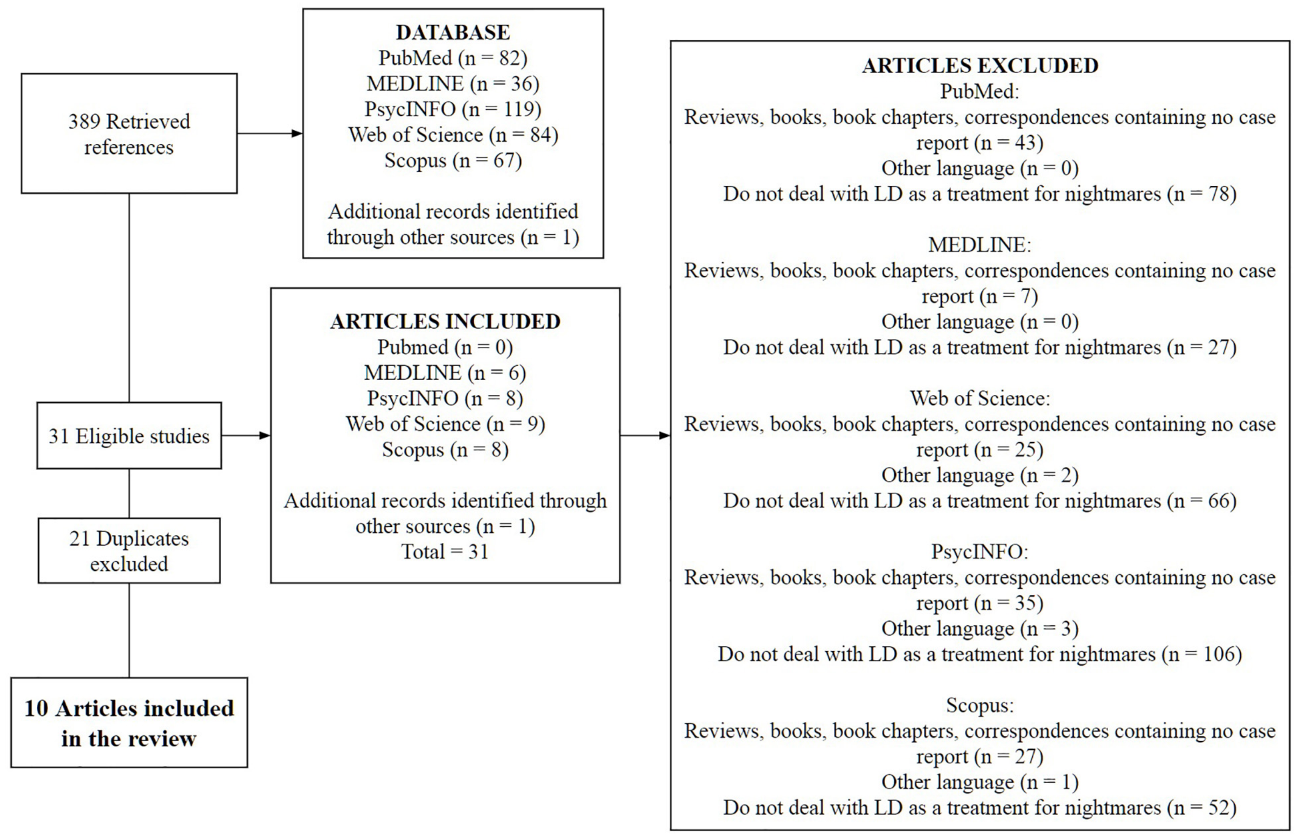

FIGURE 1 | Flowchart showing the screening of the articles that deal with LD as a treatment for recurrent nightmares.

Abramovitch, 1995; Tanner, 2004; Been and Garg, 2010). However, case reports cannot prove statistically the beneficial effect of LDT on nightmare frequency, associated distress and worsened sleep quality. Further, several cross-sectional and randomized studies reported for effects of LDT and other psychotherapeutic approaches used to induce LD in order to alleviate basic features of nightmares. Zadra and Pihl (1997) applied long-lasting progressive muscle relaxation and imagery rehearsal therapy (IRT), as a cue for induction of LD in a small sample of recurrent nightmare sufferers. They showed some positive but insignificant effects on nightmare features. Spoormaker et al. (2003) found a positive but also not significant effect of LDT on nightmare frequency and sleep quality. Spoormaker and van den Bout (2006) demonstrated that participants who received individual LDT showed a stronger decrease in nightmare frequency compared to the group that received LDT. Lancee et al. (2010) subjected a larger group of volunteers with self-reported nightmares to IRT, IRT with sleep hygiene and IRT with sleep hygiene and a LD session. They found that application of IRT only was more effective than the other interventions. More recently, Holzinger et al. (2015) subjected participants who suffered from frequent nightmares, and who did not make use of any medication to gestalt therapy (GT) and a combination of GT and LDT. The major results from this randomized study showed that the group that received GT plus LDT had better effects on nightmare features than those subjected to GT only (**Table 1**).

DISCUSSION

What Are the Neurobiological and Psychological Mechanisms That Underlie LDT?

At the neurobiological level, LDT may work by frontal activation, which inhibits the limbic system. During normal REMS, the frontal activity decreases (Maquet et al., 1996); however, during LD the frontal gamma activity (~40 Hz) increases (Mota-Rolim et al., 2008, 2010; Voss et al., 2009). The frontal region is associated with executive control, attention, rational judgment, working memory, etc. (Hobson, 2009), while the limbic system is related to emotional processes (Peterson et al., 2002). During REMS, there is also an increase in dopamine levels in limbic areas, mainly the nucleus accumbens (Joyce and Meador-Woodruff, 1997; Gottesmann, 2006; McCarley, 2007; Skrzypińska and Szmigielska, 2013). This neurotransmitter pattern and brain areas activity observed in non-lucid REMS are similar to those involved in psychosis (Tort et al., 2005), which may explain the bizarre

TABLE 1 | Summary of the included studies details.

Citation	Sample size and characteristics	Study design	Intervention(s)	Main results or outcomes
Halliday, 1982	Young, white male, farm worker who suffered vivid recurrent nightmares after a tractor accident.	Case report	The participant was told a story about people who could change their nightmare by introducing a small alteration of some traumatic objects of their dream scene 2–3 times weekly.	The man could change the recurrent nightmare scenario to a pleasant and "lucid" dream by transforming it to neutral and emotionally insignificant object: "the color of a metal shed."
Brylowski, 1990	A 35-year-old woman who had nightmares associated with borderline personality and depression.	Case report	A 4- to 6-week contact was negotiated for lucid dreaming treatment (LDT), including dream journal, mnemonic induction of lucid dreaming and reading recommendation of a book about lucid dreams during 4–6 weeks.	The techniques used helped the patient to master the negative affect, while the nightmare was still occurring, but with significantly less affective states upon awakening.
Abramovitch (1995)	A 19-year-old woman who suffered an acute nightmare disorder of returning home.	Case report	Home-based (LDT) sessions. Information about the duration and number of sessions was not provided.	The woman was able to modify her nightmare through the lucid dreaming technique.
Zadra and Pihl, 1997	$N = 5$ (recurring nightmare sufferers: 4 women (age range 22–52 years) and 1 man (42-year-old).	Case reports	Two female patients underwent progressive muscle relaxation (PMR) + imagery rehearsal therapy (IRT) + LDT. Three (2 female and 1 male) patients received LDT alone.	One female patient to PMR = IRT + LDT reported no further nightmares at a 4-year follow up. One female patient on LDT tended to decrease her nightmares frequency. Other patients (one female and one male) on LDT reported no further nightmares at 6-month and at 1-year follow-up. The other female patient did not benefit from PMR + IRT + LDT intervention. The effects of both combined and LDT alone can not be assessed statistically due to the study design and low number of reported cases.
Spoormaker et al., 2003	$N = 8$ Anxiety-provoked nightmare sufferers (2 men/6 women; mean age 27.8 years (SD 12.2).	Case reports	All participants received a 1-h Individual, home-based session consisting of (1) lucid dreaming exercises, and (2) of discussing possible constructive solutions for the nightmare.	Nightmare frequency a week decreased up to 60% but not significantly mean (SD) 2.31 (3.56) vs.0.88 (1.13), and sleep quality slightly improved, but also insignificantly due the small sample size used.
Tanner, 2004	A 23 year old woman presenting with a 17 year history of nightmares.	Case report	A combination of relaxation mnemonic procedures to increase lucid dreaming and dream rehearsal upon waking from a nightmare. Four sessions.	Nightmares frequency sharply decreased after four sessions. Further improvement was reported over the next 9 months as additional techniques were introduced and other problems.
Spoormaker and van den Bout, 2006	$N = 23$ (nightmare sufferers; 6 men/17 women; mean age: 28.4 years (SD = 7.3).	Cross-sectional pilot study	12 weeks; Three groups underwent (1) a 2-h individual LDT session ($n = 8$), (2) a 2-h group LDT session ($n = 8$), and (3) waiting list (WL) ($n = 7$) during 12 weeks.	A significant reduction of nightmare frequency for participants who received an individual session ($t(7) = 4.1$, $p = 0.002$). A significant reduction of nightmare frequency was also found in participants who took part in the group session ($t(7) = 2.6$, $p = 0.02$. No significant effects were found in the waiting list group ($t(6) = 0.6$, $p = 0.30$). There were no significant changes between pre intervention and follow-up in sleep quality and overall PTSD symptoms for any of the groups.

(Continued)

TABLE 1 | Continued

Citation	Sample size and characteristics	Study design	Intervention(s)	Main results or outcomes
Been and Garg, 2010	A 39 year old man with history of depression, PTSD and alcohol dependence. He suffered from insomnia as a result of recurring nightmares. He made use of medications to control anxiety.	Case report	Sixteen days with psychoeducation in LDT based on Wikipedia to realize becoming lucid.	The patient became able to achieve lucidity during his nightmares and then to render them pleasant dreams. The patient did not present any nightmares anymore. His sleep improved and he stopped using medication for anxiety. The patient thinks that the psychoeducation was the main factor for his improvement.
Lancee et al., 2010	*N* = 278: A heterogeneous sample of patients with nightmare disorder (age range: over 33–39 years; 76% female patients).	Randomized controlled trial	Following the exclusion criteria. 67 participants underwent IRT, 75 IRT + sleep hygiene, 71 LDT, and 62 WL. Sessions duration – 6 week. Follow-up measures at weeks 4, 16, and 42.	The IRT alone was more effective than the other intervention conditions over time as measured by the large effect sizes. The effects of LDT alone on the outcome measures were insignificant.
Holzinger et al., 2015	*N* = 40. Patients with recurrent nightmares (10 males/30 females; age range: 20–59 years) who were resistant to medications.	Randomized controlled trial	Thirty-two out of the 40 patients completed the study. One group (*n* = 16) received Gestalt Therapy (GT), while the other group (*n* = 16) received GT + LDT during 10 weeks. Following-up measures at weeks 5 and 10.	Significant reduction of nightmare frequency and improvement of sleep quality in both groups. Dream recall frequency was significantly higher in the group receiving GT + LDT. Compared to the group receiving GT only, the group receiving GT + LDT showed stronger and also significant ($p \leq 0.05$) effects of the intervention on nightmare frequency and sleep quality at the end of therapy.

aspect of dreams (which are analogous to hallucinations), and the lack of rational judgment over this bizarreness (akin the delirious thinking) (Mota et al., 2016). Thus, suppression of the limbic system by the frontal lobe activation during LD could decrease both frequency and intensity of nightmares. Finally, Dresler et al. (2012) observed that the precuneus region is linked to the first-person perspective and agency during LD, which is an important aspect for the treatment of nightmares.

At the psychological level, Rousseau and Belleville (2017) gathers possible mechanisms by which LDT and other similar treatments work, which are: modification of beliefs (Krakow et al., 2000), prevention of avoidance (Pruiksma, 2012), decreased arousal (Davis, 2009), restoration of sleep functions (Germain, 2002), emotional processing (Davis et al., 2007), and sense of mastery (Spoormaker et al., 2003). Change in beliefs can happen both through psychoeducation about the aspects of dreams (Krakow, 2015) and through psychotherapy, focusing on the nightmare theme (Harb et al., 2012). In the case reported by Been and Garg (2010), for example, the patient believes that the psychoeducation was the main factor for his improvement. Avoidance, i.e., trying not to think about the nightmare content or avoiding sleep, is associated with nightmare maintenance (Hansen et al., 2013), and being afraid to fall asleep correlates with higher nightmare frequency (Neylan et al., 1998). Relaxation exercises, as well the sense of mastery itself could help to decrease arousal (Rousseau and Belleville, 2017). Once nightmares are diminished, the subject awakes less, which allows the restoration of sleep functions such as memory consolidation and emotional processing (Germain, 2002). Finally, the belief in control, i.e., the sense of mastery, seems equally important as actually controlling the dream (Spoormaker et al., 2003). Harb et al. (2016) compared the cognitive-behavioral therapy for insomnia (cCBT-I) with IRT + cCBT-I to investigate the potential role of LD as a mechanism of action of IRT in military veterans with PTSD and recurrent nightmares. Before treatment, veterans demonstrated a LD profile characterized by high dream awareness and low dream content control. Following treatment, the control of dream content increased, but lucidity has not changed. This increase in dream content control was related to a reduction in nightmare distress.

Studies show that lucidity is not the main factor to change nightmare content or to reduce nightmare frequency (Spoormaker and van den Bout, 2006). Therefore, a relevant question is: what are the advantages of using LDT over other therapies, e.g., IRT? First, even though lucidity is not the main factor, it does not mean it has no important role. The possibility to achieve lucidity may provide the opportunity to practice self-control and pacific confrontation more directly, which is important to improve the coping ability in the waking state (Brylowski, 1990). According to Lancee et al. (2010), there are two main advantages of LDT over other therapies, especially IRT: (a) once LDT targets the nightmare within the dream, it might be specifically beneficial for people that suffer from non-recurrent nightmares; (b) LDT has more effect on nightmare intensity, because nightmare sufferers achieve a sense of control with the LD technique. Moreover, unlike LDT, IRT might only ameliorate the low intensity nightmares (Lancee et al., 2010). As another advantage, even without lucidity, LDT encourages the attitude of "this is just a nightmare, so there is no real threat." Although IRT also helps to deal with negative imagery (Krakow and Zadra, 2006), the attitude of "this is just a dream" may play an important role in the modification of belief, decrease of arousal and prevention of avoidance (see **Supplementary Material**). Despite that, more studies are needed to clarify the mechanisms of therapies that aim to treat nightmares, and to indicate their advantages and disadvantages.

How Does LDT Work on Practice?

Lucid dreaming therapy for nightmares is a focal modality of psychotherapy. It can happen in a 6-week period (Brylowski, 1990), but can produce effects in a single session (Zadra and Pihl, 1997). The first step is to make it clear that patients have the full capacity to learn how to control their dreams. The therapist guides patients to develop LD induction techniques, and help them to deal with the fear that can follow LD discovery. Once patients feel empowered about their dreams, nightmare frequency might decrease by itself (Spoormaker and van den Bout, 2006). Beyond that, if a nightmare comes up, it will tend to be less distressing, given the sense of mastery that the patient now has. The experience of facing the oneiric threat, i.e., of having a less distressing dream, seems to be essential to the decrease of the remaining nightmares.

Further, a long-term psychotherapy may be initiated, aiming to explore more profoundly the waking life and to elucidate broader questions that even may trigger the nightmares. LDT is a good precedent of a long-term psychotherapy, once it has relatively quick results, which motivates the patient to continue in therapy (Holzinger et al., 2015). Some patients may be skeptic, may have more difficulty to achieve lucidity, or may just have no time to practice frequently at home. In these cases, we recommend using techniques of external sensory stimulation during REMS or substances to induce LD more quickly (Stumbrys et al., 2012; Baird et al., 2019; Mota-Rolim et al., 2019). Nevertheless, some studies demonstrate that even when lucidity is not achieved, exercises of induction facilitates waking up from the nightmare before it becomes too scary (Brylowski, 1990; Tanner, 2004), or changes the oneiric content even without lucidity (Spoormaker and van den Bout, 2006). In these cases, the subjects incorporated elements from the exercises into the dream (Brylowski, 1990; Zadra and Pihl, 1997; Spoormaker et al., 2003). Thus, such exercises helped patients to increase the sense of control over their dreams, consequently, increasing their self-confidence. Moreover, the positive changes in the threatening content are symbolically incorporated to the dreamer's cognition (Brylowski, 1990).

As said earlier, wake up through lucidity is an option to reduce distress related to nightmares. However, LaBerge and Rheingold (1990) believe that "just wake up" is not as therapeutic as to actually control the content of the dream or the self, once it is a way to run from the nightmare, and not to face it. These authors even suggest that controlling the self is better than controlling the dream content, since in real life, it is not possible to magically change the scenario. Tholey (1988) affirms that when the dream ego looks courageously and openly at hostile dream figures, their appearance often becomes less threatening, as recently supported by Stumbrys and Erlacher (2017) empirical study. On the other hand, when one tries to make a dream figure disappear, it may become even more threatening (Sparrow, 1976). Finally, Tholey (1988) also argue that it is better to conciliate with the dream figure through constructive dialogue than to attack it. Although emotions such as intense fear can trigger lucidity faster (LaBerge and Rheingold, 1990), an unexperienced lucid dreamer is more prone to wake up from the dream than trying to control it, since the excitement caused by the discovery that one is dreaming may cause awakening (Mota-Rolim et al., 2013). Besides, even when subjects are lucid, the fear may not necessarily fade away (Hurd, 2014), thus a "runaway" behavior takes place. Initially, "just wake up" could be a useful weapon until a minimum sense of control is developed; however, it is necessary to practice for the LD scenario does not fade away causing the awakening, which allows the dreamer to explore other possibilities and face their fears.

What Are the Main Limitations of the LDT?

Halliday (1988) and Zadra (1990) reported case studies in which lucidity was achieved, but without control, and it actually worsened the nightmare. Lucid nightmares are LD with a scary and unpleasant content, in which dreamers have no control over the situation, thus they just "witness" the unfolding of the dream, being unable to deliberately wake up (Hurd, 2009; Schredl and Göritz, 2018; Stumbrys, 2018). Lucid nightmares may be even more terrifying than common nightmares (Halliday, 1988); however, Stumbrys (2018) found that the levels of nightmare vs. lucid nightmare distress do not differ. Sparrow (1991), signifying dreamer's harrowing experiences with LD, warned about the wholesale advertising of LD, since lucid nightmares frequency is associated not only to nightmare frequency, but also to LD frequency (Stumbrys, 2018). This makes patients with nightmares very vulnerable to lucid nightmares in a LDT. Therefore, some care is needed when a LDT is initiated. Fortunately, community support is helpful in reducing lucid nightmares (Hurd, 2006). Besides, it was found that dopamine agonists are useful in reducing lucid nightmares frequency (McLaughlin et al., 2015a,b, 2016); however, these studies comprise only a few cases in a very special population, which limits the generalizability of the findings. Finally, one main issue in LDT is to induce LD, which is usually difficult for most of people (Stumbrys et al., 2012), who experience LD rarely (Mota-Rolim et al., 2013). However, Dodet et al. (2015) and Rak et al. (2015) observed that narcoleptic patients report more LD than the rest of population, and that some of these patients even learned to use LD to change their recurrent nightmares. These authors suggest that the experience of these patients with LD could help other narcoleptics who suffer from frequent nightmares.

CONCLUSION

Lucid dreaming therapy may be efficient for treating nightmares, and even when lucidity is not achieved, the induction exercises assisted patients by helping them develop a critical thinking over dream content. Although induction of LD may be a feasible aid in the treatment of patients with nightmares through minimizing their frequency, intensity and psychological distress, the available literature is still scarce and does not provide consistent results. Furthermore, the samples size are limited, which precludes more significant comparisons. Therefore, more research is clearly warranted for a better estimation of the effective conductance and therapeutic outcome of LD techniques in clinical practice.

AUTHOR CONTRIBUTIONS

TM and RK conducted the literature search, selected the eligible studies, and drafted the manuscript. GF drafted the manuscript. KA selected the eligible studies and drafted the manuscript. SM-R designed the manuscript, conducted the literature search, selected the eligible studies, and drafted the manuscript. All authors worked over the first draft of the manuscript and approved the final version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02618/full#supplementary-material

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Bizarreness of Lucid and Non-lucid Dream: Effects of Metacognition

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Dreams are usually characterized by primary consciousness, bizarreness and cognitive deficits, lacking metacognition. However, lucid dreaming (LD) is a type of consciousness state during which the dreamer is aware of the fact that he or she is dreaming, without leaving the sleeping state. Brain research has found that LD shares some common neural mechanisms with metacognition such as self-reflection. With a different metacognition level, the bizarreness of LD would also change. However, the difference in bizarreness between LD and non-LD was seldom explored, and individual differences were often neglected. In the present study, considering LD prevalence in Asia was rarely studied and related results in China and Japan were very different from each other, we first investigated the LD frequency of China in a standardized way. On that basis, we collected dreams of subjects who had relatively higher LD frequency and compared bizarreness density (BD) of LD and non-LD. Moreover, to explore the relationships of metacognition traits and BD, we also measured self-reflection and insight trait by Self-Reflection and Insight Scale. We found that 81.3% of subjects have experienced LD once or more, which is similar to findings in some western countries. Besides, BD was significantly lower in LD than in non-LD. Self-reflection and insight were inversely associated with dream bizarreness. These findings indicate that self-consciousness traits extend from waking to LD and non-LD state. As a particular consciousness state, LD may shed light on the research of consciousness and dream continuity. Future research on dream bizarreness is suggested to take dream types and metacognition differences into consideration.

Keywords: lucid dream, bizarreness, self-reflection and insight, prevalence, self-consciousness, continuity hypothesis

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INTRODUCTION

In ancient China, Zhuang Zhou's dream of becoming a butterfly was a famous story. In his dream, Zhuang Zhou turned into a butterfly, forgetting that he was a human being. When he woke up, he realized that he was still a human and began to think about whether he was a butterfly which was dreaming, just dreaming of becoming a person (Fang, 2010). From a psychological point of view, Zhuang Zhou lost normal self-reflection and insight function when dreaming. When he woke up, he regained these functions and could reflect on whether he was dreaming at that moment.

The Dream Argument of Descartes also believed that individuals could not test whether they are dreaming or not in dreams (Haldane and Rosswrited, 1973).

Edelman (1992) proposed two kinds of consciousness: Primary consciousness is a simple consciousness shared by humans and mammals, including perception and emotion. Whereas secondary consciousness or higher-order consciousness enables a cognitive subject to think abstractly, recognize his or her own behaviors or emotions, and have the concept of past and future. In different states, the intensity and characteristics of human consciousness will change. When awake, individuals can have secondary consciousness to supplement primary consciousness. However, dreaming is mainly characterized by primary consciousness, lacking secondary consciousness (Hobson, 2009). In non-lucid dreams, metacognition like self-reflection was also found to be lower than in waking (Rechtschaffen, 1978; Bradley et al., 1992; Kahan and LaBerge, 1996).

However, there is sometimes an exception called lucid dreaming (LD). It is a kind of consciousness state during which the dreamer is aware of the fact that he or she is dreaming, without leaving the sleeping state (LaBerge and Rheingold, 1990). In that state, individuals may restore some reflective consciousness and sometimes have partial control over the content of their dreams (Dresler et al., 2014). LaBerge et al. (1981) and Fenwick et al. (1984) provided evidence for LD by letting participants demonstrate their lucid state during dream periods using predefined eye-movement signals. It was also found by Erlacher and Schredl (2010) that rehearsing in LD can enhance related performance in waking life. As a psychological phenomenon with a physiological basis, the objectivity of LD has been proved. This special state of consciousness is of considerable significance to the investigation of consciousness.

Many cognitive defects in dreams also occur in mental disorders. Freud (1958) said that psychotic episodes have something in common with dream characteristics. Jung (1934) also mentioned that if a person gets out of the bed and shows the content of the dream during dreaming, we can see some symptoms of dementia praecox in him. In dreaming, the prefrontal cortex of the brain is often inhibited, and cognitive functions like attention and working memory that normally work in waking state are offline (Fuster, 2015). Hobson (1997) suggested that dreaming can be seen as a model for psychosis. The lack of self-reflection in dreams is like the lack of insight in mental patients. The aminergic inhibition and cholinergic excitation shift the chemical balance within the brain, which is responsible for the delirium in dreams (Hobson et al., 2000).

In contrast, LD is very special, and it still retains higher-order consciousness functions including metacognition compared with non-LD. Blagrove (2011) proposed that whether dreams and waking life are continuous needs to be augmented by an insight dimension. It was proved that personal insight would increase by examining dream content (Edwards et al., 2015; Blagrove et al., 2019). In fact, there is also a continuity of insight function between wake and dream state. Neuroimaging and electroencephalogram (EEG) research showed that the frontal areas of the brain, which are related to psychotic insight, are highly activated in LD (Dresler et al., 2015; Voss et al., 2018). To some extent, LD can be seen as a model for insight into the psychotic state. It was found that metacognition is not completely deficient during both LD and non-LD (Kahan and LaBerge, 1994, 1996). In the special sleep state of LD, individuals can still have many cognition functions which usually appear when awake.

However, people generally have a tendency to think that there are many bizarre elements in LD contents. It is relevant to the low frequency of LD, and the fact there are many strange sleep phenomena often associated with LD, such as false awakening and out-of-body experience (Green and McCreery, 1994; Blanke and Arzy, 2005). Therefore, there is a discrepancy of LD bizarreness between brain research and common sense. It seems that lucid dreams are unrelated to schizotypy and dissociation (Knox and Lynn, 2014; Aviram and Soffer-Dudek, 2018), or at least, are related to them less strongly than other unusual sleep experiences (Watson, 2001). According to dream research, bizarreness is a very important feature of dream content and can be seen as a result of impaired cognitive processing (e.g., Hobson et al., 1987). With a high level of metacognition function, the bizarreness of LD content should be lower than that of non-LD content. Research on LD content needs to be carried out.

Although most people experience LD very occasionally, still, many people experienced LD at least once. The prevalence of LD was very different and controversial. In the only study on the prevalence of LD in China, 92% prevalence of LD was measured (Yu, 2008). It is the highest data in the world as far as we know. In another Asian sample, Japan, 47% LD prevalence was detected (Erlacher et al., 2008). The results of the two Asian samples are very different from each other. Ribeiro et al. (2016) suggested that methodological differences may lead to differences in the prevalence of LD. Hence, we measured the LD prevalence of China in a standardized way proposed by Schredl and Erlacher (2004).

There are not only differences in the level of metacognition between dream and waking, but also between dream and dream (Kahn and Hobson, 2005). Defining dreams as an intrinsically bizarre thing or accurate response to waking experiences does not explain the diversity of dreams, so the attention should be focused on the differences between dream experiences (review see Rosen, 2018). If the level of metacognition affects the bizarreness of dream, there will be more metacognitive activities and less bizarre elements in LD compared with non-LD. However, the difference in bizarreness between LD and non-LD was seldom explored, and individual differences were often neglected.

Therefore, this study first adopted a within-subject design to explore the dream bizarreness difference between LD and non-LD of the same individual. After that, we further explored how bizarreness differs on different levels of metacognitive traits. In the neuroimaging research of Dresler et al. (2012) about LD, increased activations were found in the right dorsolateral prefrontal cortex which is associated with self-focused metacognitive evaluation, and in the bilateral frontopolar areas which are implicated in the processing of one's own thoughts and feelings. Filevich et al. (2015) also found that LD shares some common neural mechanisms in the frontopolar cortex and hippocampus with thought monitoring and self-reflection. Secondary consciousness like self-awareness is a key to LD, and its level may also affect the bizarreness of dreams. Thus, self-reflection and insight traits were chosen as metacognitive variables.

One thorny problem is that even for those who have a higher frequency of LD, this frequency is still not high. It is difficult to collect lucid dreams from different individuals through dream diaries or laboratory experiments. Induction techniques such as bedtime cues can greatly increase the chances of having LD (Schädlich and Erlacher, 2012), but this will reduce the ecological validity of the study. Taking these into account, we selected the most recent dream paradigm adopted by Domhoff (1996) to allow participants to report a lucid dream that has already taken place. Another problem to be noticed is that some studies measured dream bizarreness through a self-assessment method. For one thing, some individuals would tend to regard the strangeness of LD-related phenomena as the bizarreness of LD contents. It may lead to the overestimation of the LD bizarreness. For another, judgment criteria are different among subjects and cannot be objectively compared. Therefore, our present study used an other-rating method to reduce the error.

We hypothesized that (1) the bizarreness of non-LD is higher than that of LD for the same individual. (2) High metacognitive traits or self-consciousness of waking are related to the reduction of bizarreness in dreams.

MATERIALS AND METHODS

Participants

Participants were all undergraduates or postgraduates of universities recruited from online student groups in Guangzhou. Overall, 326 persons (232 women, 94 men) completed our first survey. The mean age of the sample was 22.24 ± 2.96 years, from 18 to 33. According to the result of the first survey, 176 (54.0%) of these participants had a relatively higher LD frequency (equal or higher than 2–4 times a year). They were invited to take part in the next experiment which requires subjects to report dreams. Totally, 67 (38.1%) persons (51 women, 16 men) completed the second part, with an average age of 21.63 ± 2.92 years, from 18 to 29.

Materials

The lucid dream frequency scale (Schredl and Erlacher, 2004) is composed of an eight-point rating question (0, never; 1, less than once a year; 2, about once a year; 3, about two to four times a year; 4, about once a month; 5, about two or three times a month; 6, about once a week; 7, several times a week) and a standard definition of LD ("*During LD, one is–while dreaming–aware of the fact that he or she is dreaming. It is possible to wake up deliberately, control the dream action, or observe the course of the dream with this awareness passively*"). The retest reliability of the scale was $r = 0.89$ in the student sample (Stumbrys et al., 2013). Moreover, we provided an example of lucid dream narrative as proposed by Saunders et al. (2016) to increase the confidence of results. An example in the study of Neider et al. (2011) was given. The dream recall frequency scale was a seven-point rating question (0, never; 1, less than once a month; 2, about once a month; 3, twice or three times a month; 4, about once a week; 5, several times a week; 6, almost every morning) with the retest reliability of $r = 0.83$ (Schredl et al., 2002). Results obtained can be recoded to get units in frequency per month or week by using the class means. These two questions were translated into Chinese.

Dream Collection adopted the recent dream paradigm (Domhoff, 1996), participates were asked to report a most recent lucid dream and a most recent non-lucid dream. They needed to describe these two dreams as fully and precisely as they could, including settings, people, animals, and so on. According to the classic method of Hall and Van de Castle (1966), 50–300 words of each report was required to judge. These were all presented in the online form, which is a valuable source of information that can provide enough privacy for participants to report more real and complete dreams (Voss et al., 2013).

Self-reflection and Insight Scale (SRIS: Grant et al., 2002) is the tool we used to measure metacognition traits of waking life during waking. It consists of Self-Reflection (SR) subscale and Insight (IN) subscale. SR refers to an understanding of one's thoughts, feelings, and behavior, including 12 items. IN refers to cognition of one's internal state, including 8 items. Liu et al. (2018) have translated it into Chinese version. The retest reliability of the two subscales is $r = 0.81$ and $r = 0.61$, respectively. In our study, the internal consistency reliability of SR ($\alpha = 0.82$) and IN ($\alpha = 0.71$) was also checked.

Procedure

In order to provide sufficient privacy to ensure authenticity, we recruited participants in the college network communities of Guangzhou. Participants were told that this was a study of dreaming. By clicking on the web link, they completed a questionnaire including questions about the frequency of LD and dream recall. At the end of the questionnaire, they were invited to leave an email address if they were willing to participate in the follow-up study.

Based on the results of the LD frequency investigation, we screened the subjects for the second part. Among these 326 participants who completed the questionnaire, 176 people had a relatively higher LD frequency (equal or higher than 2–4 times a year). Of them, 149 subjects also left their mailboxes. Then, they were invited to participate in the second part including dream reports. Subjects needed to report a most recent lucid dream and a most recent non-lucid dream. After that, they finished the Self-Reflection and Insight Scale (SRIS). Altogether 67 subjects completed the dream report and submitted the spreadsheet as requested. Finally, we got 67 pairs of dreams. The first part was voluntary, while subjects who finished the second part would get feedback of their dreams and monetary compensation.

Dream Bizarreness Scoring

The system of Revonsuo and Salmivalli (1995) was used to score the bizarreness of dream contents. This method consists of two steps. The first step is to identify 14 different kinds of elements in the dream report, including events, actions, place, time, animals, cognition, body parts, plants, objects, self, language, emotions, persons, and sensory experiences. Each element can only be categorized as one of the 14 elements. The second step is to score each element as either bizarre or non-bizarre. There are two kinds of possible bizarre elements: vagueness element and incongruous element. And the latter includes exotic elements, internally distorted or contextually incongruous elements, and impossible elements.

Two judges who were blind to the study purpose were trained together at first. Then the dream contents were scored independently by them. After that, judges crosschecked the scores and resolved disagreements by discussing together. In total, 110 (5.4%) of the 2032 elements were dropped because no agreement on the scores could be reached between the two judges. Of the final 1922 scored elements, 1813 elements were initially independently classified as the same content category; 1771 elements were initially independently scored as the same bizarreness category. Thus, the content agreement was 94.3%, and the bizarreness agreement was 92.1%. Bizarreness density (BD) was calculated in order to balance the difference in the word count of dream reports by dividing the number of bizarreness elements by the total number of elements.

Data Analysis

Statistical analyses were applied by the IBM SPSS 19.0 software package for Windows. We used Spearman rank correlation to assess the relationship between LD frequency and non-LD recall frequency. ANOVA was applied to check the bizarreness difference between LD reports and non-LD reports within-subjects controlling for gender. Linear regression analysis was the statistical tool we used to assess the relationships of self-reflection and insight with bizarreness, respectively.

RESULTS

To analyze the prevalence of LD in China, we measured the frequency of LD. In total, 81.3% of 326 participants reported having at least one lucid dream in their life. According to the definition of Snyder and Gackenbach (1988), 30.4% of these subjects were frequent lucid dreamers (frequency equal or higher than once a month), and the other subjects were infrequent lucid dreamers. These are close to the data of the university student sample in German (see **Table 1**). The average frequency of LD was 1.02 ± 2.57 lucid dreams a month. The mean dream recall frequency was equal to 3.84 ± 2.30 times per week. Dream recall frequency and LD frequency were significantly related ($r = 0.265$, $p < 0.0001$).

Bizarreness density values of LD reports were significantly lower than BD values of non-LD reports [$n = 67$, non-LD versus LD on BD: $F(1,65) = 7.562$, $p = 0.008$, mean ± SD LD: 0.15 ± 0.08 non-LD: 0.20 ± 0.11]. There was no significant main effect of gender [$F(1,65) = 2.977$, n.s.]. The interaction of dream type and gender was not significant [$F(1,65) = 1.446$, n.s.].

The mean self-reflection values of the 67 participants was 56.82 ± 6.62. There was a significant linear correlation of self-reflection and dream type with BD [$F(2,131) = 10.689$, $p < 0.001$, $R^2 = 0.14$, $n = 67$]. Self-reflection was negatively correlated with BD ($B = -0.004$, $t = -3.165$, $p = 0.002$) (see **Table 2**). The mean insight values of the 67 subjects was 33.01 ± 4.26. There was a significant linear correlation of self-reflection and dream type with BD [$F(2,131) = 9.914$, $p < 0.001$, $R^2 = 0.13$, $n = 67$]. Insight was inversely correlated with BD ($B = -0.006$, $t = -2.929$, $p = 0.004$) (see **Table 3**).

TABLE 1 | Lucid dreaming frequency of the Chinese and German sample.

Categories	Relative frequency	
	Chinese present study (*N* = 326)	German Schredl and Erlacher (2004) (*N* = 439)
Never	18.7%	18.0%
Less than once a year	12.0%	7.5%
About once a year	15.3%	10.9%
About 2 to 4 times a year	23.6%	26.7%
About once a month	11.7%	16.2%
About 2 to 3 times a month	11.7%	10.3%
About once a week	5.2%	8.0%
Several times a week	1.8%	2.5%

TABLE 2 | Regression coefficients of dream type and self-reflection on bizarreness density.

					95.0% Confidence interval for B	
Variable	*B*	*SE*	β	*t* value	Lower bound	Upper bound
Intercept	0.470	0.073	N/A	6.453	0.326	0.615
Dream type	−0.053	0.016	−0.273**	−3.371**	−0.085	−0.022
Self-Reflection	−0.004	0.001	−0.256**	−3.165**	−0.006	−0.001

**$p < 0.01$.

TABLE 3 | Regression coefficients of dream type and insight on bizarreness density.

					95.0% Confidence Interval for B	
Variable	*B*	*SE*	β	*t* value	Lower bound	Upper bound
Intercept	0.436	0.067	N/A	6.496	0.303	0.569
Dream type	−0.053	0.016	−0.273**	−3.354**	−0.085	−0.022
Insight	−0.006	0.002	−0.238**	−2.929**	−0.009	−0.002

**$p < 0.01$.

DISCUSSION

Lucid Dreaming Prevalence in the Chinese Sample

In the present study, we first investigated the prevalence and frequency of LD in China. Our results showed that the prevalence of LD in Chinese university students sample is 81.3%, which is very similar to what was found in some other countries: In the German sample, 82% of the participants reported the occurrence of at least one lucid dream (Schredl and Erlacher, 2004); among Israeli students, 78.61% of LD prevalence was found by using a clear definition (Aviram and Soffer-Dudek, 2018); likewise, 77.2% of the Brazilian subjects had at least one LD experience in their whole lifetime (Mota-Rolim et al., 2013); when the definition of LD was presented in French students, the prevalence found was 81.05% (Ribeiro et al., 2016). The previous study in China found a high LD prevalence of 92%. However, only a short question about LD frequency was asked in that study. The lack of a clear definition and an example could cause subjects to overestimate LD frequency and prevalence (Snyder and Gackenbach, 1988). Our research gave a clear definition and an example of LD. Different descriptions of LD may result in our different findings. In Japan, another Asian country, the incidence rate of LD measured was only 47%. Japan has a different history of the understanding on dreams from the West. Even if dreams are considered as a scientific phenomenon in the modern century, Japanese still retains animism on dreams since ancient time (Koyama, 1995). Thus, dreaming is very private for Japanese and hard to talk about, especially strange dreams like LD. The attitude of Japanese people toward dreams might cause the low prevalence of LD in previous studies. In short, our present study found that as a common physiological phenomenon of humans, the LD prevalence in China is not much different from that in Western countries.

Relationships of Dream Type and Metacognition Traits With Dream Bizarreness

The bizarreness of LD and non-LD were checked within-subjects. We found that the BD of LD reports was significantly lower than that of non-LD reports. As mentioned before, bizarreness can be seen as a result of metacognition reduction in dreams. Our results on dream contents showed that the decrease of metacognition activity is not so prominent in LD. That is consistent with the existing brain science research mentioned before that LD has some common neural mechanisms with thought monitoring and self-reflection. Watson (2001) found that LD was weakly correlated with schizotypy and dissociation, which are often seen as bizarre cognition phenomena. However, Aviram and Soffer-Dudek (2018) proposed that associations of symptoms with LD may due to the use of LD induction techniques which cause disturbed sleep, instead of LD *per se*. Gackenbach (1988) measured the bizarreness of LD and non-LD on 21 elements, whereas the bizarreness scores of non-LD were only significantly higher than that of LD on 3 kinds of elements. In our study, we used a within-subject design to balance the effects of individual differences. It may explain the difference between our results.

Ogilvie et al. (1982) thought that individuals begin to realize the dream state in LD is because they have noticed the bizarre things. However, there are also many strange elements in non-LD, and individuals cannot recognize them. Hobson (2009) believed that bizarreness or inconsistency is often unable to be recognized in the dream state. Therefore, there is no necessary relationship between having LD and noticing bizarre elements. Another possible explanation is suggested by our result: For an individual, the higher level of metacognition in LD may allow him or her to realize the sleeping state. In other words, dream bizarreness may not be the cause of LD emergence, but the result of metacognition level changes followed by LD state.

Furthermore, we also explored the relationships between metacognition traits and dream bizarreness. Self-reflection and insight were inversely associated with dream bizarreness. Our results suggested that metacognition traits are not only reflected in waking, but also in dreaming; not only reflected in non-LD, but also in LD. Metacognitive activity is often inhibited in dreams, but this kind of reduction is also different among different individuals. Individuals with higher metacognition traits would still have more metacognition activities in dreams and lower dream bizarreness values.

Continuous Self-Consciousness Across LD, Non-LD, and Waking

There has always been a controversy between continuity and discontinuity in the field of dream research. The continuity hypothesis is based on overlaps of dream and wakefulness (e.g., Schredl and Hoffman, 2003; Malinowski and Josie, 2015). Sometimes what people have in their dreams are also reflected in their waking life. In contrast, the discontinuity hypothesis focuses on the differences between waking and dreaming (eg., Jung, 1960; Hobson et al., 1987). Although the metacognition function in LD we found is far better preserved than in non-LD, it is still incomplete compared with the waking state. Most lucid dreams are not that lucid in general. A study of frontal areas in LD state demonstrated that LD is more likely a middle state between waking and non-LD (Voss et al., 2009). Individuals in LD still cannot fully have memories of the past and future or maintain the awareness of their own state. Nevertheless, the interruption of self-consciousness is not only a characteristic of dream cognition but also a characteristic of waking cognition (Horton, 2017). For example, a person may mistake the date of the previous day for today when he or she is awake. There are many things in common between waking and dreaming.

Partly due to the memory consolidation process in the sleeping state, contents of dreaming are not continuous with waking-life experiences (Horton and Malinowski, 2015). Nevertheless, Stumbrys (2011) proposed that the lucidity in dreams, like mindfulness in wakefulness, presents a possible continuity in the self-consciousness across the sleep-wake cycle. The results of our study confirmed this opinion. We found that higher self-reflection and insight traits are related to less dream bizarreness. Participants showed consistency in LD, non-LD, and waking, which supported the continuity hypothesis of waking and dreaming. Self-reflection and insight traits extend from waking life to dreams.

Limitation and Suggestion

First of all, participants were all college students in the present study. The university student sample was used by most of the existing research on LD prevalence. However, there are age differences in the prevalence and frequency of LD (Voss et al., 2012). Future research could expand the group of participants and take demographic information into account. Mota et al. (2016) found that psychotic patients who have LD experience didn't present milder psychiatric symptoms than patients who don't have LD experience. LD may have very different meanings for normal people and psychiatric patients. Therefore, psychiatric patients should also be taken into consideration in the future.

Secondly, the present study found that LD prevalence in China is very similar to that in some western countries. However, it's not enough to assert that culture has less relevance to the prevalence of LD. Individual differences like mindfulness, which is associated with the LD prevalence, are sometimes strongly different in different cultures (Stumbrys et al., 2015). LD prevalence may also vary within a culture at different times. Therefore, in order to explore the degree of the relationship between LD prevalence and culture, LD prevalence across cultures and at different times within a culture are planned to be investigated. Aviram and Soffer-Dudek (2018) mentioned that assessing LD with a single item would overlook the complexity of LD. Thus, LD characteristics like awareness and control should also be investigated separately.

Thirdly, the two judges, although not knowing the research hypothesis, could easily tell whether a dream was lucid or not from its content. Although the scoring had objective criteria and there were two independent judges to improve reliability, it would be meaningful to explore the influence of knowing lucidity on dream bizarreness scoring in the future. In this study, we only preliminarily explored the bizarreness difference between LD and non-LD. In order to explore more detailed changes in the bizarreness of LD, future research may divide LD into different stages (e.g., dream prior to lucidity, dream during lucidity), which are judged separately for bizarreness.

What's more, it is hard to collect a complete lucid dream from each subject since LD seldom occurs. Besides, LD is particularly susceptible to suggestion before sleep. Therefore, this study only collected already happened dreams, using the most recent dream paradigm to ask each participant to report a most recent LD. However, errors may still occur because of memory bias and the fact that only one lucid dream is collected from each person. In future research, it would be better to ask subjects to keep a long-term dream diary without telling them about LD to get enough lucid dreams from each subject. And then identify lucid dreams and analyze these dreams together.

In addition, this present study is correlational, so no causal inference can be made. Other metacognition aspects like reality monitoring are also closely related to LD (Corlett et al., 2014). Dopamine can mediate metacognitive activities, such as self-awareness and reality monitoring (Schnider et al., 2010; Joensson et al., 2015). On the premise of not harming the health of subjects, drugs that promote dopamine secretion can be used to see the changes of dream bizarreness in future studies.

CONCLUSION

Considering LD prevalence was rarely studied and related results were controversial in Asian countries, we first investigated the LD frequency of China in a standardized way. We found that the prevalence of LD in China is similar to findings in western countries. To the best of our knowledge, our present study is the first study to compare dream bizarreness of LD and non-LD contents within subjects. We found that the bizarreness of LD is lower than that of non-LD, which also proved that LD is not as strange as usually considered. In general, dream bizarreness is related to individual differences in metacognition traits, and subjects with higher self-reflection and insight would have lower dream bizarreness.

The results of this study revealed that there is a kind of continuous self-consciousness across waking, LD, and non-LD state. As a special consciousness state, LD may shed light on the research of consciousness and dream continuity hypothesis. Based on our findings, future research is suggested to treat dream bizarreness in a more general way. Dream types, individual differences in metacognition should be taken into consideration.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the School of Psychology, South China Normal University, Human Research Ethics Committee. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

CY designed this research and finished it. HS contributed to the manuscript submitting and provided the language help.

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Are Lucid Dreams Good for Us? Are We Asking the Right Question? A Call for Caution in Lucid Dream Research

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Lucid dreams (LD), i.e., dreams in which one is cognizant of the fact that one is dreaming, have become well-known in recent years, and their deliberate induction has become widespread. This popularity partly stems from theoretical notions conceptualizing LD as adaptive to mental health. However, empirical evidence for that is equivocal. Moreover, there are at least two reasons why frequent deliberate LD induction may theoretically also be hypothesized to be deleterious to mental health: (1) possibly disrupted sleep quality and (2) possibly disrupted reality–fantasy boundaries. Below, I will discuss evidence regarding relations of LD with well-being vs. psychopathology and then consider each of these two potential disruptions. I will conclude by suggesting that the focus on potential benefits of LD is accompanied by a disregard of potential risks of frequent deliberate LD induction.

LD have become increasingly well-known in recent years, with representations in popular media (e.g., the 2010 sci-fi thriller "Inception") and several cyber-forums and blogs dedicated to the topic, with thousands of participants (e.g., the Dreamviews LD forum[1] has over 93,000 members). LD may occur spontaneously, yet techniques for deliberate LD induction (e.g., LaBerge and Rheingold, 1990) have been gaining popularity. Induction techniques have become so popular that 35% of first-year Psychology undergraduate students had tried to deliberately initiate LD at least once (Aviram and Soffer-Dudek, 2018).

Why do people wish to volitionally induce LD? Partly because it is tempting to enter—without using any physical substance—a state of altered consciousness in which one can perform feats not possible in real life (e.g., flying), by exerting control over the dream scenario. But also, since LD are considered by many as an ideal state, promoting well-being and psychological growth (Tholey, 1988; Green and McCreery, 1994), a stance readily adopted by bloggers. Reasons for lucid dreaming are usually wish fulfillment and problem-solving, although many also report aims such as overcoming fears and healing (Stumbrys and Erlacher, 2016). However, as will be reviewed below, empirical evidence in favor of LD as promoting psychological well-being is equivocal, and also, despite common notions, empirical evidence suggests that most LD are not characterized by an ability to control dream events.

LD are considered as indicating mental health and well-being (Snyder and Gackenbach, 1988; LaBerge, 2014). Indeed, in one study they were associated with increased mental health and self-confidence (Doll et al., 2009). Another study exploring LD and personality found that lucid dreamers were socially bold, dominant, experimenting, enthusiastic, and warm (Gruber et al., 1995). LD have also been associated with creativity (Blagrove and Hartnell, 2000) and with psychological resilience in the face of traumatic stress (Soffer-Dudek et al., 2011). Although LD may often be triggered by nightmares, they tend to conclude with positive emotion

[1]"Lucid Dreaming—Dream Views" Forum (n.d.). Available online at: https://www.dreamviews.com/ (accessed October 2, 2019).

(Aviram and Soffer-Dudek, 2018). According to Dresler et al. (2015), neurocognitive evidence suggests that insight into dreaming (LD) may be a model for insight into one's illness in schizophrenia, which is a positive prognostic factor.

LD have often been characterized as including experienced control, enabling the dreamer to alter dream events (e.g., Gackenbach, 1988). Accordingly, LD has been related to (waking personality) internal locus of control (Blagrove and Tucker, 1994; Blagrove and Hartnell, 2000; Patrick and Durndell, 2004). Because control over dream events is considered an inherent part of LD, control items have often been included as indicators of lucidity (e.g., Watson, 2001) or mentioned as part of the LD definition (e.g., Tart, 1988). However, studies disentangling dream awareness from control have shown that uncontrolled LD are more common than controlled LD; this was found in a non-clinical sample of young adult undergraduate students (Aviram and Soffer-Dudek, 2018), a large sample of children and adolescents aged 6–19 (Voss et al., 2012), and a clinical sample of veterans suffering from post-traumatic stress disorder (PTSD) (Harb et al., 2016). Relatedly, in a preliminary study assessing whether LD may be used to practice a motor task, over half of lucid dreamers were unable to practice efficiently in the dream because of distractions, suggesting limited control. Interestingly, only those in control showed a performance benefit (Schädlich et al., 2017).

Additionally, even when there is control in LD, it is unclear whether this is necessarily beneficial for mental health. On one hand, veterans with PTSD whose nightmare distress decreased exhibited an increase in LD control (Harb et al., 2016). Also, students reporting high LD control reported less psychopathological symptoms than those reporting low LD control (Aviram and Soffer-Dudek, 2018). On the other hand, Mota et al. (2016) found, contrary to their hypothesis, that individuals suffering from psychotic symptoms had significantly higher LD control compared to healthy participants. They suggested that LD in a psychotic population is not recommended because they may further empower deliria and hallucinations, favoring internal over external reality. Indeed Holzinger (2014) suggested that some individuals may misuse LD, and caution should be exerted especially regarding psychotic clients. Notably, despite very different samples, two different studies showed that lucid dreamers were not better off psychologically (i.e., did not have lessened symptoms) compared to non-lucid dreamers (Mota et al., 2016; Aviram and Soffer-Dudek, 2018). In other words, in both studies, specific LD characteristics were related to psychopathology, but mere LD frequency was not. Dream characteristics related to lessened symptoms are not just control but also confidence of the lucidity and dream length, together labeled as LD intensity (Aviram and Soffer-Dudek, 2018). Importantly, however, those who were high in intensity were not different in psychopathological symptom scales compared to non-lucid dreamers. Their advantage was only compared to those who had LD awareness coupled with low control or intensity. Further research is needed to continue to examine whether the combination of high dream awareness with low dream control might be indicative of psychopathology. Such a notion would be compatible with the finding that veterans with PTSD demonstrated a LD profile characterized by high dream awareness and low control (Harb et al., 2016). In another study, Jones and Stumbrys (2014) expected sports students reporting LD to have higher mental health and perceive themselves as physically fit. However, they found no relation to mental health and an inverse relation to reported physical fitness.

Importantly, LD have been advocated as a therapeutic approach (lucid dream therapy, LDT; Gavie and Revonsuo, 2010), training individuals in induction techniques. This is usually aimed at chronic nightmare sufferers so that they can gain control over their nightmares by altering the ending of the dream scenario. Although there is some preliminary evidence in favor of LDT for nightmare treatment, it is inconsistent, the sample sizes are small, the effects are weak, and there is a need for more research (Macêdo et al., 2019). The mechanism of change is unclear as several participants improved without achieving LD (Zadra and Pihl, 1997; Spoormaker et al., 2003; Spoormaker and van den Bout, 2006). Possibly, the mere idea that they can gain control, rather than dream awareness *per se*, was responsible for the improvement. Notably, there is no evidence supporting LDT over other empirically based therapies (Lancee et al., 2010). Thus, it is not yet clear whether training people to achieve LD is worthwhile. Finally, LD has not shown any beneficial effect for PTSD symptoms (Spoormaker and van den Bout, 2006; Lancee et al., 2010; Harb et al., 2016).

Research on LD induction has mainly explored whether LD may be efficiently induced and whether it may carry psychological benefits. However, possible adverse consequences of LD induction have scarcely been investigated. Below, I will suggest two variables worthy of such consideration: sleep quality and psychological reality–fantasy boundaries.

Sufficient good sleep quality and sleep hygiene are crucial for mental and physical health (e.g., Benca et al., 1992; Kahn-Greene et al., 2007; Cappuccio et al., 2010). In addition to insufficient or poor sleep, unusual dreaming may also be considered as a form of sleep disruption, when arousal or vigilance permeate nocturnal consciousness (Soffer-Dudek, 2017). LD theoretically also represent arousal within sleep, but they do not show the robust relationships with distress shown by other unusual sleep experiences (Soffer-Dudek, 2017). However, that conclusion was based mostly on studies that assessed LD by averaging dream awareness with dream control into a single measure. Moreover, those studies did not separate spontaneous LD from deliberate induction. These facts may have weakened the relationships with distress and sleep problems.

LD is a hybrid sleep–wake state, with increased activity in frontal areas, which are usually suppressed during sleep (Voss et al., 2009; Dresler et al., 2012). This neurocognitive evidence is compatible with the phenomenological evidence, i.e., LD are characterized by increased metacognition, insight, critical thinking, and vigilance/monitoring compared to normal dreaming. Indeed, a tendency for having LD was associated with higher neural activation in areas considered responsible for thought monitoring (Filevich et al., 2015). Although we generally regard critical thinking and meta-cognition as adaptive, they are not part of normal sleep and dreaming; our brain probably tends to inhibit prefrontal cortical activity in sleep for a reason. Thus, a question arises: is it possible that frequent engagement in LD (as may occur following deliberate attempts at induction) may disrupt sleep, possibly resulting in adverse effects for our health? This is a question worth exploring as there are correlational data showing a relationship between LD and sleep problems, poor sleep quality, and nightmares. Specifically, Schadow et al. (2018) found that LD were related to poor sleep quality in two samples: university students ($N = 444$) and a community sample ($N = 1,380$). Notably, the relation was higher in the latter, suggesting that perhaps student samples have limited variance in terms of sleep quality. The shared variance between LD and poor sleep was also shared with nightmares (as demonstrated by mediation analysis), raising several causal hypotheses: each of the three variables may be the origin of the others. Similarly, LD were associated with nocturnal awakenings (Smith and Blagrove, 2015). Despite these correlations, it may be claimed that LD is unlikely to disrupt sleep as most lucid dreamers do not spend much of their sleep-time in LD in absolute terms. Possibly, LD *induction* may be the culprit disturbing sleep; for example, the "wake back to bed" technique (LaBerge, 1985) requires deliberate sleep interruption. Indeed Smith and Blagrove (2015) showed that the use of the alarm clock "snooze" button significantly associated with LD, perhaps with LD resulting from those brief morning awakenings. In Aviram and Soffer-Dudek (2018), the frequency of attempting to deliberately induce LD using induction techniques (rather than spontaneous LD) was the factor associated with sleep problems, stress, dissociation, schizotypy, depression, and obsessive–compulsive symptoms. Relatedly, in a study where the experimental group underwent a LD intervention promoting LD induction and then followed with daily diaries, there was a robust correlation between LD and depression (Taitz, 2011).

The disruption of the sleep–wake cycle is inherently linked with indistinct boundaries between waking and sleeping conscious experience; sleepiness may permeate the waking state and arousal may pervade dreaming (Soffer-Dudek, 2017). This may be particularly true for LD induction as techniques such as reality testing (Levitan and LaBerge, 1989) or the reflection technique (Tholey, 1988) require, to some extent, disruption of sleep hygiene by deliberate confusion of the sleep and waking states (e.g., scheduled awakenings in the middle of the night or asking oneself "am I dreaming?" during the day). The blurring of boundaries between reality and dreaming are theoretically related to psychosis-proneness/schizotypy and dissociative symptoms. Indeed lucid dreamers had impaired reality monitoring, with more confabulatory errors (Corlett et al., 2014), and as mentioned, lucid control was heightened in a psychotic group (Mota et al., 2016). LD were suggested to be part of a continuum pertaining to bizarre cognitions during the day and during the night due to their correlation with dissociation, schizotypy, and unusual sleep experiences (Watson, 2001). Indeed they were associated with parapsychological experiences such as out-of-body experiences and apparitions (Alvarado and Zingrone, 2007). In a longitudinal exploration, Aviram and Soffer-Dudek (2018) demonstrated that those who reported engaging in deliberate LD induction had an increase in schizotypy and dissociative symptoms over the span of the following 2 months. This directional finding, predicting change over time, is superior to cross-sectional designs; however, experimental research exploring possible harmful effects of induction is needed.

In conclusion, it seems that we may be cultivating a shared blind spot by focusing solely on the possible beneficial effects of LD induction, without taking into account possible risks. Might frequent induction be deleterious to sleep hygiene and sleep–wake psychological boundaries? If so, is it worth it? And do potential risks pertain specifically to vulnerable individuals, e.g., those high in baseline dissociation/schizotypy? We need more research to answer these questions with confidence. I hope LD researchers will consider these questions in their future research.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Lucid Dreaming, Nightmares, and Sleep Paralysis: Associations With Reality Testing Deficits and Paranormal Experience/Belief

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Focusing on lucid dreaming, this paper examined relationships between dissociated experiences related to rapid eye movement (REM) sleep (lucid dreaming, nightmares, and sleep paralysis), reality testing, and paranormal experiences/beliefs. The study comprised a UK-based online sample of 455 respondents (110 males, 345 females, *Mean age* = 34.46 years, *SD* = 15.70), who had all previously experienced lucid dreaming. Respondents completed established self-report measures assessing control within lucid dreaming, experience and frequency of nightmares, incidence of sleep paralysis, proneness to reality testing deficits (Inventory of Personality Organization subscale, IPO-RT), subjective experience of receptive psi and life after death (paranormal experience), and paranormal belief. Analysis comprised tests of correlational and predictive relationships between sleep-related outcomes, IPO-RT scores, and paranormal measures. Significant positive correlations between sleep and paranormal measures were weak. Paranormal measures related differentially to sleep indices. Paranormal experience correlated with lucid dreaming, nightmares, and sleep paralysis, whereas paranormal belief related only to nightmares and sleep paralysis. IPO-RT correlated positively with all paranormal and sleep-related measures. Within the IPO-RT, the Auditory and Visual Hallucinations sub-factor demonstrated the strongest positive associations with sleep measures. Structural equation modeling indicated that Auditory and Visual Hallucinations significantly positively predicted dissociated experiences related to REM sleep, while paranormal experience did not. However, paranormal experience was a significant predictor when analysis controlled for Auditory and Visual Hallucinations. The moderate positive association between these variables explained this effect. Findings indicated that self-generated, productive cognitive-processes (as encompassed by Auditory and Visual Hallucinations) played a significant role in conscious control and awareness of lucid dreaming, and related dissociative sleep states (sleep paralysis and nightmares).

Keywords: lucid dreaming, dissociated experiences, REM, reality testing, paranormal experiences

INTRODUCTION

Lucid Dreaming Background

Lucid dreaming is a dissociated state, which combines aspects of waking and dreaming (Schredl and Erlacher, 2004; Voss et al., 2009; LaBerge et al., 2018). Specifically, it denotes conscious awareness of dreaming during ongoing sleep (Baird et al., 2019). A central characteristic is that experiencers are typically able to signal their lucid state during dream periods using pre-agreed eye-movement signals (LaBerge, 1980; LaBerge et al., 2018). Concomitantly, lucid dreaming possesses consciousness-related features such as access to waking memories, increased insight and control, positive affect, body dissociation, and logical thought (LaBerge et al., 1981; Voss et al., 2009, 2018). Other criteria used to distinguish lucid dreams are memory of the waking state, sentience of freedom of decision, and full intellectual abilities (Tholey and Utecht, 1987; Lee, 2017). However, few lucid dreams include all of these features (Zink and Pietrowsky, 2013).

The concept of lucid dreaming pre-dates modern science as evinced by the work of ancient scholars (Baird et al., 2019). The modern conceptualization of lucid dreaming arose from Frederik van Eeden's examination of his personal dream experiences. van Eeden (1913) defined lucid dreams as a state in which "…the reintegration of the psychic functions is so complete that the sleeper remembers day-life and his own condition, reaches a state of perfect awareness, and is able to direct his attention, and to attempt different acts of free volition" (pp. 149–150).

The development of physiological measurement and enhanced understanding of rapid eye movement (REM) sleep enabled researchers to produce empirical evidence that supported the existence of lucid dreaming and facilitated the development of objective measurement techniques. For instance, the ability to record pre-agreed eye movement sequences within lucid dreams became an established procedure (LaBerge et al., 1981, 2018).

Understanding of lucid dreaming has developed over recent years. Illustratively, Stumbrys et al. (2014) conducted a large-scale survey ($N = 684$) that identified important characteristics of lucid dreams. They found that lucid dreamers usually have their first experiences during adolescence, and these occur spontaneously. They noted also that the average lucid dream duration is about 14 min. In terms of phenomenology, lucid dreamers are typically active within their dreams and direct various actions (e.g., flying). Although, they are not always able to achieve their goals due to awakening, obstacles within the dream environment, or failing to recall intention (Stumbrys et al., 2014).

Incidence of lucid dreaming varies across studies as a function of methodology (researcher questions, classification criteria, type of data collection used, etc.) and sample type (see Saunders et al., 2016). A meta-analysis undertaken by Saunders et al. (2016) provides the best approximation of prevalence (number of individuals experiencing at least one lucid dream) and frequency (those reporting one or more lucid dreams per month). This estimated that 55% of adults have had at least one lucid dream in their lives, with 23% of adults experiencing lucid dreaming regularly (once per month or more).

Individual Differences Related to Lucid Dreaming

Noting individual differences in prevalence and frequency, much research has focused on identifying the psychological variables that facilitate lucid dreaming. Notably, work examining the role of personality has found that the Big Five personality factors (openness to experience, conscientiousness, neuroticism, extraversion, and agreeableness) explain a small but substantial portion of variation (Hess et al., 2017). Specifically, Hess et al. (2017) found that openness to experience positively predicted lucid dreaming frequency, whereas agreeableness correlated negatively. Furthermore, controlling for nightmare frequency eliminated the relationship between neuroticism and lucid dreaming frequency. The openness findings concurred with Schredl and Erlacher (2004), who reported small significant relationships between lucid dreaming frequency, openness to experience, associated dimensions (thin boundaries, absorption, imagination), and openness facets of fantasy, aesthetics and feelings.

In addition to the Big Five personality factors, lucid dreaming correlates with specific personality characteristics (Blagrove and Tucker, 1994; Blagrove and Hartnell, 2000). For instance, frequent lucid dreamers (vs. non-lucid dreamers) score significantly higher on internal locus of control, need for cognition and creativity (Blagrove and Hartnell, 2000). Zink and Pietrowsky (2013) propose that these characteristics index cognitive complexity and flexibility. They also suggest a preference for self-focused attention, cognitive activity, and strong imaginative pursuits. Overall, these conclusions are consistent with studies that report self-reflectiveness and active control are integral features of lucid dreaming (Blagrove and Hartnell, 2000).

Noting this, Zink and Pietrowsky (2013) postulated that creativity plays a principal role in lucid dreaming. Indeed, Stumbrys and Daniels (2010) found that lucid dreaming contributed to problem solving in creative tasks. Alongside creativity, lucid dreaming correlates with related variables. Explicitly, fantasy proneness and absorption (Koffel and Watson, 2009). These constructs also relate to other sleep experiences (i.e., retrospective dream recall and dream salience; bizarreness, vividness, colorfulness, and impact of dreaming) (Koffel and Watson, 2009). Overall, related literature suggests that the correlated constructs of creativity, fantasy proneness and absorption represent a cognitive style based on intensive and absorptive imaginative involvement (Levin and Young, 2002).

Reality Testing and Lucid Dreaming

Within the psychological literature, there exist different definitions of reality testing. The researchers used the conceptualization employed by the reality testing (IPO-RT) subscale of the Inventory of Personality Organization (IPO) (Lenzenweger et al., 2001). The IPO is a self-report measure that classifies personality pathology within clinical and non-clinical samples (Smits et al., 2009; Lenzenweger et al., 2012; Preti et al., 2015). The selection of the IPO-RT derived from the observation that the subscale indexes internally generated creative, imaginative and vivid mental sensations/imagery. Explicitly, the IPO-RT delineates reality testing as "the capacity to differentiate self from non-self, intrapsychic from external stimuli, and to maintain empathy with ordinary social criteria of reality" (Kernberg, 1996, p. 120). Accordingly, the IPO-RT focuses on information processing and provides an assessment of evaluative mechanisms (Langdon and Coltheart, 2000). Thus, high scores on the IPO-RT are indicative of a self-oriented, subjective information processing style, which indexes individual reliance on internally generated data, specifically intensive, absorptive imaginative involvement.

Noting the main features of lucid dreaming, and the fact that reality testing shares important attributes with lucid dreaming (creativity, inner focus, fantasy proneness, etc.) this paper examined the degree to which reality testing predicted lucid dreaming. Congruent with this perspective, researchers use the IPO-RT as an indirect, proxy measure of intuitive thinking style (Dagnall et al., 2017). This approach derives from the work of Epstein (1990, 1994), who developed cognitive-experiential self-theory, which differentiates experiential (fast, automatic, holistic, and characterized by proneness to generalization/association) and rational (slow, intentional, effortful, and logical) processing. In this context, high scores represent a preference for subjective, internally generated information and index greater tendency to reality testing deficits.

It is important to note that the IPO-RT samples a broad spectrum of cognitive-perceptual phenomena. Recognizing this, Irwin (2004) contended that the single factor solution depicted in the original paper represented an oversimplification of domain content. This applied to sleep research, implies that particular aspects of reality testing may be more predictive of lucid dreaming. Recognizing this, the present paper treated the IPO-RT as a multidimensional measure. The factorial structure selected derived from Dagnall et al. (2017), who identified four factors: hallucinations (auditory and visual), delusional thinking (beliefs contrary to reality), social deficits (difficulties reading social cues), and sensory/perceptual confusion (inability to understand feelings and sensations). These factors accounted for 55% of response variance and were conceptually congruent with the construct of reality testing within the IPO-RT (Bell et al., 1985; Caligor and Clarkin, 2010).

Subsequent psychometric evaluation of the IPO-RT by Dagnall et al. (2018) confirmed the presence of a bifactor structure consisting of a general dimension encompassing the four distinct, but inter-correlated sub-factors. Consideration of the role that sub-factors of reality testing play in lucid dreaming provides a more precise, fine-grained understanding of the cognitive-perceptual conditions involved in lucid dreams.

Lucid Dreaming and Paranormal Experiences/Beliefs

In addition to the IPO-RT, the present study included paranormal measures (i.e., belief and experience). Previous work informed this decision. Firstly, Glicksohn (1990) found that belief in the paranormal correlated positively with subjective paranormal experiences, which in turn were associated with incidence of at least one altered state of consciousness and level of absorption. Based on this finding, Glicksohn (1990) concluded that altered states of consciousness often reflect psychological elements of the relationship between paranormal belief and experience. Pertinent to the present paper, altered states of consciousness indexed phenomena related to the sleep–wakefulness continuum: lucid dreams, transitions between sleep and wakefulness (hypnagogic and hypnopompic states), and out-of-the-body experience (i.e., the experience of separation from the physical body). Moreover, paranormal experience correlated with incidence of lucid dreaming.

Secondly, although the direct relationship between paranormal belief and lucid dreaming is weak (see Glicksohn, 1990; Denis and Poerio, 2017), studies generally observe significant positive relationships between paranormal belief and major constructs associated with lucid dreaming. Notably, openness to experience (Smith et al., 2009), creativity (Irwin, 1993; Thalbourne and Delin, 1994; Thalbourne, 2005), and boundary thinness as measured by transliminality (Dagnall et al., 2010c). Transliminality denotes hypersensitivity to psychological material (Thalbourne and Maltby, 2008). Particularly, it is "a hypothesized tendency for psychological material to cross (trans) thresholds (limines) into or out of consciousness" (Thalbourne and Houran, 2000, p. 853).

Finally, belief in the paranormal correlates positively (moderately) with proneness to reality testing deficits (Drinkwater et al., 2012; Dagnall et al., 2014). Cumulatively, these findings suggest relationships between lucid dreaming, reality testing deficits and experience of the paranormal.

Other Dissociated Experiences Related to Rapid Eye Movement Sleep (Sleep Paralysis and Dreaming) and Paranormal Experiences/Beliefs

With relevance to the present study, it is worth noting that Glicksohn (1990) found that only paranormal experience predicted lucid dreaming. Cognizant of this, the authors focused on commonly encountered 'productive' psychic experiences (see Glicksohn, 1990; Dagnall N.A. et al., 2016). Specifically, receptive forms of psi (telepathy, precognition, premonition, and remote viewing) and communication with spirits (contacting the deceased, psychic ability, mediumship, and spiritualism). Thematically, these phenomena comprise the mental transmission and reception of information via unknown powers or forces, and are concomitant with an open and intuitive approach to experiences (Schmeidler, 1985).

Alongside lucid dreaming, the authors included other dissociated experiences related to REM sleep (i.e., sleep paralysis and dreaming). Sleep paralysis was justified because it correlates positively with lucid dreaming (Denis and Poerio, 2017), and experiencers frequently report concomitant unusual/anomalous perceptions and sensations (Denis et al., 2018). Sleep paralysis combines elements of wakefulness and REM sleep, characterized by the inability to perform voluntary movements during sleep onset or awakening (i.e., the sleeper is "immobilized" yet perceptually awake) (see American Academy of Sleep Medicine, 2014; Jalal, 2018).

A key feature of sleep paralysis relevant to the current paper was accompanying hallucinations (strong visual imagery) (Spanos et al., 1995). These often take the form of uncanny "ghost-like" experiences and evoke extreme fear reactions (Jalal, 2018). Cheyne places these into three categories: intruder (sense of evil presence and multi-sensory hallucinations of intruder), incubus (feeling of pressure on the chest, suffocation, and physical pain), and vestibular-motor (feature illusory-movement and out-of-body experiences) (Cheyne et al., 1999b; Cheyne, 2003). Intruder and incubus hallucinations typically co-occur and are accompanied by fear, whereas vestibular-motor hallucinations are more positive (Cheyne, 2003).

As with lucid dreaming, studies report that personality factors influence occurrence of sleep paralysis. Particularly, thinner personality boundaries correlate with pleasant sleep paralysis, and individuals with higher absorption demonstrate greater propensity to sleep paralysis with hallucinations (Lišková et al., 2016).

Moreover, Denis and Poerio (2017) found that sleep paralysis and lucid dreaming were associated with belief in the paranormal. Denis and Poerio (2017) suggest openness to experience explains this connection. In addition, imaginal capacity plays an important role in both lucid dreaming and sleep paralysis. Relatedly, the strongest predictor of sleep paralysis episodes was nightmares (Spanos et al., 1995; Lišková et al., 2016). Nightmares are extremely frightening dreams from which the person is directly awakened (Spoormaker et al., 2006). Although, the relationship between nightmares and lucid dreaming is complex and difficult to establish, nightmare prevalence and distress is also associated with higher levels of fantasy proneness, and psychological absorption. Noting this, the present study considered nightmares together with lucid dreaming and sleep paralysis for completeness.

The Present Study

The linkage between other dissociated experiences related to REM sleep and paranormal experiences/beliefs suggests that factors share common features, which merits further investigation. Certainly, previous studies such as Denis and Poerio (2017) have reported weak associations between paranormal belief, dissociative experiences, lucid dreaming, sleep paralysis, daydreaming, and imagery. Hence, the present study extended understanding of the relationship between cognitive-perceptual personality factors by examining the extent to which reality testing and paranormal belief/experience predicted lucid dreaming and sleep-related phenomena (i.e., sleep paralysis and dreaming). The inclusion of reality testing derived from the constructs focus on intra-psychic activity and overlap with factors linked to lucid dreaming (i.e., creativity, imagination, fantasy proneness, and absorption). These elements link with consciousness and belief/experience of the paranormal.

Accordingly, the authors hypothesized that reality testing would correlate with belief in and experience of the paranormal, and predict lucid dreaming, sleep paralysis and nightmares. Given that the present study included only respondents who experienced lucid dreaming and focused on control of lucid dreaming, the authors tentatively anticipated correlations between sleep-related factors. This postulation resulted from the view that experiencers of lucid dreaming possess a greater awareness of sleep-related phenomena, especially when experiences reference perception of visual imagery and imagined sensations.

Consistent with previous work and the supposition that 'experience' more directly indexes acceptance of the existence of paranormal forces than belief, the researchers posited that only paranormal experience (not belief) would predict lucid dreaming. This notion is congruent with attributional models, which regard the labeling of anomalous experiences as 'paranormal' as the final process stage (see Irwin et al., 2013). Finally, the inclusion of a range of sleep-related measures enabled the researchers to determine whether reality testing and paranormal measures were similarly predictive of lucid dreaming, sleep paralysis, and nightmares.

MATERIALS AND METHODS

Procedure

Prior to participation, potential respondents received background information. This stated the nature of the study and outlined ethics. Only respondents providing informed consent received the materials booklet. Instructions asked respondents to carefully read, answer all questions, and take their time. Participants worked through the measures at their own pace and there was no maximum time limit. To prevent order effects questionnaire position rotated.

Within the present study, data collection occurred at one point in time. Such cross-sectional designs are frequently criticized because they can result in common method variance (Spector, 2019). To prevent common method variance, the researchers employed procedural remedies (Krishnaveni and Deepa, 2013). Firstly, the study brief and scale instructions emphasized that each measure assessed a different construct. This created psychological distance between the scales. Separation strategies, such as this have previously successfully reduced common method variance (Podsakoff et al., 2003). Secondly, the study brief provided information intended to reduce the potential for social desirability effects and evaluation apprehension by stating that there were no correct answers, and advising respondents that they should answer questions honestly.

Participants

The study sample comprised 455 respondents, (Mean age, M) = 34.46 years, SD = 15.70, range 18–77. There were 110 males (24%), M = 25.31 years, SD = 9.56, range 19–77; and 345 females (76%), M = 28.00 years, SD = 11.76, range 18–75. For all variables, skewness and kurtosis values were within the recommended range of −2.0 to +2.0 (Byrne, 2010). Participant recruitment was via emails to university staff/students and local stakeholders (businesses, leisure and vocational/sports classes). If potential participants had not experienced lucid dreams or were younger than 18 years of age participation discontinued. Other studies have also focused on respondents who have experienced sleep-related phenomena (see Lišková et al., 2016; study of sleep paralysis). These factors were the only exclusion criteria.

Measures

Dissociated Experiences Related to Rapid Eye Movement Sleep

Lucid dreaming

Four items indexed subjective reporting of lucid dreaming (frequency and control). In order to confirm that respondents understood what lucid dreams were the first item acted as a screening check. This included a brief definition preceded by a rating scale, "During lucid dreaming, one is—while dreaming—aware of the fact that one is dreaming. It is possible to deliberately wake up or to control the dream action or to observe passively the course of the dream with this awareness" (Snyder and Gackenbach, 1988).

Frequency was assessed using an eight-point rating scale (0 = never, 1 = less than once a year, 2 = about once a year, 3 = about two to four times a year, 4 = about once a month, 5 = about two to three times a month, 6 = about once a week, 7 = several times a week) (Schredl and Erlacher, 2004; Stumbrys and Erlacher, 2017). This item ensured that respondents had experienced lucid dreams. Respondents reporting lucid dreams rated the extent (in percentages) they were able to maintain conscious awareness for a sufficiently long period of time; completely control their dream body (movements and actions); and design their dream surroundings (to make landscape or environment and occurring dream characters to appear, disappear, or change) (Stumbrys and Erlacher, 2017). In this study, internal consistency was good for this scale, α = 0.81.

Nightmares

Two items assessed the degree to which respondents experienced and recalled nightmares (Schredl et al., 2016). A brief definition of nightmares appeared prior to scale completion, "A nightmare is a vivid dream that is frightening and disturbing, the events of which you can remember clearly and in detail when you wake up."

The first item asked, "How often do you experience nightmares?" Respondents answered using an eight-point Likert scale (0 = never, 1 = less than once a year, 2 = about once a year, 3 = about two to four times a year, 4 = about once a month, 5 = about two to three times a month, 6 = about once a week, 7 = several times a week). The second item asked, "How distressing are your nightmares?" was measured using a five-point scale (0 = not at all distressing, 1 = not that distressing, 2 = somewhat distressing, 3 = quite distressing, and 4 = very distressing). The third item assessed recall, "How often do you wake up and recall a dream" (Schredl, 2004). Participants responded via a seven-point Likert scale (1 = never, 2 = less than once a month, 3 = about once a month, 4 = twice or three times a month, 5 = about once a week, 6 = several times a week, 7 = almost every morning). Alpha reliability for this measure was satisfactory, α = 0.68.

Movement

A final single item measured respondent experience of sleep paralysis, "Sometimes when falling asleep or when waking from sleep, people may experience a brief period of inability to move, even though they are fully conscious and awake. How often do you recall this experience?" (Cheyne et al., 1999a). Participants responded via a four-point Likert scale (1 = never, 2 = once, 3 = two to five times, and 4 = more than five times).

The Reality Testing Subscale of the Inventory of Personality Organization (IPO-RT)

The IPO-RT (Lenzenweger et al., 2001) assesses the ability to differentiate self from non-self, intrapsychic from external stimuli, and to maintain empathy with ordinary social criteria of reality (Kernberg, 1996). This perspective derives from an information-processing approach to belief generation (see Langdon and Coltheart, 2000). Consequently, researchers use the IPO-RT to assess proneness to reality testing deficits (Irwin, 2004; Dagnall et al., 2017). Particularly, as an index of the tendency to engage in subjective-intuitive thinking (Denovan et al., 2017). The IPO-RT comprises 20-items that appear as statements (e.g., "I believe that things will happen simply by thinking about them"). Respondents specify their level of agreement on a five-point Likert scale. Possible responses range from 1 = never true to 5 = always true. Summation of item totals produces scores between 20 and 100. Higher scores indicate propensity to reality testing deficits. Previous research has established that the IPO-RT is psychometrically robust. Explicitly, good internal consistency, test–retest reliability, and construct validity (Lenzenweger et al., 2001). In this study, good internal consistency existed, α = 0.92.

Paranormal Measures

Manchester Metropolitan University New (MMU-N)

This study used the MMU-N (Dagnall et al., 2010a,b) to assess belief in the paranormal in preference to the Revised Paranormal Belief (Tobacyk and Milford, 1983) and Australian Sheep-Goat (Thalbourne and Delin, 1993) scales because the MMU-N measures a broader range of beliefs, and samples these in greater depth. The MMU-N provides both overall and dimensional, sub factor scores (i.e., hauntings, superstitions, religious belief, alien visitation, extrasensory perception, psychokinesis, astrology, and witchcraft) (Dagnall et al., 2010a,b). These subscales are conceptually coherent, possess good face validity and are composed of items clearly related to the assigned factor label. The MMU-N comprises 50-items presented as statements (e.g., 'there is a devil' and 'poltergeists exist') to which participants respond using a seven-point Likert scale (ranging from 1, strongly disagree, to 7, strongly agree). Both subscales and the overall measure possess good to excellent external reliability (Dagnall et al., 2010a). The measure has featured in published studies, where it has demonstrated good concurrent validity. In the current study, this scale evidenced good reliability, α = 0.96.

Paranormal Experience

A series of items asked respondents whether they had genuinely experienced paranormal/psychic phenomena (i.e., communication with the dead, psychic, mediumship, spiritualism, telepathy, precognition, premonition, and remote viewing). These items represented core subjective experiences related to receptive psi and life after death (see Drinkwater et al., 2013, 2017a). To ensure that respondents understood what each phenomenon was, a definition appeared within each category. For example, 'Mediums receive and relay information from deceased people to the living. In the context of this definition, have you ever personally experienced mediumship? 'Summation of category scores produced an overall experience total. Scores ranged from 0 to 8, with higher scores indicating greater experience of paranormal/psychic phenomena. This method of measuring experienced paranormal/psychic phenomena is well-established (Dagnall et al., 2019). Satisfactory alpha reliability existed for this measure, α = 0.74.

For analysis, the researchers used mean total score for each variable (see **Table 1**).

Ethics Statement

As preparation for a grant bid (October 2018), the researchers gained ethical endorsement for a series of studies examining psychological and neuropsychological factors associated with self-professed psychic ability/mediumship. Following formal submission, the Director of the Research Institute for Health and Social Care and the Manchester Metropolitan University Faculty of Health, Psychology and Social Care Ethics Committee granted ethical approval.

Data Analysis

Data screening occurred prior to computation of descriptive statistics (means, *SD*s, and correlations) and model testing. Model testing via AMOS26 (IBM SPSS) comprised structural equation modeling, which is a sophisticated analytic technique that tests hypotheses by computing the weight of standardized regression paths between variables of interest (depicted as latent variables). Structural equation modeling incorporates measurement error in its model estimation, and utilizes fit indices to evaluate the extent to which observed data corresponds with proposed, conceptual models.

Preceding model testing, confirmatory factor analysis examined the adequacy of each study instrument and a measurement model scrutinized interactions between latent variables and accompanying outcomes. A structural model subsequently assessed hypothesis-driven relationships among latent variables (Anderson and Gerbing, 1988). Specifically, the degree to which reality testing and paranormal belief and/or experience predicted sleep-related outcomes (lucid dreaming, sleep paralysis, and nightmares).

A range of indices determined model fit, specifically absolute fit indices (chi-square statistic, root-mean-square error of approximation, RMSEA; standardized root-mean-square residual, SRMR), and relative fit indices (comparative fit index, CFI; incremental fit index, IFI). Chi-square considers the extent to which a model reproduces data, with non-significant *p*-values indicative of good fit. However, chi-square frequently rejects models informed by large samples due to its sensitivity to sample size. Consequently, other indices require inspection (Kline, 2010).

Root-mean-square error of approximation assesses the distance between the reproduced covariance matrix and the sample-based covariance matrix, and includes a 90% confidence interval (CI) to judge precision of fit. SRMR indexes the average of standardized residuals between hypothesized and actual covariance matrices (Cangur and Ercan, 2015). RMSEA and SRMR statistics of 0.08–1.0, 0.06–0.08 and $\leq$0.05 indicate marginal, satisfactory and good fit (Browne and Cudeck, 1993). Relative fit indices compare the performance of a tested model to a null model (also called an 'independence' model) (Ching et al., 2014). Values above 0.90 represent good fit (Hu and Bentler, 1999).

RESULTS

Descriptive Statistics

Descriptive statistics and correlations appear in **Table 1** alongside univariate kurtosis and skewness data. All values fell within the recommended range of −2 to +2 (Byrne, 2010). Given a large number of correlations existed, for comparison purposes adjustment to the significance level occurred using a sequential method suggested by Benjamini and Hochberg (1995); demonstrated by Williams et al. (1999). In this, ranking of *p*-values (from smallest to largest) takes place, resulting in adjusted critical *p*-values for statistical inference, according to the formula of $I/K \times 0.05$ (i.e., observed *p*-value rank/number of comparisons × level of significance). All comparisons utilized the 0.05 significance level. This method regulates the false positive rate, ensuring that no more than 5% of results identified as significant are in the wrong direction.

Using the Benjamini and Hochberg procedure, total IPO-RT (reality testing) evidenced small to medium (albeit significant) correlations with paranormal belief, experience, lucid dreaming, nightmares, and sleep paralysis. The Auditory and Visual Hallucinations subfactor of reality testing (compared with other subfactors) demonstrated the strongest associations with paranormal belief, experience, lucid dreaming, nightmares, and sleep paralysis. Of the paranormal measures, paranormal experience correlated most strongly with these outcomes. This result was consistent with study expectations and previous literature (Glicksohn, 1990). Accordingly, subsequent analyses focused on Auditory and Visual Hallucinations and paranormal experience. Given small correlations existed between Auditory and Visual Hallucinations and paranormal experience with lucid dreaming and nightmares, these variables had relatively low predictive value in the structural model.

Confirmatory Factor Analyses

Confirmatory factor analysis occurred for each selected scale. Research indicates that Auditory and Visual Hallucinations is an intercorrelated but distinct unidimensional subfactor of IPO-RT (Dagnall et al., 2018). Paranormal experience also comprised one factor because the variable derived from experiences that were similar in theme and response scale. These indexed the most commonly reported attributes of paranormal experience (receptive psi and life after death) (see

TABLE 1 | Means, standard deviations and correlations for all study variables (*N* = 453).

Variable	*M*	*SD*	Skew	Kurt.	1	2	3	4	5	6	7	8	9	10
1. IPO-RT	40.93	13.37	0.85	0.64		0.89**	0.76**	0.66**	0.92**	0.49**	0.37**	0.19**	0.18**	0.18**
2. AVH	11.96	4.81	0.88	0.28			0.56**	0.52**	0.74**	0.47**	0.41**	0.20**	0.17**	0.18**
3. SD	7.02	2.94	0.97	0.62				0.33**	0.65**	0.22**	0.19**	0.09	0.04	0.16**
4. Confusion	8.51	2.61	0.18	−0.29					0.48**	0.31**	0.09*	0.12*	0.25**	0.07
5. DT	13.42	5.56	0.92	0.55						0.50**	0.38**	0.17**	0.15**	0.17**
6. PB	170.46	53.32	−0.83	−0.50							0.52**	0.04	0.18**	0.09*
7. PExp	1.83	1.87	1.13	0.76								0.11*	0.12*	0.18**
8. LD	56.26	71.44	1.39	1.15									0.25**	0.23**
9. Nightmare	11.81	3.48	−0.09	−0.26										0.24**
10. SP	1.92	1.08	0.70	−0.98										

*IPO-RT, Inventory of Personality Organization-Reality Testing subscale; AVH, Auditory and Visual Hallucinations; SD, social deficits; DT, delusional thinking; PB, paranormal belief; PExp, paranormal experience; LD, lucid dreaming; SP, sleep paralysis. *p < 0.05, **p < 0.01 (also less than the Benjamini and Hochberg adjusted critical p-values).*

Drinkwater et al., 2013, 2017b). A two-factor correlated model examined lucid dreaming and nightmares (dreaming) given these constructs share semantic similarities (i.e., relate to types of dreaming). Confirmatory factor analysis excluded item 1 of lucid dreaming because the purpose of this item was to screen participants for inclusion in the study.

Prior to confirmatory factor analysis, data screening using Mardia's test (Mardia, 1970) for selected study measures (Auditory and Visual Hallucinations, paranormal experience, lucid dreaming, and nightmares) indicated multivariate non-normality. Specifically, for Auditory and Visual Hallucinations multivariate kurtosis equaled 24.29 (critical ratio = 26.38); paranormal experience multivariate kurtosis = 41.25 (critical ratio = 34.71); and Dreaming (i.e., lucid dreaming and nightmares) multivariate kurtosis = 19.14 (critical ratio = 20.79). Consequently, subsequent confirmatory factor analyses utilized bootstrapping (1,000 resamples) to generate accurate bias-corrected model estimates (at the 95% confidence level). Nevitt and Hancock (2001) established that naïve bootstrapping is a sound alternative to other maximum likelihood robust approaches (e.g., Satorra–Bentler chi-square), and functions well even in instances of significant non-normality.

The Auditory and Visual Hallucinations unidimensional model indicated good fit on all indices but RMSEA, which reported marginal fit, χ^2 (8, N = 453) = 44.02, CFI = 0.97, IFI = 0.97, SRMR = 0.03, RMSEA = 0.10 (CI of 0.07 to 0.13). All items loaded greater than 0.32. The unidimensional solution for paranormal experience evidenced good fit on CFI, IFI, and SRMR, and satisfactory RMSEA, χ^2 (19, N = 453) = 60.52, CFI = 0.94, IFI = 0.94, SRMR = 0.05, RMSEA = 0.07 (CI of 0.05 to 0.09). All items demonstrated factor loadings greater than 0.32, but item 8 (0.24). The correlated two-factor model for Dreaming reported good fit overall, χ^2 (8, N = 453) = 7.87, CFI = 1.0, IFI = 1.0, SRMR = 0.02, RMSEA = 0.01 (CI of 0.00 to 0.05). High factor loadings (above 0.5) existed for all items.

Structural Equation Modeling

Consistent with the study hypotheses, the structural model tested the notion that Auditory and Visual Hallucinations and paranormal experience correlated positively and were predictive of greater levels of lucid dreaming, nightmares, and sleep paralysis. Prior to model testing, data screening (i.e., Mardia's test; Mardia, 1970) indicated multivariate non-normality, as multivariate kurtosis = 120.03 (critical ratio = 41.09). Similar to confirmatory factor analyses, structural equation modeling utilized bootstrapping with 1,000 resamples.

A test of the measurement model (which depicted latent variables as correlated) suggested good relative fit and satisfactory absolute fit, χ^2 (180, N = 453) = 476.56, CFI = 0.91, IFI = 0.91, SRMR = 0.06, RMSEA = 0.06 (CI of 0.05 to 0.07). A test of the hypothesized model (Model 1) depicting predictive relations from Auditory and Visual Hallucinations and paranormal experience to lucid dreaming, nightmares, and sleep paralysis indicated good relative and satisfactory absolute fit, χ^2 (181, N = 453) = 451.27, CFI = 0.92, IFI = 0.92, SRMR = 0.06, RMSEA = 0.06 (CI of 0.05 to 0.06). Computing a new model (Model 2; **Figure 1**) and correlating error terms between paranormal experience items 6 and 7 ('Precognition' and 'Premonition') resulted in good fit on all indices but SRMR, which reported satisfactory fit, χ^2 (180, N = 453) = 392.59, CFI = 0.93, IFI = 0.93, SRMR = 0.06, RMSEA = 0.05 (CI of 0.04 to 0.06). Statisticians caution against correlating error terms, unless appropriate justification exists (Byrne, 2010). In this case, both items belonged to the same scale and indexed a 'sensation' concerning perception of future events. Comparing the Akaike Information Criterion (AIC) of Model 1 (593.27) and Model 2 (536.59) revealed that Model 2 offered a superior fit to the data, given a lower value existed.

Inspection of standardized regression paths revealed that Auditory and Visual Hallucinations positively predicted lucid dreaming (β = 0.19, p = 0.003), nightmares (β = 0.16, p = 0.024), and sleep paralysis (β = 0.15, p = 0.016). Auditory and Visual Hallucinations also demonstrated a moderate positive correlation with paranormal experience (0.51, $p < 0.001$). However, paranormal experience did not significantly predict either outcome (lucid dreaming β = 0.02, p = 0.785; nightmares β = -0.06, p = 0.449; sleep paralysis β = 0.12, p = 0.098). An alternative model (Model 3) constrained the regression paths from Auditory and Visual Hallucinations to lucid dreaming outcomes to zero, thereby examining the influence of paranormal experience whilst

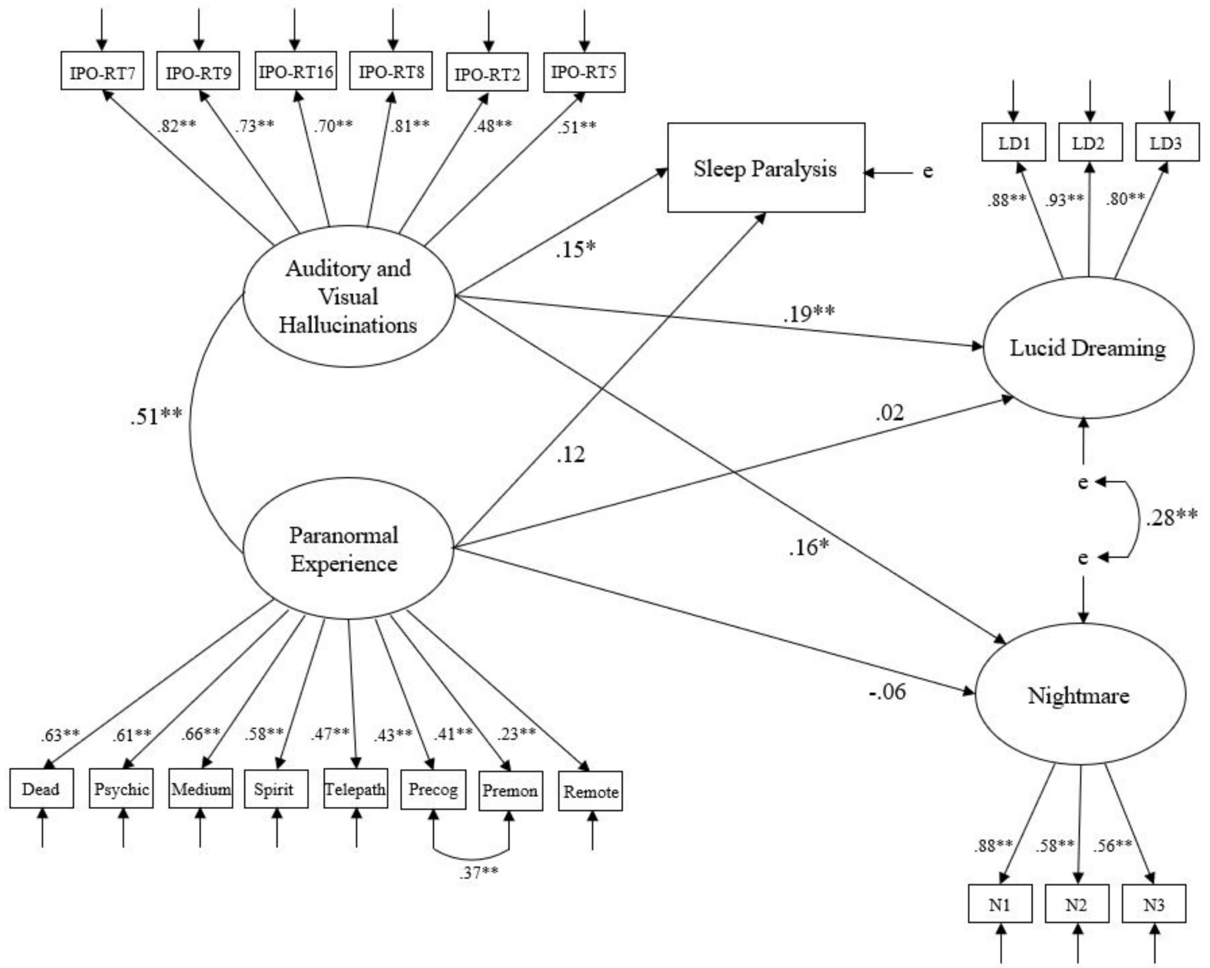

FIGURE 1 | Model 2 – Hypothesized structural relationships between Auditory and Visual Hallucinations, paranormal experience, lucid dreaming, nightmares, and sleep paralysis. Ellipses indicate latent variables, squares indicate measured variables, and 'e' represents error of measurement. Lines between latent variables represent standardized coefficients; $^*p < 0.05$, $^{**}p < 0.01$.

controlling for Auditory and Visual Hallucinations. Although this model reported weaker fit compared with Model 2 (i.e., a higher AIC of 600.27), paranormal experience significantly predicted lucid dreaming ($\beta = 0.16$, $p = 0.018$) and sleep paralysis ($\beta = 0.22$, $p = 0.002$), but not nightmares ($\beta = 0.09$, $p = 0.160$). These findings inferred that Auditory and Visual Hallucinations was a significant positive predictor of lucid dreaming and its related facets, whereas paranormal experience was not. However, paranormal experience was a significant predictor when marginalizing the influence of Auditory and Visual Hallucinations. In addition, paranormal experience, and Auditory and Visual Hallucinations demonstrated a positive association with one another.

DISCUSSION

Examination of zero-order correlations revealed weak positive relationships between proneness to reality testing deficits (IPO-RT) and sleep-related variables (lucid dreaming, nightmares, and sleep paralysis). Explicitly, higher levels of self-oriented, subjective information processing style were associated with greater perceived control within lucid dreams, Nightmare experience and recall, and incidence of sleep paralysis. Although as predicted, paranormal measures positively correlated with proneness to reality testing deficits, relationships between belief and experience and sleep measures varied as a function of dissociated state. Specifically, paranormal belief correlated weakly with sleep paralysis and nightmares. Whereas, paranormal experience demonstrated similar weak relationships with lucid dreaming and sleep paralysis.

These outcomes aligned largely with previous research. Notably, Glicksohn (1990) who reported positive relationships between paranormal belief and subjective paranormal experience, and between subjective paranormal experience and lucid dreaming. Furthermore, Glicksohn (1990) also observed that paranormal belief was not associated with lucid dreaming. Differential relationships between lucid dreaming and paranormal factors within the current paper support the notion that 'experience' is a better predictor of lucid dreaming (conscious awareness and control) than belief. In the context of this article, this makes intuitive and conceptual sense because experiences focused on perception of productive phenomena (i.e., receptive psi and life after death; paranormal experience).

Paranormal explanations notwithstanding, from a psychological perspective experience(s) directly inform conclusions about the existence of supernatural forces (Irwin et al., 2013), and indirectly tap into creative, imaginative and control elements of consciousness. Contrastingly, beliefs do not require an experiential basis. Accordingly, they are abstract and less tangible than subjective paranormal experiences.

This supposition is consistent with previous work that found that reporting of spontaneous paranormal experiences was associated with openness to and exploration of psychological space (Holt et al., 2004; Drinkwater et al., 2017a). This is also congruent with the finding that internal sensitivity predicts propensity to psi experiences (Honorton, 1972). In turn, these factors may also explain in part the relationship between paranormal experience and lucid dreaming.

Examination of the predictive model provided further insights into the relationships between lucid dreaming, reality testing and paranormal experience. Although, paranormal experience correlated moderately with Auditory and Visual Hallucinations, it did not significantly predict nightmares and sleep paralysis. Controlling for Auditory and Visual Hallucinations resulted in significant predictive relationships between lucid dreaming, nightmares, and sleep paralysis. Given that Auditory and Visual Hallucinations demonstrated positive significant relationships with lucid dreaming, nightmares, and sleep paralysis, it is likely that this explained the majority of the variance when predicting the sleep-related outcomes.

With regard to dissociated experiences related to REM sleep, the emergence of Auditory and Visual Hallucinations as the major factor IPO-RT facet makes conceptual sense. Auditory and Visual Hallucinations possesses thematic correspondence with lucid dreaming (i.e., fantasy proneness and creativity) and links to constructs related to sleep paralysis and nightmares (i.e., hallucinations and strong visual imagery; Spanos et al., 1995). Hence, examining IPO-RT subfactors in the current study provided theoretical insights, which further understanding of the connection between lucid dreaming control and cognitive-perceptual individual differences arising from thinking style. Specifically, that the productive, 'creative' elements of reality testing linked to fantasy proneness explain the construct's association with lucid dreaming. Other elements of reality testing (i.e., social deficits, confusion, and delusional thinking) make no significant contribution to lucid dreaming control. The finding that paranormal experience predicted lucid dreaming in the absence of Auditory and Visual Hallucinations accords with Glicksohn (1990).

Considering the content of sleep-related measures, lucid dreaming items were highly associated, whereas nightmare items demonstrated only weak and moderate relationships. This pattern of results indicated that aspects of lucid dreaming (maintaining conscious awareness, dream body control and design of dream surroundings) were more coherent and closely aligned than features of nightmares (frequency, distress, and dream recall). This was compatible with item level content, which in the case of nightmares sampled a spectrum of construct content. Sleep paralysis because it indexed frequency, rather than intensity and/or content, correlated weakly across lucid dreaming and nightmare items.

Limitations and Suggestions for Future Research

A potential limitation of the present study was the use of self-report measures to assess dissociated experiences related to REM sleep. Although this is a well-established and frequently used approach, critics have questioned the accuracy of measurement instruments, particularly the degree to which they provide valid insights into complex cognitive-perceptual processes. In the context of sleep, there is evidence that suggests that self-report measures provide valid snapshots of sleep-related behaviors.

For instance, Biddle et al. (2015) found that self-reports for habitual sleep duration and onset time were effective compared to an objective measure (i.e., at least 7 days of actigraphy monitoring) within large-scale studies. However, they also found that indifferences, such as those observed in clinically heterogeneous samples could produce biased estimates. In such circumstances, the use of objective measures is necessary. Within the present study, there was no evidence of systematic bias in sleep behavior. Hence, it is reasonable to assume that the self-report measures provided reasonably valid insights into factors related to incidence and frequency.

Moreover, there remains concerns about the extent to which self-report measures provide accurate assessments of reality testing (Denovan et al., 2017). Reality testing is a complex cognitive-perceptual factor that involves both knowledge of and control of cognition (Larkin, 2009; Schneider and Artelt, 2010). These underlying mechanisms are not easy to assess consciously. From this perspective, the IPO-RT indexes subjective awareness of reality testing errors. The reflective, spontaneous evaluation of reality testing decisions means that judgments may often lack veracity and/or comprehension.

This a problem that applies to cognitive functions generally. Accordingly, researchers often report weak relationships between subjective and objective measures of cognitive performance (Reid and MacLullich, 2006; Buelow et al., 2014). Noting this, future studies may wish to assess reality testing via concurrent measures to ensure that the outcomes reported in this article do not reflect an artifact of the measure used. Although, it is worth noting that the IPO-RT has proved psychometrically robust and is commonly employed by researchers. Generally, the use of self-report measures facilitate studies such as the present one because they are expedient, easy to administrate, accessible, possess wide reach, easy to score, and do not draw upon researcher assessments (Bell et al., 1985).

Despite the robust methodology of the present study and its outcomes being consistent with corresponding research, there are potential limitations that restrict extrapolation of findings. One foremost concern centres on the use of a cross-sectional design, where data collection occurred at one point in time. Critics point out that it is impossible to establish causality via cross-sectional designs. This prevents definitive conclusions because outcomes may result from other unaccounted variables.

In addition to this, observed relationships were small and require cautious interpretation. This issue is not unique to the present study, but is a problem inherent within studies examining relationships between sleep-related factors and personality generally (see Denis and Poerio, 2017; Aviram and Soffer-Dudek, 2018). Notwithstanding these concerns, conclusions were consistent with hypotheses and previous research. Noting concerns, future work could evaluate the current findings via a longitudinal study. The inclusion of multiple time points enables the observation of factors across time and ensures greater measurement consistency. This approach is beneficial to theory development because it will reveal the extent to which sleep-related states are temporally stable, and provide insights into the degree to which cognitive-perceptual personality factors, such as Auditory and Visual Hallucinations and preferential thinking style (subjective, intuitive, intra-psychic, etc.) interact with sleep-related states over time. Furthermore, use of longitudinal models enables the development of causal models.

A further potential limitation within the present study was the failure to screen for sleep-related conditions and psychiatric disorders. In the case of sleep-related conditions, researchers have linked narcolepsy with changes in dream mentation. Particularly, higher dream recall frequency and lucid dreaming (Dodet et al., 2015; Rak et al., 2015). Recent work has also reported an association between narcolepsy and creativity (Lacaux et al., 2019). Narcolepsy is a chronic sleep disorder characterized by excessive daytime sleepiness, disrupted nocturnal sleep, REM sleep occurring at the onset of sleep, and cataplexy (sudden loss of skeletal muscle tone in response to strong emotional stimuli) (Singh et al., 2013). Although narcolepsy is rare (1 in 2,000 people; Scammell, 2015) and therefore unlikely to have a significant effect on the results of this paper, subsequent research should screen for potentially conflating sleep-related conditions. In addition to this, future work could also control for psychiatric disorder. This is important because conditions such as psychosis can effect lucid dreaming (Mota et al., 2016; Voss et al., 2018) and predisposition to fantasy proneness and delusional beliefs (Tan et al., 2019). Moreover, these variables correlate positively with belief in the paranormal (Irwin et al., 2012a,b). In the current paper, these factors were unlikely to have influenced the reported outcomes because the sample was non-clinical. Regardless, it is important that future related work controls for these variables as they potentially influence incidence and experience of lucid dreaming.

Another possible limitation was the recruitment method used. The researchers advertised the study via emails to university staff/students and local stakeholders (businesses, leisure and vocational/sports classes), and invited only respondents who had experienced lucid dreams. In terms of sample composition, this approach has typically produced large data that were commensurate with equivalent studies (see Dagnall et al., 2014; Dagnall N. et al., 2016, Dagnall et al., 2019). Furthermore, there is no reason to believe that these samples are not reflective of the general population. This is especially true as the constructs indexed were psychological rather than ability based. Restricting selection to respondents who had experienced lucid dreaming was a prerequisite of the study aim, specifically the intention to examine how experience of lucid dreaming related to dissociated experiences related to REM sleep, proneness to reality testing deficits, and paranormal experiences/beliefs. Although this approach reduced variability with correlations, it avoided conflation by including participants who had not experienced lucid dreaming. In the case of the focal variable, lucid dreaming intensity, this is a major concern since there is a discrete difference between experiencing (absence vs. presence) and level (low to high). Combing these elements in analysis has a distorting effect on intensity by drastically reducing mean values. Noting these concerns, succeeding research should attempt to replicate outcomes with different more heterogeneous samples, and compare experiencers vs. non-experiencers of lucid dreams on study variables.

Overall, the present study provides a firm foundation for subsequent work on dissociated experiences related to REM sleep. This could consider incidence alongside factors such as control, intensity and content. Research might also usefully examine cultural and age-related differences.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Manchester Metropolitan University Faculty of Health, Psychology and Social Care Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AD and ND focused theoretically, analyzed the data, and developed the article. KD collected the data and reviewed the draft.

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Dark Triad Traits and Sleep-Related Constructs: An Opinion Piece

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INTRODUCTION

Good quality sleep is vital to health and psychological functioning (see Steptoe et al., 2008). Indeed, insufficient sleep has a negative effect on chronic disease incidence and development (Perry et al., 2013). Alongside health implications, the investigation of sleep is important because it conceptually informs a range of academic disciplines (neuropsychology, physiology, psychology, etc.). Acknowledgment of these factors has stimulated research, which historically has identified sleep-related dissociative states (nightmares, dreams, etc.), and outlined factors that influence the timing, duration, and quality of sleep.

From a psychological perspective, investigators have placed great emphasis on examining relationships between sleep states, personality factors (e.g., Randler et al., 2017), and related constructs (e.g., creativity). However, relatively few studies have focused on lucid dreaming (LD) (e.g., Schredl et al., 2016).

LD is a distinct behavioral state characterized by awareness of dreaming during sleep, which involves the ability to control dream events, and/or purposefully awaken (Harb et al., 2016). Future individual differences research needs to consider LD since the phenomenon has important implications for models of human cognition. Explicitly, LD provides insights into the nature and constraints of consciousness, particularly the potential for reflective mindfulness (Kahan and LaBerge, 1994). Additionally, LD has useful applications for experiencers (solving waking problems, physical/mental healing, training motor skills, etc.) (Stumbrys and Erlacher, 2016), and possesses potential therapeutic benefits (e.g., reducing nightmare frequency) (Holzinger et al., 2015).

Even fewer studies in the domain of personality and individual differences research have examined relationships between LD and socially aversive traits (Marcus and Zeigler-Hill, 2015). This is an important research gap to bridge as interest in dark traits is ever increasing and related constructs (i.e., Machiavellianism, narcissism and psychopathy) possess characteristics, which are likely to affect lucid dreaming. In this context, the influence of the Dark Triad (DT) personality construct is fundamental (Paulhus and Williams, 2002). The recent emergence of work investigating associations between darker, social malevolent personality traits and variations in sleep-related behavior and states reflects this (e.g., Yang et al., 2019).

From this perspective, the DT is particularly important. The DT refers to three personality dimensions marked by manipulation and callousness: Machiavellianism, subclinical narcissism, and subclinical psychopathy (Jones and Paulhus, 2014). Machiavellianism denotes a calculative attitude encompassing the ability to control others, deception, self-centeredness and immorality. Although, individuals scoring high on Machiavellianism present as charming and impressive, these speciously "attractive" attributes mask propensity to hypocrisy, cynical worldview, and scheming.

Narcissism reflects a clash between grandiose identity and underlying insecurity that manifests as the need for constant ego-reinforcement (Jones and Paulhus, 2014). Several studies report the existence of two or more forms of narcissism (Miller et al., 2011). The most prevalent distinction being between grandiose and vulnerable. Grandiose comprises grandiosity, aggression and dominance, whereas vulnerable narcissism reflects a defensive and insecure grandiosity that obfuscates adverse cognitions, perceptions, and emotions (i.e., feelings of inadequacy, incompetence, and negative affect) (Miller et al., 2011).

Psychopathy indexes deficits in affect (i.e., callousness; disregard for others and lack of empathy) and self-control (i.e., impulsivity) (Hare, 1970; Cleckley, 1976; Lykken, 1995). Callousness is typically short-term. Hence, psychopaths lie for immediate rewards, even when this undermines their long-term goals (Paulhus and Williams, 2002). Thus, in the context of psychopathy, callous manipulation combines with immediate tendencies such as thrill seeking and recklessness to prompt related dispositions, and facilitate corresponding behaviors (Hare and Neumann, 2008). Authors often make a distinction between primary and secondary psychopaths. Historically, researchers have often linked primary psychopathy to genetic factors and secondary psychopathy to social factors (Skeem et al., 2007). Primary psychopaths are callous, calculating, manipulative, and deceitful, whereas secondary psychopaths share antisocial behaviors with primary psychopaths, but are remorseful and fearful (Sethi et al., 2018).

INDICATIVE RESEARCH

To explore further LD and individual differences, investigators need to consider the findings/scope of previous work. This has demonstrated that DT traits can influence sleep-related states/behavior and has produced theoretically important findings. For instance, Jonason et al. (2013) observed a link between "darker" DT elements (Machiavellianism, secondary psychopathy, and exploitive narcissism) and a night specialism (chronotype). This predisposes individuals toward optimal cognitive performance during the hours of darkness.

Additionally, Sabouri et al. (2016) found that Machiavellianism and psychopathy were associated with higher sleep disturbances, increased anxiety sensitivity, and greater intolerance of uncertainty. These outcomes aligned with previous research documenting relationships between negative affect and poor sleep (Whiteside and Lynam, 2001; Brand et al., 2016). Noting this, Sabouri et al. (2016) concluded that the association between DT traits and sleep disturbance arises from unfavorable cognitive–emotional processes. Specifically, rumination, poor coping strategies, and low emotion regulation. Relatedly, Yang et al. (2019) found Machiavellianism was directly associated with poor sleep quality, and indirectly associated via greater anger rumination. Additionally, primary and secondary psychopathy were indirectly associated with poor sleep quality via greater anger rumination. Secondary psychopathy had the strongest direct effect on poor sleep quality among the DT traits.

These findings were congruent with preceding studies reporting relationships between poor sleep, reduced emotion regulation (Brand et al., 2016), and lack of impulse control (Becker, 2014). In this context, LD may reduce negative emotions by allowing the dreamer to take control of the dream. Knowing that it is possible to govern dream content can facilitate the reduction of adverse affective content. Earlier work suggests that this can reduce distress within nightmares (Gavie and Revonsuo, 2010), and concomitantly lessen nightmare frequency and intensity, leading to better life quality during wakefulness (Soffer-Dudek, 2017).

DISCUSSION

Although studies examining relationships between sleep-related states and personality traits make important contributions to conceptual understanding of sleep, several methodological issues limit the generalizability of findings. For prospective research on LD and the DT to be effective, researchers need to acknowledge these concerns when designing studies, and discussing outcome implications.

A major limitation of previous work is that studies have typically used a cross-sectional method. This is where researchers collect data simultaneously, at one time point and/or within a brief duration (Levin, 2006). The cross-sectional method is criticized because responses represent only a "snapshot" of characteristics associated with the measured outcome at a particular point in time. Consequently, data provides only "estimates" of prevalence within populations. This explains why cross-sectional studies frequently provide limited correlation-based analysis and report weak correlations.

Even when researchers employ sophisticated analytical techniques, causation remains an issue. Particularly, it is difficult to conclude whether sleep-related experience/behavior derives from personality factors or causes enduring behaviors and perceptions. One potential remedy within mediation-based studies is reverse testing, where analysis compares the predicted model against an alternative. This statistically assesses whether the indirect effect of independent variable (X) on the dependent variable (Y) via the intervening factor (M) is significantly different from zero. Despite providing some indication of causality this approach is not always successful (Lemmer and Gollwitzer, 2017).

Another issue with cross-sectional studies is common method variance (CMV) (Chang et al., 2010). This denotes shared variance arising from the method used, rather than the constructs observed (Podsakoff et al., 2003). CMV creates false internal consistency, correlation arising from common context. This manifests as the tendency to respond consistently to unrelated items. Hence, one index of sleep may influence scores on another, or responses on DT factors. This is a major concern within sleep-related research because observed relationships are often weak, and CMV can inflate correlations (Lindell and Whitney, 2001). Thus, without safeguards there is an increased possibility of type 1 error. Studies can reduce the dangers of CMV by creating psychological distance between constructs, and by employing instructions that reduce social desirability effects and evaluation apprehension (Podsakoff et al., 2003). To guard against CMV, studies investigating relationships between LD and the DT should employ protocols that emphasize differences between constructs and response scales.

Furthermore, while repeated cross-sectional studies can enhance the reliability of findings, the cross-sectional approach still fails to control for the effects of unaccounted factors. One such variable, which investigators have frequently included in sleep-related research, is mental toughness. Mental toughness is a generic term that denotes enabling psychological resources that promote positive mental health and performance across a range of achievement contexts (Dagnall et al., 2019; Drinkwater et al., 2019). Noting this generality, Gucciardi (2017) defined mental toughness as "a state-like psychological resource that is purposeful, flexible, and efficient in nature for the enactment and maintenance of goal-directed pursuits" (p. 18).

Intervening constructs that influence relationships between sleep-related states and personality factors are problematic because they produce complex effects. For instance, greater mental toughness is associated with better sleep quality, shorter sleep onset latency, fewer awakenings, longer sleep duration, and reduced sleep complaints (Brand et al., 2014a,b). Additionally, higher levels of mental toughness correlate with positive psychological health outcomes (Gerber et al., 2018). Pertinently, mental toughness influences also DT traits. Particularly, Papageorgiou et al. (2019) observed that the subclinical narcissism to mental toughness pathway in their model predicted lower levels of psychiatric symptoms. Moreover, Papageorgiou et al. (2017) reported that mental toughness facilitated the development of the adaptive aspects of narcissism (e.g., coping behaviors).

Noting these factors, subsequent work on the relationship between LD and the DT should control for mental toughness, consider the role of moderating/mediating factors generally, and examine effects over extended periods using multiple time points. Although, multiple time point studies are prone to logistical difficulties (i.e., recruitment and retention) and expensive in terms of time and cost, they provide a nuanced understanding of how personality traits effect sleep-related measures over time (relationship stability).

Regarding LD, the use of standardized definitions and measurement indexes is vital to cross study comparisons. In the case of classifications, there exists significant variation across studies. For instance, while several use the Schredl and Erlacher (2004) conceptualization (e.g., Denis and Poerio, 2017), others employ different wording (e.g., Sestir et al., 2019), or have devised alternative measures (Aviram and Soffer-Dudek, 2018; the Frequency and Intensity Lucid Dream questionnaire, FILD).

Moreover, studies also index different aspects of LD. For instance, alongside prevalence and frequency (see Snyder and Gackenbach, 1988) papers often include measures of control and dream environment manipulation (Stumbrys and Erlacher, 2017). To ensure comparability it is important that researchers examining LD agree on standard operationalizations and indices. This is especially important when prior research is relatively limited as outcome variations resulting from different measurement instruments can produce conceptual fragmentation. This problem is not unique to LD. Indeed, work investigating other sleep-related states/behaviors draws on a range of measurement tools and indexes a variety of indicators. For example, there are multiple scales used to assess insomnia.

A further issue is that sleep-related studies regularly use self-report. Critics question the validity and accuracy of these because they assess psychological processes indirectly by drawing upon metacognitive insight and recall (Lance and Vandenberg, 2009). This leaves self-report measures vulnerable to subjective bias. Hence, it is advisable to corroborate LD self-report findings with objective indices.

Researchers examining the influence of the on sleep-related states/behavior need also to consider the role of DT sub-factors. Illustratively, Jonason et al. (2013) reported that only exploitive narcissism was associated with night specialism. Moreover, primary and secondary psychopathy have different relationships with anxiety-related constructs. Primary correlates negatively, whereas secondary is positively associated. This suggests that effects will vary as a function of DT factor type.

Finally, future studies need to establish cross-cultural, age and gender invariance. This will help to counter potential measurement bias. In the case of the Short Dark Triad (SD3, Jones and Paulhus, 2014), researchers report the instrument is invariant for language and culture (Pechorro et al., 2019). It is essential that investigators similarly evaluate sleep-related measures.

Addressing these issues will ensure that future research examining relationships between the DT and sleep-related measures generates more robust, convincing findings.

AUTHOR CONTRIBUTIONS

ND and AD: article development and composition. KD: draft review and creative oversight.

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On Moving the Eyes to Flag Lucid Dreaming

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Keywords: Lucid dream, REM (Rapid Eye Movement) sleep, scanning hypothesis, eye movement, dream imagery

INTRODUCTION

Lucid dreaming (LD) started to be scientifically investigated through instructing dreamers to move their eyes as soon as they become lucid (Hearne, 1978; LaBerge et al., 1981). LD signaling through pre-agreed eye movements (PAEM) is possible because eye muscles are exempt from the muscular atonia that accompanies REM sleep (Aserinsky and Kleitman, 1953; Jouvet, 1962). In addition, it is hypothesized that eye movements during REM sleep relate to dreaming imagery (Roffwarg et al., 1962); however, studies that compared the direction of eye movements with dream recall yielded inconsistent results (for review see Arnulf, 2011). Moreover, it is not yet clear whether it is physiologically possible to move the eyes consciously and voluntarily during a pure REM sleep episode, as required for the PAEM. Consistently, it was found that frontal gamma activity (∼40 Hz) increases during LD, suggesting that LD is a mixture of REM sleep and waking (Mota-Rolim et al., 2008; Voss et al., 2009). Besides, alpha bursts (∼10 Hz) were preliminary observed during some PAEM (Mota-Rolim, 2012), which suggests that, in these cases, the PAEM may be performed in a transition from REM sleep to waking. Finally, despite being the most used technique to record LD, there is still no consensus regarding how to apply the PAEM in the lab. In this article, I will delve into the issues of recording LD through PAEM.

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THE SCANNING HYPOTHESIS

The relation between eye movements during sleep and dreams was initially described by Aserinsky and Kleitman (1953), who observed that the sleeper eyes sometimes moved "rapidly, jerky, and binocularly symmetrical." These pioneer researchers also found that upon waking up sleepers during this period—named "rapid eye movement sleep," or "REM sleep"—most of them report dreams with intense visual imagery. Subsequently, in the first attempts to investigate the association between eye movements and dream imagery, it was observed a positive relation between the direction of rapid eye movements and gaze direction during the dream in 70–80%, as reported following awakenings (Dement and Kleitman, 1957; Dement and Wolpert, 1958; Roffwarg et al., 1962). These results gave rise to the "scanning hypothesis" (Roffwarg et al., 1962), which postulates that the eye movements during sleep are directed by the dream imagery, in a comparable way as during the waking state, in which the eyes move toward scanned objects (for comprehensive reviews, see Arnulf, 2011; and Hong et al., 2018). Based on these findings, and on the fact that during REM sleep the limb—but not eye—muscles are atonic, Hearne (1978) and LaBerge et al. (1981) developed the PAEM technique aiming to objectively record LD in the laboratory.

Studies that Corroborate the Scanning Hypothesis

Physiological Conditions

After the first studies that gave rise to the scanning hypothesis (Dement and Kleitman, 1957; Dement and Wolpert, 1958; Roffwarg et al., 1962), it was found a positive relationship between gaze direction subjectively experienced during LD and the actual eye gazes objectively measured (Tholey, 1983). A subsequent study investigating non-LD found similar results (Herman et al., 1984). More recently, LaBerge et al. (2018) reported that the eye movements during tracking of a target during lucid REM sleep are similar to those of waking perception (sustained smooth pursuit) and different from those of visuomotor imagination (saccadic eye tracking). Since perceiving, imagining, and dreaming activate the same brain areas for a given sensory modality (Farah, 1988; Ishai and Sagi, 1995; O'Craven and Kanwisher, 2000; Siclari et al., 2017), LaBerge et al. (2018) argued that during dreaming (but not during imaging) there are both low competition among sensory inputs and high activation in extrastriate visual cortices. Thus, the experience of image vividness is similar to waking perception and activates the primary pursuit temporal pathway that drives the related motor regions of the cerebellum (Krauzlis, 2004). LaBerge and colleagues also found that subjective eye gazes during LD are associated with corresponding rotations of the eyes, supporting the scanning hypothesis. However, not all rapid eye movements would track the dream imagery, thus they consider that there are multiple sources of eye movements in REM sleep, and only a fraction of them scans dream images.

According to Jouvet (1967), there is a close temporal relationship between the rapid eye movements and a phasic activity that starts in the pons, then propagates to the lateral geniculate nucleus until it reaches the occipital region. These ponto-geniculo-occipital (PGO) waves were first described in cats (Jouvet et al., 1959) but exist in other mammals including macaques and baboons (Datta, 1997). Interestingly, REM sleep amount (out of total sleep time) varies considerably among terrestrial mammals: approximately 56% in the platypus, 40% in ferrets, 23% in humans, 18% in cows, and 3% in the mongoose lemur (the lowest REM sleep amount of all) (Madan and Jha, 2012). In humans, Miyauchi et al. (2009) observed an activation of the primary visual cortex associated with the rapid eye movements, which suggests the existence of PGO waves in our specie, and a link between PGO spikes, rapid eye movements and the visual aspects of dreaming.

Pathological Conditions

Subjects with REM sleep behavior disorder have no muscle atonia during REM sleep, and their dream reports are congruent with the abnormal behaviors (Schenck et al., 1986). When their rapid eye movements accompany a goal-oriented behavior (e.g., climbing a ladder), 90% of the cases were related to their action (Leclair-Visonneau et al., 2010), which supports the scanning hypothesis.

Studies That Do Not Corroborate the Scanning Hypothesis

Physiological Conditions

After the pioneer works that compared the direction of eye movements during REM sleep with gaze direction in the dream (Dement and Kleitman, 1957; Dement and Wolpert, 1958; Roffwarg et al., 1962), two studies yielded inconsistent results, with a concordance rate varying from 9 to 32%, which was below chance (Moskowitz and Berger, 1969; Jacobs et al., 1972). In addition, some subjects awakened during phasic REM sleep (defined by rapid eye movement bursts) do not report dreaming (Siclari et al., 2013). Moreover, visual dreams are reported during both REM sleep with no rapid eye movements (tonic REM sleep) (Foulkes and Pope, 1973; Hobson et al., 2000; Hodoba et al., 2008) and non-REM sleep (Cavallero et al., 1992; Fosse et al., 2001; Mota-Rolim et al., 2015; Siclari et al., 2017). Additional studies in other animals also do not corroborate the scanning hypothesis. In monkeys, for example, Zhou and King (1997) found that some binocular rapid eye movements are not conjugated, that is, they do not move toward the same direction and thus lack a fixation point, which would prevent these eye movements to "watch" dream images.

Pathological Conditions

Despite the fact that congenitally blind individuals do not experience "visual" dreams and display rapid eye movements (Gross et al., 1965; Kerr et al., 1982), a recent work found that the frequency of their gazes is reduced and bears no relation with dream content (Christensen et al., 2019). In cats, when the visual cortex is removed the rapid eye movements are preserved (Jouvet, 1962), and the PGO waves, which may induce the formation of the images and other visual aspects of dreams, are generated simultaneously and in parallel with the rapid eye movements (Vanni-Mercier and Debilly, 1998).

LUCID DREAMING AS A REM SLEEP TO WAKING TRANSITION

In addition to the controversies surrounding the scanning hypothesis, it is unclear whether the eyes can be moved—in a voluntary and conscious way—within REM sleep, that is, without arousal or waking features. For example, the alpha rhythm power (∼10 Hz) increases during LD (Ogilvie et al., 1982; Tyson et al., 1984; Mota-Rolim et al., 2008), but alpha oscillations are associated with waking state with eyes closed (Berger, 1929; Adrian and Matthews, 1934). Similarly, frontal gamma power (∼40 Hz) increases during LD (Mota-Rolim et al., 2008; Voss et al., 2009), which suggests that LD is a mixture of REM sleep and waking consciousness. This supports the finding that the brain mechanisms that underlie the eye movements during sleep differ from those during wakefulness (Abe et al., 2008). In fact, frontal association areas control the eye movements during waking (together with other regions of the cingulate and parietal cortices) (Johnston and Everling, 2008), but during REM sleep these frontal areas are hypo-active (Maquet et al., 1996).

Furthermore, bursts of alpha activity during some PAEM were preliminary observed (Mota-Rolim, 2012). These alpha bursts occurring during REM sleep without muscle tone modification are classified as micro-arousals (Cantero and Atienza, 2000; Cantero et al., 2000). This suggests that, at least in some cases, the PAEM may be performed in a micro-arousal, i.e., a transitional phase from REM sleep to waking, and not within a pure REM sleep state. This may happen mainly for the naïve lucid dreamers—i.e., those who do not experience LD frequently, and who represent the vast majority of lucid dreamers. These subjects often report that they wake up as soon as they try to perform the PAEM, as if the required mental effort would induce a micro-awakening or a more superficial sleep. They also tend to wake up right after becoming lucid and have less control over the oneiric content (Mota-Rolim et al., 2013). On the other hand, Rak et al. (2015) found that narcoleptic patients—who experience fast transitions between waking and sleep—have more LD than the general population, and the mental effort needed to achieve and sustain a lucid REM sleep might be lower in these patients (Dodet et al., 2014). In a similar way, experienced lucid dreamers—a minority of people who have LD very often—have longer and more stable LD, as well as higher control over the dream content. In these people, LD may happen during a steady REM sleep state. Noteworthy, since recording LD is complex and costly, most sleep labs investigate experienced lucid dreamers, which increases the chance to successfully record an LD (but usually at the cost of small sample size). Besides, transferring these lab results to the general population (i.e., naïve lucid dreamers) should be done with caution.

TOWARD A STANDARDIZATION OF THE PAEM

The PAEM technique to flag LD during REM sleep has been widely used in physiological (LaBerge et al., 1981; Brylowski et al., 1989; Mota-Rolim et al., 2010; Dresler et al., 2012), pathological (Tang et al., 2006; Dodet et al., 2014; Oudiette et al., 2018), and artificial (Stumbrys et al., 2013; Mota-Rolim et al., 2019) conditions. Additionally, LD flagged by PAEM has also been described during non-REM sleep stages N1 (sleep onset) and N2 (superficial sleep) (LaBerge, 1980; Stumbrys and Erlacher, 2012; Mota-Rolim et al., 2015), but not during N3 (deep sleep).

Despite being the most used technique to record an LD, there is still not a consensus about how exactly PAEM should be applied, which resulted in several variations of the method, regarding mainly: (1) the number of eye movements, (2) the amount of series of eye movements, (3) the way these movements should be performed, and (4) when they should be performed. Below I detail each of these four points and suggest ways to standardize them for future studies.

1) The number of eye movements: Even though the involuntary eye movements of REM sleep being isolated, it is common to observe bursts of 2 to 5 consecutive eye movements (Arnulf, 2011). This happens especially in the elderly (Ficca et al., 1999), and resembles the PAEM. Thus, the minimum number of eye movements required to differentiate the voluntary ocular gazes from the involuntary ones that characterize REM sleep would be 6 (Mota-Rolim, 2012).
2) Amount of series of eye movements: Dreamers could also be instructed to perform more than one series of PAEM, for example, the first series when they realize that they became lucid, and another series when they believe they are close to waking up. This would improve the technique, and consequently strengthen the reliability of the study.
3) How the eye movements should be performed: While most LD researchers instruct dreamers to shift their gaze laterally (Mota-Rolim et al., 2008; Voss et al., 2009; Dresler et al., 2012), others instruct to "scan the horizon" from left to right (Dodet et al., 2014). As a way to standardize the PAEM technique, LD researchers can follow the instructions suggested by Baird et al. (2019) (adapted from LaBerge et al., 2018), which require asking the dreamer to move the eyes all the way to the left and then to the right (as if looking at each of the ears) through a continuous movement without pausing.
4) When the eye movements should be performed: In addition to during dreaming, this technique could also be practiced during the waking state (with eyes open and closed) before starting the experiment, which constitutes a valuable opportunity for researchers to view the fingerprints of each individual and also provide feedback.

CONCLUSIONS

Despite some studies have found a relation between subjective eye movements that would scan the dream scenes and actual eyeball rotations during REM sleep, the scanning hypothesis is still controversial. More studies are also necessary to clarify whether the PAEM are realized during a pure REM sleep episode, or else mixed with (micro)-arousal/waking, especially in naïve lucid dreamers. Finally, since the PAEM constitute the most used method to scientifically study LD, a consensus on how to apply this technique in a standardized way is clearly warranted.

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The author confirms being the sole contributor of this work and has approved it for publication.

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OPINION
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Dreams and Dissociation—Commonalities as a Basis for Future Research and Clinical Innovations

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Dissociative symptoms refer to a spectrum of non-ordinary disruptive experiences from "zoning out," to out-of-body experiences, to outright distortions in the fundamental sense of self, with Dissociative Identity Disorder (DID) as its most debilitating manifestation (Holmes et al., 2005). Dissociative symptoms range from 1 to 3% among general population and from 4 to 14% among psychiatric patients (Sar, 2011). In psychiatric patients, dissociative symptomatology can have a serious impact. Mean impairment scores of patients with dissociative disorders on measures of psychosocial, occupational, and interpersonal functioning are >50% higher than those of patients with other mental disorders (Mueller-Pfeiffer et al., 2012), and dissociative symptomatology is strongly related to self-harm and multiple suicide attempts (Foote et al., 2008). Relative to 17 other mental disorders, patients with dissociative disorders consumed the highest number of outpatient therapy sessions (Mansfield et al., 2010). Importantly, although dissociative symptoms are most salient and persistent in dissociative disorders such as DID, they are considered transdiagnostic phenomena and comorbid with many other conditions (e.g., psychotic illness, anxiety, depression).

No evidence-based treatment consensus exists for dissociative disorders due to lingering controversies. Two perspectives, the trauma model and sociocognitive model, have vied for acceptance and empirical support over decades. The trauma model posits a causal relation between trauma and dissociative symptoms (Dalenberg et al., 2012; Vissia et al., 2016). Accordingly, dissociation is viewed as a coping mechanism triggered by childhood trauma in which distinct personality states, for example, arise to detach from emotionally overwhelming memories (Van der Hart et al., 2006).

In contrast, the sociocognitive model contends that dissociative symptoms are shaped by social learning and cultural expectancies regarding clinical features of dissociation, as portrayed by media and reified by inadvertent therapist cueing. The model assumes that vulnerable patients come to adopt a narrative of being populated by distinct selves to explain mood swings, impulsive actions, and other puzzling behaviors (Lynn et al., 2019). Rapprochement between these models is needed and could be facilitated by fundamental research that clarifies antecedents and correlates of dissociation, including co-occurring sleep problems, that would potentially facilitate treatment consensus and innovation.

DISSOCIATION AND SLEEP

Previous studies have secured moderate-to-high correlations of dissociative symptoms with sleep disturbances as well as provided evidence for disturbed sleep playing a causal role in dissociative symptoms (Watson, 2001; Van der Kloet et al., 2012a; Merckelbach et al., 2017; Schimmenti, 2017): Whereas sleep loss induces dissociative symptoms (Van Heugten – Van der Kloet et al., 2015) sleep improvement, in contrast, reduces dissociative symptoms (Van der Kloet et al., 2012a), indicating an association of a labile sleep-wake cycle with both acute and chronic sleep disturbances and dissociative symptoms among healthy and clinical populations.

An important theoretical and research question is whether dissociative symptoms, which range on a continuum of severity, are triggered by disruptions in memory and metacognitive processing that occur during sleep states, with disruptions during REM sleep of particular relevance, that carryover to waking life. When sleep and dream systems become impaired, memory processes during (REM) sleep become dysregulated and engender information overload from internal and external sources that (a) overwhelms cognitive processing, (b) impairs integration of self-relevant information and memories, and (c) induces dissociative symptoms, which are potentially manifested in fragmented (i.e., dissociated), dream-like mentation, illusions, delusions, memory distortions, and, ultimately, a disturbed sense of self (McNamara, 2013). Dreamlike phenomena, which are ordinarily confined to sleep, thus intrude into waking consciousness and are expressed as dissociative symptoms, including depersonalization and derealization, and, in the extreme case, identity fragmentation evident in DID.

CONSCIOUSNESS AND DREAMING

Conscious states may be defined as representations of brain states that arise as a function of shifting dynamics of large-scale neuronal networks (Freeman, 2000; Varela et al., 2001; Bob and Louchakova, 2015). (Libet, 2006) posited that subjective experience is represented in the brain by synchronized activities of large numbers of neurons, referred to as a "cerebral mental field." This conceptualization affords description of subjective experiences in terms of constantly morphing brain activation patterns that not only generate consciousness via intricate feedback loops, but consciousness, itself, reciprocally affects brain dynamics. Neural systems thus create mental representations of perception, cognitive functioning, memory, and consciousness more broadly (Freeman, 2000; Singer, 2001). Interestingly, stressful experiences can affect the neural mechanisms that enable integration of contents of consciousness, potentially fueling dissociation of conscious awareness and memory (Bob, 2003; Spiegel, 2012) and disrupting sleep.

What is the role of dreams in processes related to dissociation (failure to integrate mental content into conscious awareness), defined conventionally as: "a disruption of and/or discontinuity in the normal, subjective integration of one or more aspects of psychological functioning, including—but not limited to—memory, identity, consciousness, perception, and motor control" [DSM-5; American Psychiatric (American Psychiatric Association., 2014)]. Dissociative states not only occur during wakefulness among healthy individuals and those with mild dissociative symptoms, but they are also manifested during dreams, typically related to shifts in dream scenes and particularly during nightmares and recurrent dreams (Hartmann, 1998; Bob, 2004; Schonhammer, 2005). Among 43 patients diagnosed with dissociative identity disorder (DID), 57% indicated that their "alter personalities" presented as dream characters in their dreams (Barrett, 1994). Dream characters can be viewed as hallucinated projections of the fragmented self; dreaming, in turn, may reflect dissociative states represented during memory processing in REM sleep (Bob, 2004; Stickgold and Walker, 2005).

In contrast with the synchronized activity of large groups of neurons in the "cerebral mental field," in some states of consciousness, such as dreaming, meditation, divergent thinking, and dissociative states, neural network patterns may function in a more chaotic, unstable, and non-linear fashion (Kahn and Hobson, 1993; Bob, 2003) in which a small perturbation in the system can resonate and induce large changes in the system's behavior (Bob and Louchakova, 2015). For example, flexibility of mental processes facilitates generating patterns that create the subjective experience of coming up with "novel" ideas (Freeman, 2000). During chaotic brain states, activities usually take place in various regions of the brain acting simultaneously but independently. When the strength of the associations and information processing systems among these regions is greatly attenuated or impoverished and mental contents become fragmented and disorganized, dissociated mental states may arise (Bob, 2003). The sudden transitions of dream objects and sceneries experienced in dreams, may reflect dissociation related to rapid shifts in neural patterns related to chaotic or—as they are also called—self-organizing neural activities, mainly stemming from the pontogeniculo-occipital (PGO) systems in the brain (Kahn and Hobson, 1993).

LUCID DREAMING

A particular type of dreaming may be of special interest in this respect: lucid dreaming. According to Voss and Hobson (2014), insight, control, and dissociation represent the defining criteria for lucid dreaming. Insight refers to metacognitive reflective thought, i.e., the dreamer is aware that she is dreaming, and it is considered the core criterion. Control allows the dreamer to change the dream plot, and dissociation happens when the dreamer experiences the dream as feeling unreal (similar to waking derealization) or sees herself from a distance [similar to waking depersonalization; (Voss et al., 2018)]. This third person perspective can also entail the dream experience itself. Dreamers then experience the dream sequence from the outside, as if the dream were a movie. By this definition, lucid dreaming can be viewed as "a dissociative mental state of consciousness in which the dream self separates from the ongoing flow of mental imagery." (Voss et al., 2018, p.3). However, in lucid dreams a sense of reality or awareness of dreaming is superimposed on the "unreality" of the dream, whereas in depersonalization/derealization, a sense of unreality is superimposed on the "reality" of mundane waking existence. Thus, in lucid dreams meta-consciousness is preserved to a greater extent than in non-lucid dreams, whereas in depersonalization/derealization, meta-consciousness of the self and the surround is compromised relative to everyday normative experiences. These differences between lucid dreaming and dissociative experiences might explain why the correlation between measures of lucid dreaming and dissociation, while statistically significant, is weaker than the correlation between unusual sleep experiences (e.g., sleep paralysis, hypnagogic hallucinations, nightmares) and dissociation (Van der Kloet et al., 2012a). We suggest that such "dream-like" experiences infiltrate waking consciousness to create an experience of unreality that is expressed as dissociative experiences and symptoms.

Can dissociation be experienced as beneficial? Dissociation is usually transient during waking and associated with daydreaming and fantasy proneness in healthy adults (Van der Kloet et al., 2012b), at the mild end of the dissociation continuum. In the context of psychiatric diagnoses, some theorists have described dissociation as a protective mechanism to cope with emotional pain in posttraumatic stress disorder via downregulation of the limbic system, thereby suppressing unconscious affect (Lanius et al., 2010) and enabling self-conscious emotions via activation of the ventral prefrontal cortex [VPFC; (Damasio, 1988)]. In psychosis, dissociation is often undesirably associated with positive symptoms. However, Dalle Luche (2002) advanced a nuanced view by proposing that dissociative thought is more fleeting in the early stages of psychosis, whereas the loss of a sense of self is more prominent in the later stages of illness. Viewed in this light, dissociative cognition in lucid dreaming mirrors the type of dissociation experienced in the early stages of psychosis. Although attempts to control dream content can disturb sleep, an increase of lucid dreaming and accompanying dissociative thought may also be desirable as the heightened insight/meta-consciousness may be associated with a weakening of psychosis-like experiences. In general, lucidity in dreaming has been linked with positive rather than negative emotions. In normal REM dreaming, due to attenuation of the VPFC, unconscious emotions take the stage. In lucid dreaming, with the VPFC switched on again, self-conscious emotions take the lead and unconscious emotions are down-regulated. This process engenders an overall reduction of emotionality compared with regular dreams (Voss et al., 2018). Indeed, dissociative thought seems to down-regulate negative emotion both in dreaming as during wake (LaBerge and Rheingold, 1991; Voss et al., 2013), with parallels in lucid dreaming and psychiatric illness [but see (Mota et al., 2016)].

FODDER FOR FUTURE

Our discussion implies that it is possible to enhance insight and meta-consciousness via lucid dreaming in patients suffering from psychiatric disorders such as in dissociation and psychotic illness, in order to reduce negative emotions. Training the frontal lobe explicitly to create insight in the delusional feature of a dream may provide a foundation of enhancing reflective thought during the daytime as well. Indeed, researchers have piloted lucid dreaming as a clinical treatment in various groups with mixed results (Spoormaker and Van den Bout, 2006; Lancee et al., 2010). However, we suggest that therapists make explicit the purpose of enhancing meta-consciousness across the entire sleep-wake continuum to enhance generalizability of outcomes across the sleep/wakefulness spectrum and continuum of severity of dissociative symptoms. Notably, researchers have successfully treated patients with dissociative identity disorder with transdiagnostic interventions geared to improve sleep, enhance meta-consciousness, and emotion regulation, and decrease fragmentary, hyperassociative thinking that marks both dissociative conditions and dream consciousness (Mohajerin et al., 2019).

Treatment costs of patients with dissociative psychopathology are very high, while psychological interventions are generally not evidence-based and innovative treatments stagnate due to lingering controversies across theoretical camps. This state of affairs also impacts innovation in treating psychiatric conditions (e.g., PTSD, borderline personality disorder, schizophrenia spectrum disorders) with high comorbidity with dissociative conditions [see (Lynn et al., 2019)]. Moreover, dissociative comorbidity is a severity marker signaling poor prognosis.

As ineffective and non-optimal treatments impose considerable burdens on patients and society, novel research programs focusing on the relations among dissociation, the sense of self, and sleep and dreaming are a priority. Studying both the chaotic and the deterministic brain state during sleep and wakefulness may provide insight into important functions of perception, memory, and cognition and what happens when they become dissociated. In doing so, the study of dissociation may provide important clues regarding the nature of human consciousness itself. Importantly, this effort will inform clinicians and researchers alike and serve as an impetus for new treatment studies, including research evaluating interventions targeting dissociative psychopathology via enhancing sleep and metacognitive processing.

AUTHOR CONTRIBUTIONS

DH wrote the original version of the manuscript, which was edited by SL.

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Is There a Link Between Frequency of Dreams, Lucid Dreams, and Subjective Sleep Quality?

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A lucid dream is a dream in which one is conscious of dreaming and can possibly control the dream or passively observe its unfolding. Frequencies of lucid dreaming (LD), dream with awareness, and dream with actual control were previously investigated in a French student population. As a student population usually differs on oneiric and sleep characteristics (such as sleep quality) from the general population, more investigations were needed. Additionally, it is yet unresolved if LD is related to one's overall sleep quality. This study aims at describing and comparing dream experience frequencies (dream, lucid dreams, awareness, and control) and sleep quality assessed with the Pittsburgh Sleep Quality Index (PSQI) among students ($n = 274$) and in a general population sample ($n = 681$). It also aims at evaluating if dream experience frequencies can predict sleep quality across these two samples. Predictive models of PSQI score controlling for age and gender were not significant in the student group while they were all marginally predictive for the general population. However, none of these models showed that the frequency of dream experiences could actually help predict the quality of sleep as the significance of the model was carried over only by the gender variable. These results are discussed in line with previous studies on LD frequencies. Several methodological adjustments for future study are proposed.

Keywords: dreaming, lucid, consciousness, frequency, prevalence

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INTRODUCTION

Lucid dreaming (LD) is defined as a dream in which the dreamer, while dreaming, is aware that he or she is dreaming. In such a dream, the dreamer has the possibility to control the dream content or to observe the dream unfold passively (Schredl and Erlacher, 2004). A definition of LD has gained popularity in the scientific literature over the last two decades that stipulates that "*In lucid dreams, one has awareness that one is dreaming during the dream. Thus it is possible to wake up deliberately, or to influence the action of the dream actively, or to observe the course of the dream passively*" (Schredl and Erlacher, 2004).

Lucid dreaming can be apprehended in different ways. For instance, LD can be conceived as a hybrid state of consciousness in which subjective experience is seen as similar to wake like functioning while the dreamer remains asleep. The extents of this theory are that insight (awareness) concerning the dream state and volitional control are features of wake functioning and therefore the sign of an atypical functioning when occurring in dreams (Voss et al., 2009). Within the context of this conception, LD is considered as an abnormality which is a consequence of a shift in brain activity that alters normal REM sleep toward waking functioning (that feature insight and ego) while the dreamer still exhibits atonia and rapid eye movement burst (Voss et al., 2009, 2015). The hybrid theory has recently been put forward to posit that an increased frequency of LD could potentially dysregulate sleep and have an incidence on one's sleep quality (Vallat and Ruby, 2019). This conception has evolved progressively in favor of other views that invite to consider more contrasts or gradations between states of consciousness (see for instance the Space of Consciousness Model from Voss et al., 2015). The continuum perspective is another way to consider LD in which awareness or control are not specifically attributed to wake or dream-like functioning (Stumbrys, 2011). In such conception, the heightened REM brain activity that is shown when one is LD presents no strong rationales to unfavorably influence typical sleep quality.

The main question that will be addressed in this study is the existence of an influential link between the frequency of dream experiences and the overall sleep quality. Determining the existence of a detrimental or beneficial effect of LD on sleep quality can provide information about what it is and how it should be addressed when evaluated in our research. Previous studies have obtained results concerning this relation between LD and sleep parameters. For example, Denis and Poerio (2017) investigated LD in an online survey based on a large population sample (18–82 years, n = 1,928). Their results have highlighted correlations between LD and sleep paralysis episodes. No more correlation between LD and the other sleep quality parameters evaluated with the eight-item Sleep Condition Indicator (SCI) were found (Espie et al., 2014; Denis and Poerio, 2017). Alternatively, a psychology student-based sample (n = 187, 73% women) proposed two questionnaires and a sleep diary across a period of 2 months (Aviram and Soffer-Dudek, 2018). LD frequency obtained using a 5-item scale in the first questionnaire was weakly (r = 15) associated to a poorer sleep quality as reported by the global sleep assessment questionnaire (Aviram and Soffer-Dudek, 2018). Specifically, only the frequency of deliberate attempts to experience the lucid dream state (through techniques designed to increase the likelihood of LD) was associated with a sleep problem among the five items (momentary frequency, prolonged frequency, spontaneous frequency, frequency of attempt, and frequency of success). In another study, the relationship between LD frequency and sleep quality was investigated in two samples: students (n = 442) and general population (n = 1,380) (Schadow et al., 2018). In this study of Schadow et al. (2018), sleep quality was assessed over the course of 2 weeks for the student sample. A composite score on the perceived quality of sleep was calculated on 11 items based on the SF-B sleep questionnaire (Görtelmeyer, 1986, cited in Schadow et al., 2018). For the general population group, perceived sleep quality was assessed using a general questionnaire based on the last month. LD frequency was calculated using the same LD scale as the one in the present study in the two groups. LD was related to a poorer sleep quality in both groups, but this relation disappeared when controlling for nightmare frequency. Finally, a recent diary study performed for 5 weeks that included 149 participants showed that having a lucid dream during a night can be correlated with a higher feeling of being refreshed at wake, contrasting the view of LD as detrimental (Schredl et al., 2020).

Considering these contrasted results, pursuing these investigations of how LD influence sleep quality is a necessity. For this aim, general sleep quality characteristics can be assessed by subjective reports using the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The PSQI could be valuable as it investigates sleep quality over the last month and propose a score calculated over seven components (sleep latency, sleep duration, sleep efficiency, sleep disturbances, medications, and daytime dysfunction). Concerning dream experiences frequencies (typical dream, lucid dream, dream with awareness, and dream with control), a previous study revealed that they are susceptible to relate differently with sleep characteristics, precisely parasomnias correlated with dream control frequency only when these correlations were not found for LD evaluated with a definition or with the question of dream awareness (Ribeiro et al., 2016). Thus, relying on the same methodology for assessing dream experience frequencies as the aforementioned study could reveal a specific relationship with sleep quality that would not have been apparent otherwise. Comparing these two sample types should be done while controlling for age and gender as these factors are supposed to influence dream frequency and sleep quality (Schredl and Reinhard, 2008).

There are few up-to-date investigations of sleep quality and dream experience frequencies among French students; a previous study was performed on 1,137 students (Vallat et al., 2018). The students who were selected in the study of Vallat et al. (2018) were those who did not report any sleep disorders; as a consequence of this selection, the sleep quality possibly have been overestimated and it could be a need to extend such type of study to a more open to everybody sample without any precise inclusion criteria. To our knowledge, there are no studies describing and comparing the results of dream experiences frequency and sleep quality obtained with French students and with a general population sample using the same methodology. However, college students commonly exhibit sleep difficulty singularities in terms of subjective sleep quality (Lund et al., 2010; Lopes et al., 2013). Defining sleep quality on French students is of high importance as, for instance, it could be informative in terms of prevention strategy.

In another scope, continuing to define what LD is and how it is represented in different populations remains critical given its significance for the understanding of consciousness (Noreika et al., 2010). To our knowledge, it is not yet known what causes the difference in the frequency of dream experiences observed in several studies (see Table 1 on Ribeiro et al., 2016); therefore, using an unselected general sample to complete observation previously made on students is of importance.

The aim of the present study is to evaluate if dream experience frequencies (dream, lucid dreams, awareness, and control dreams) are related to subjective sleep quality (assessed with a total score of the PSQI). Within this scope we will describe dream experience frequencies and subjective sleep quality. In light of previous study, we hypothesize that sleep quality will be influenced marginally by atypical dream experiences frequencies.

MATERIALS AND METHODS

Participants

Two samples of French participants were included in this study (final sample $n = 955$). The student sample was recruited using the university's online communications and social networks. They were 274 (219 women) undergraduate students with a mean age of 21.33 ± 3.27 years ranging from 19 to 52 years. The population-based sample was recruited using online communication and the university students relayed the call for participation. No selection criterium was indicated. They were 681 with a mean age of 34.63 ± 15.56 years ranging from 19 to 89 years. There were 400 women and 241 men. Both groups completed the questionnaire from January to February 2020. Out of 1,054 participants, 99 were excluded from analysis as participants indicated "No" or "Rather not" to the following question: "*Does this questionnaire contain answers that reflect (your) actual reality?*"

In a study investigating subjective sleep parameters, the gender factor can rationally be supposed to influence the results (Schredl and Piel, 2003; see Schredl and Reinhard, 2008). Dream experiences frequencies and score of the PSQI have been compared across genders. In the student group, comparison was significant for dream recall frequencies ($p = 0.018$). In the general population, the comparison was significant for dream recall frequency as well ($p = 0.004$) and total score of the PSQI ($p < 0.001$). These two comparisons were still significant ($p < 0.001$) when using age as a covariate, as age is also a common factor to control in dream studies (Nielsen, 2012). As a consequence, every comparison made in the "Result" section will be controlled for gender and age. All of the variables in this study were compared between groups, this comparison is available in **Supplementary Materials**.

This study was carried out within the framework of French legislation on ethics and data protection. All participants completed a separate consent form that guaranteed anonymity, informed them of the scope of the study and the possibility of stopping it at any time.

TABLE 1 | Descriptive data for all dream-related experiences frequencies.

	Student $n = 274$		General pop. $n = 681$	
	Counts	Percentage	Counts	Percentage
Dreaming				
Less than once a month	23	8,39	163	23,94
Once a month	30	10,95	72	10,57
Two or three times a month	28	10,22	100	14,68
Once a week	55	20,07	117	17,18
Two or three times a week	83	30,29	143	21
Four or more times a week	55	20,07	86	12,63
Lucid dreaming				
Never	99	36,13	344	50,51
Less than once a year	43	15,69	80	11,75
About once a year	25	9,12	51	7,49
About 2 to 4 times a year	48	17,52	98	14,39
About once a month	25	9,12	43	6,31
About 2 to 3 times a month	17	6,2	36	5,29
About once a week	12	4,38	12	1,76
Several times a week	5	1,82	17	2,5
Dream with awareness				
Never	55	20,07	185	27,17
Once	25	9,12	70	10,28
Less than once a year	45	16,42	107	15,71
Many times a year	63	22,99	107	15,71
Many times a month	26	9,49	51	7,49
many times a week	60	21,9	161	23,64
Dream with control				
Never	391	44,53	122	57,42
Once	45	8,39	23	6,61
Less than once a year	83	13,5	37	12,19
Many times a year	55	14,6	40	8,08
Many times a month	25	4,01	11	3,67
Many times a week	82	14,96	41	12,04

Material

Participants were requested to fill in a 150-question composite questionnaire online based on the study of Ribeiro et al. (2016). Only questions pertaining to this study are addressed in the following section.

Participants' demographics and characteristics included gender and date of birth. The question concerning occupation concerned whether the participant was a student or not, and if they felt like their sleep schedule was constrained by their daily activity. The wording of this yes/no explorative question was "Do your professional, associative or domestic activities require you to go to bed or get up at specific times?"

In order to assess sleep quality, we used the PSQI total score which is based on 17 questions that evaluate seven components labeled as follows: sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, medications, daytime dysfunction (Buysse et al., 1989; Léger et al., 2006). The PSQI is the most commonly used generic measure in clinical and research setting and has been demonstrated to have an adequate content validity, a good construct validity and a good discriminative validity (Mollayeva et al., 2016).

In the questionnaire, four questions on dream experiences concerned dream frequency, LD frequency, dreams with awareness frequency, and dreams with control frequency. These questions were reformulated in order to ensure a good comprehension in French language but were conceptually similar to those typically used in the literature (Stepansky et al., 1998; Watson, 2001; Fassler et al., 2006; Soffer-Dudek et al., 2011).

The wording of the dream frequency question was: "*In the past 6 months, how often have you been able to remember at least one of your dreams when you woke up?*" (0 = Less than once a month, 1 = Once a month, 2 = Two or three times a month, 3 = Once a week, 4 = Two or three times a week, and 5 = Four times a week or more).

The LD frequency question was preceded by a definition of LD: "*During* LD, *one is – while dreaming – aware of the fact that one is dreaming. It is possible to deliberately wake up or to control the dream action or to observe passively in the course of the dream with this awareness.*" The question was "*Referring to the definition below, how often have you experienced* LD?" (0 = never, 1 = less than once a year, 2 = about once a year, 3 = about 2–4 times a year, 4 = about once a month, 5 = about 2–3 times a month, 6 = about once a week, 7 = several times a week). The definition and frequency scale were extracted from Schredl and Erlacher (2004).

Awareness and control were both evaluated on the same 6-point rating scale (0 = never, 1 = once, 2 = Less than once a year but more than just once, 3 = many times a year, 4 = many times a month, 5 = many times a week). For awareness the wording of the question was "*While dreaming, have you ever been aware that you were actually dreaming?*" and to control the wording was "*While dreaming, have you ever been able to control the content of your dream?*"

The order of the questions concerning LD, awareness, and control was proposed in two versions (the question of LD was presented after or before the two questions on awareness and control). The original French wording for all questions are accessible as **Supplementary Material** of the present article.

Procedure

By clicking on the hyperlink associated with the recruitment text, participants were redirected to the questionnaire hosted on a Google form. Once the questionnaire was completed, all responses were entered into an online spreadsheet and transferred to an Excel spreadsheet where duplicate data were excluded. During pretest, the estimated time for completing the questionnaire was 20 min or more. All statistics were performed using R and/or Jamovi (Fox and Weisberg, 2018; R Core Team, 2019; The jamovi project, 2020).

RESULTS

Results are presented aligned with our aims: description of the results, investigation of how dream experiences could be related to sleep characteristics as assessed by the PSQI, and sample comparison on each indicator of the present study.

All comparisons considered the effect of age and gender as these factors are known to potentially influence dream frequency (Schredl and Reinhard, 2008). All of the variables in this study were compared between groups, this comparison is available in **Supplementary Materials**.

Descriptive Data on Dream Experience Frequencies and Sleep Characteristics

Summarized answers to questions about the frequency of dream experiences (frequency of dreaming, LD, consciousness, and control) are available in **Table 1**.

Summarized answers to questions about sleep quality as assessed with the PSQI are summarized in **Table 2**.

TABLE 2 | Descriptive data for the PSQI across the two groups.

	Student *n* = 274		**General pop. *n* = 681**	
	Counts	**Percentage**	**Counts**	**Percentage**
Sleep quality				
Score = 0	9	3,28	52	7,64
Score = 1	128	46,72	322	47,28
Score = 2	113	41,24	251	36,86
Score = 3	24	8,76	56	8,22
Sleep latency				
Score = 0	51	18,61	149	21,88
Score = 1	74	27,01	225	33,04
Score = 2	76	27,74	183	26,87
Score = 3	73	26,64	124	18,21
Sleep duration				
Score = 0	95	34,67	249	36,56
Score = 1	92	33,58	214	31,42
Score = 2	57	20,8	136	19,97
Score = 3	30	10,95	82	12,04
Sleep efficiency				
Score = 0	179	65,33	455	66,81
Score = 1	60	21,9	98	14,39
Score = 2	17	6,2	75	11,01
Score = 3	18	6,57	53	7,78
Sleep disturbance				
Score = 0	12	4,38	38	5,58
Score = 1	208	75,91	469	68,87
Score = 2	49	17,88	160	23,49
Score = 3	5	1,82	14	2,06
Medication				
Score = 0	240	87,59	593	87,08
Score = 1	9	3,28	33	4,85
Score = 2	13	4,74	14	2,06
Score = 3	12	4,38	41	6,02
Daytime dysfunction				
Score = 0	28	10,22	101	14,83
Score = 1	97	35,4	278	40,82
Score = 2	107	39,05	233	34,21
Score = 3	42	15,33	69	10,13
PSQI Score, Mean (SD) *n* for score >5	8.67 (3.41) *n* = 225		8.33 (3.46) *n* = 537	

Sleep Quality and Dream Experience Frequencies, a Regression Analysis

We performed linear regression analysis to investigate whether the global PSQI score variance could be explained by LD frequency. Within this scope, dream experiences frequencies were recoded as a frequency per month using the class means. As indicated above, age and gender have been added as covariates and factors. Summary for this analysis is available in **Table 3**. Noticeably, the model was significant (with a p-value lower than 0.05) only when gender was added as a covariable; a closer analysis of the model coefficient confirmed that LD did not participate to this significance. In other world, lucid dream frequency

TABLE 3 | Model fit measures and model coefficient for the regression analyses concerning sleep quality and lucid dreaming frequency.

Model fit measures						
			Overall model test			
Model	***R***	***R*²**	***F***	**df1**	**df2**	***p***
1 LDF_Recoded	0.0122	1.49e-4	0.142	1	953	0.706
LDF_Recoded						
2 LDF_Recoded and DRF_Recoded	0.0393	0.00154	0.735	2	952	0.480
LDF_Recoded						
3 LDF_Recoded, DRF_Recoded, and age	0.0561	0.00315	1.002	3	951	0.391
4 LDF_Recoded, DRF_Recoded, age, and college student	0.0711	0.00506	1.207	4	950	0.306
5 LDF_Recoded, DRF_Recoded, age, college student, and gender	0.1362	0.01854	3.585	5	949	0.003

To isolate the singular effect of gender, we chose to test the prediction of the PSQI score by our variable of interest in five models by adding a control variable one by one. The model coefficients presented in the table beside concern the complete model (5) as being the only one significant. LDF: lucid dreaming frequency and DRF: Dream recall frequency.

Model coefficients – PSQI_total.				
Predictor	**Estimate**	**SE**	***t***	***p***
Intercept	29.3085	17.13169	1.711	0.087
LDF_Recoded	−0.0141	0.04014	−0.352	0.725
DRF_Recoded	0.0128	0.01505	−0.352	0.725
College_Student:			0.851	0.395
Yes – No	0.3093	0.26823	1.153	0.249
Birth	−0.0104	0.00864	−1.208	0.227
Gender:				
Men – Women	(0.8753	0.24241	(3.611	(0.001

does not help to predict sleep quality significantly. These tests were also performed for dream recall frequency, awareness, and control with similar outcomes suggesting that dream experience frequency does not predict significantly PSQI score.

Linear regression tables for the comparison mentioned above and for separate regression analysis depending on the group are available in the **Supplementary Material**.

DISCUSSION

This study was primarily conducted to evaluate how dream frequency could predict sleep quality in these two samples: a student and a general population sample. The research also aimed at describing the frequency of dream experiences (dreaming, LD, awareness, and control) and sleep quality as measured by the PSQI in these two samples.

Concerning LD frequency, individuals in the general population group have a prevalence (one or more occurrences during their lifetime) of LD of 49.49%. Even though the present general sample showed a wide age range, it was not a representative sample, however, dream recall frequency is close to that of a representative German sample in which 51% of participants reported having a lucid dream at least once (Schredl and Erlacher, 2011). In the same group, 15.86% were considered to have frequent lucid dreams because they had lucid dreams at least once a month, compared to 20.1% in the German representative sample (Snyder and Gackenbach, 1988). In the group of students, 63.87% reported having one or more lucid dreams, while 81.05% reported having such a dream in the 2015–2016 study (Ribeiro et al., 2016) and 82% of the student sample of Schadow et al. (2018). In the same group, 21.52% were frequent lucid dreamers, while 36.36% of students were considered lucid dreamers in 2015 and 36.9% in Schadow et al. (2018). In other words, the frequency of LD is lower in this study than in a previous study, while instructions and timing of data collection (beginning of the year) are noticeably similar (Ribeiro et al., 2016). This discrepancy could be explained by the fact that in 2015, students did not indicate which disciplines they were involved in, whereas the students in this study are all psychology students. Another explanation could come from the fact that participants saw all questions about consciousness and control in this questionnaire whereas they had only seen LD ones in the other study.

Concerning the answers to question about the dream of awareness and dream with control frequencies, participants were 72.83% to indicate one dream or more with awareness of the dream state in the general population group and 79.93% in the student group; they were 73.38% in the student group of the 2016 study (Ribeiro et al., 2016). Participants were 42.58% to indicate one dream or more with control of the dream state in the general population group and 55.47% of the student group; they were 50.65% in the student group of 2016 (Ribeiro et al., 2016).

This study did not find links between dream experiences frequencies (dream, lucid dream, awareness dreams, control dream) and sleep characteristics assessed with the PSQI for the student and the general group. Noticeably, the extent of the variance explained of significant models was rather low and only the gender predictor carried on this significance. Moreover, Schadow et al. (2018) have proposed that the occurrence of lucid dreams is not *per se* related to sleep quality but a consequence of higher nightmare frequencies. We believe that the present investigation participates in an accumulation of studies that invite to consider general LD occurrence as innocuous for sleep characteristics, but more studies are still needed. Aviram and Soffer-Dudek (2018) have indicated that LD can be beneficial or detrimental to a person's well-being, depending on the context in which lucidity occurs, such as whether or not people have attempted to induce it. Some of these techniques can be expected to disrupt sleep parameters; for example, some dreamers use devices that randomly send a red light into the eye during sleep in the hope of waking the individual sufficiently to experience LD (Stumbrys et al., 2012; Mota-Rolim et al., 2019). Therefore, future investigation of relation between LD frequency and sleep quality should focus specifically on instances where there is an increase to its frequency (Vallat and Ruby, 2019; Soffer-Dudek, 2020). In light of the present study, we believe that these future studies would benefit from using several operational definitions of dream lucidity to conduct their investigations. The Frequency and Intensity Lucid Dreaming (FILD) questionnaire may be of interest in this regard (Aviram and Soffer-Dudek, 2018). Another proposition is the Lucid dreaming Skills Scale (LUSK) that investigates frequency of LD, awareness/perception, dream control, and problems associated with being lucid during dreams using 22 items (Schredl et al., 2018). As a comment on possible future study: it would also be important to assess whether individuals who use lucid dream induction methods do so in an attempt to cope with their sleep problem. Indeed, this simple fact could lead to a misinterpretation of LD as being detrimental to sleep quality (see discussion on Schredl et al., 2020).

Additionally, the state-of-the-art on typical dreams invites also to mitigate the proposition of a detrimental effect of dream recall frequency on sleep quality, for instance, a decline in sleep quality was associated with a decline in dream recall for individuals with insomnia (Pagel and Shocknesse, 2007). For future research, we recommend using the scale proposed in the MADRE questionnaire as its metric properties are better known as the one we used in this study (for a French validation see Schredl, 2004; Schredl et al., 2014; Ghorayeb et al., 2019).

CONCLUSION

Frequencies of dream-related experiences were in the range of previous studies and 49.5% of individuals in the general population group indicated having experience LD at least once during their lifetime. No specific link was found between atypical dream consciousness frequencies and sleep quality as expressed with a total score of the PSQI. The present result and all the others that have failed to link LD to diminished sleep quality could be an invitation to conceptualize consciousness and control as phenomena that can participate in the diversity of dream phenomenology rather than as features of waking that are insinuated into dream phenomenology in a context of abnormality. Effect of induction strategies that impact directly sleep parameters on sleep quality remains to be investigated.

DATA AVAILABILITY STATEMENT

The dataset generated for this study is available in the **Supplementary Material** and on request to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

NR conducted the study and wrote the manuscript. YG and VQ supervised the research and contributed to the writing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.01290/full#supplementary-material

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Wake Up, Work on Dreams, Back to Bed and Lucid Dream: A Sleep Laboratory Study

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Lucid dreaming offers many opportunities to study consciousness processes. However, laboratory research in this area is limited because frequent lucid dreamers are rare. Several studies demonstrated that different methods of induction could increase the number of lucid dreams. In four field studies, a combination of a wake-up-back-to-bed (WBTB) sleep protocol and a mnemonic technique (MILD) showed promising results. To further investigate the effectiveness of this combined approach, we conducted a sleep laboratory experiment with four different conditions. The general experimental procedure was the following: Participants were awakened after 6 h of sleep from a subsequent REM period and kept awake for 30 or 60 min, during which they were asked to practice MILD or a control task (e.g., reading). Then they returned to bed for a morning sleep period. In the first condition eleven sport students, who attended a seminar on sleep and dreams, spent one night in a sleep laboratory. To avoid biases due to the seminar attendance (e.g., higher motivation), in the second condition 15 participants who did not attend the seminar were recruited. In the third condition, 14 sport students were tested with a shorter awakening period (30 min). Finally, the fourth condition served as a control condition, whereas eleven sport students slept two non-consecutive nights in a laboratory. Instead of MILD, in one night the participants read a book (fiction, unrelated to dreams), while in the other night they played a Nintendo Wii video game. In the first three conditions, six (54%), eight (53%), and five participants (36%) reported lucid dreams during the morning sleep period, whereas three, (27%), four (27%), and two participants (14%) produced PSG-verified eye signals. In contrast, in the reading condition, only one (9%) participant reported lucid dreams and no eye movements. No lucid dreams were observed in the Wii condition. The findings of the present study show that by using a combination of WBTB and MILD, lucid dreams can be effectively induced in people who are not selected for their lucid dream abilities.

Keywords: lucid dream induction, wake-up-back-to-bed, mild, sleep laboratory, morning sleep

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INTRODUCTION

A lucid dream is a dream in which the dreamer is aware that he or she is dreaming and can often consciously influence dream content (LaBerge, 1985). Sleep laboratory studies show that lucid dreaming usually occurs during REM sleep (LaBerge, 1990), however, in some cases lucid dreams have also been found during NREM sleep (Stumbrys and Erlacher, 2012). Lucid dreams are linked with higher levels of automatic nervous system activity (LaBerge et al., 1986), but also with more pronounced H-reflex suppression (Brylowski et al., 1989). Neurophysiological studies found increased activation during REM lucid dreaming especially in frontal and frontolateral regions but also in temporoparietal regions as well as an functional connectivity between those areas (Voss et al., 2009; Dresler et al., 2012; Baird et al., 2018). This specific dream state offers many opportunities to study consciousness processes (Baird et al., 2019) or psychophysiology in general (LaBerge et al., 2018).

In the general population, studies suggest that about a half of the general population had a lucid dream at least once in their lifetime and about one out of five people are having them at least once a month (Schredl and Erlacher, 2011; Saunders et al., 2016). Though, only 1% of general population experience lucid dreams frequently – several times a week (Schredl and Erlacher, 2011). Lucid dreams can start spontaneously, but most people applied different techniques to learn who to lucid dream (cf. Stumbrys et al., 2014).

In the literature different techniques have been proposed to increase the frequency of lucid dreams. In a systematic review by Stumbrys et al. (2012) in total 35 studies were identified which tested induction techniques empirically. Out of the 35 studies 11 were conducted as sleep laboratory studies whereas the other 24 were done as field experiments – in some cases with low methodological quality. While none of the induction techniques were verified to induce lucid dreams reliably, consistently and with a high success rate, some methods showed to be promising. One of such methods is a combination of Mnemonic Induction of Lucid Dreams (MILD) in combination with special sleep-wake-patterns, e.g., when a person wakes up in early morning hours and after a certain period of time goes back to bed and takes a nap, known as wake-up-back-to-bed (WBTB).

Mnemonic induction of lucid dreams is a cognitive technique based on prospective memory training and applied upon awakening from a dream (Stumbrys and Erlacher, 2014). The technique involves the dreamer rehearsing the dream and visualizing becoming lucid in it while setting an intention to remember to recognize that one in dreaming. LaBerge (1980) established MILD when working on his doctoral dissertation. At the baseline, when he did not apply any induction technique, LaBerge had less than one lucid dream per month. When he developed MILD, it increased his lucid dreams frequency to 18–26 lucid dreams per month and up to four lucid dreams per night. Further evidence for the effectiveness of MILD comes from ten studies (Kueny, 1985; LaBerge, 1988; Levitan, 1989, 1990a,b, 1991a; Edelstein and LaBerge, 1992; Levitan et al., 1992; LaBerge et al., 1994; Levitan and LaBerge, 1994) whereas all of them were conducted by LaBerge's research group (Stumbrys et al., 2012).

When using MILD after an awakening in early morning hours (i.e., in a combination with WBTB), lucid dreams seem to be much more likely during following naps than the night before (Levitan et al., 1992). Furthermore it was shown that when using with MILD, it is most effective to use WBTB for a period of 30–120 min (LaBerge et al., 1994). The shorter periods of wakefulness, such as taking a nap after 10 min (LaBerge et al., 1994) or immediately after awakening (Levitan, 1991a) are less effective for MILD practice. The same is true for longer periods of wakefulness, such as taking a nap after 4 h (Levitan, 1990a) or 14–17 h after the bed time (Levitan et al., 1992).

While all previous MILD + WBTB studies were conducted only as field experiments, we carried out a sleep laboratory study to investigate the effectiveness of this combined technique. The study included four experiments. In the first experiment, we tested the effectiveness of MILD with 60 min of WBTB with sports students who attended a seminar on sleep and dreams. In the second experiment, to eliminate possible biases due to the seminar attendance, the same procedure was repeated with people who did not attend the seminar. In the third experiment, a shorter time interval of sleep interruption was introduced (30 min). Finally, in the fourth experiment in contrast to dreamwork that has been accomplished during the period of awakening in previous experiments, two alternative activities were tested: a cognitive activity (reading) and a balancing exercise (Wii video game).

MATERIALS AND METHODS

Participants

Table 1 shows the description of the samples for the four conditions of the sleep laboratory study. In the condition 1, 3, and 4, the participants were students from Heidelberg University and took part in a weekly seminar about "Sleep and Sports" at the Institute of Sports and Sports Sciences given by one of the authors (DE). Participants for the experiment therefore were self-selected by their interest in dreams and lucid dream research. No exclusion criteria were made. Participation in the laboratory study was part of the seminar requirement, however, participation was not obligatory because alternative course credits could be received. Most of the participants of the second condition were also voluntary students from Heidelberg University, but who did not attend the seminar. At the time of data collection (2010–2011), ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Participants provided written informed consent before the beginning of the study and the experiment was conducted in accordance with the Declaration of Helsinki [Statistics transferred to **Table 1**].

Dream Recall and Lucid Dream Recall Frequency

The participants completed a dream questionnaire (cf. Schredl et al., 2014). In this questionnaire dream recall frequency was measured on a seven-point rating scale ranging from "0 - never" to "6 - almost every morning." Re-test reliability for this scale is high (r = 0.85; Schredl, 2004). Units of mornings per week were calculated by recoding the scale to their class means (*0* = 0, *1* = 0.125, *2* = 0.25, *3* = 0.625, *4* = 1.0, *5* = 3.5, *6* = 6.5). Lucid dream recall frequency was measured on an eight-point rating scale ranging from "0 -never" to "7 - several times a week." Re-test reliability for this scale is high (r = 0.89; Stumbrys et al., 2013a). Units of mornings per months were calculated by recoding the scale to their class means (*0* = 0, *1* = 0.042, *2* = 0.083, *3* = 0.25,

TABLE 1 | Participants characteristics.

	Study condition					
	1 (60 min + MILD)	2 (60 min + MILD)	3 (30 min + MILD)	4 (60 min + Reading/Wii)	Test statistic	*p* =
N (male/female)	11 (6/5)	15 (9/6)	14 (11/3)	11 (5/6)	χ^2 (3) = 3.13	0.37
Age	23.73 ± 1.49	23.79 ± 2.82	24.86 ± 2.11	24.91 ± 2.17	F(3,47) = 1.11	0.35
DRF[a] (dreams/week)	2.22 ± 1.49	2.37 ± 2.30	2.59 ± 1.74	1.81 ± 2.17	F(3,47) = 0.40	0.75
LDRF[b] (lucid dreams/month)	0.16 ± 0.30	0.37 ± 0.47	0.54 ± 0.70	0.44 ± 0.78	F(3,47) = 0.92	0.35

[a] *Dream Recall Frequency,* [b] *Lucid dream recall frequency.*

4 = 1.0, *5* = 2.5, *6* = 4.0, *7* = 18). A definition was provided to ensure a clear understanding of lucid dreaming: "In lucid dreams, one has awareness that one is dreaming during the dream. Thus it is possible to wake up deliberately, or to influence the action of the dream actively, or to observe the course of the dream passively" (for the importance of a clear definition, see Snyder and Gackenbach, 1988).

Polysomnography

In all experiments, polysomnography (PSG) was conducted to register sleep stages. PSG recording included electroencephalogram (EEG: F3, F4, C3, C4, CZ, O2, O1), electroocculogram (EOG), submental electromyogram (EMG), and electrocardiogram (ECG). EEG electrodes were placed according to the international Ten-Twenty system (Jasper, 1958). A XLTEK Trex longtime EEG recorder was used to record sleep data with a DC amplifier and sample rate of 250 Hz. Sleep stages were manually scored according to the AASM criteria (Iber et al., 2007).

Mnemonic Induction of Lucid Dreams (MILD)

Mnemonic induction of lucid dreams is based on the ability to remember and perform future actions (i.e., prospective memory). It works best after a spontaneous awakening with dream recall. From this dream different events or objects that are highly improbable or bizarre should be identified and could thus be used to recognize the experience as a dream (so-called dream signs). Afterward, while lying in bed and returning to sleep, the individual has to visualize the dream and upon encountering a dream sign imagine oneself becoming lucid and set an intention to remember: "Next time I'm dreaming, I will remember to recognize that I'm dreaming" (LaBerge et al., 1994; Stumbrys and Erlacher, 2014). For the experimental night MILD was introduced to the participants for the first time. The technique was embedded in the wake period of the WBTB procedure and was divided into three parts: (1) writing the dream report; (2) finding dream signs; (3) practicing MILD.

Procedure

Before the sleep laboratory night, participants received information about the study night and the goals of the study. All steps of the procedure were explained in a written form and participants provided written informed consent.

In conditions 1–3, the participants spent a single night and in condition 4 the participants spent two non-consecutive nights in a dark and quiet room at the Institute of Sports and Sports Sciences (Heidelberg University) with continuous PSG recording. They arrived at 9:00 pm and the experimenter familiarized them with the room and setting. Then the participants prepared themselves for the night and all electrodes were attached by the experimenter. After the recording signals were checked, the experimenter explained to the participants the definition of a lucid dream and trained them in left-right-left-right (LRLR) eye movements to signal a possible lucid dream (cf. LaBerge, 1990). The LRLR signal was trained in front of the recording screen to give the feedback to the participants. The participants were also instructed about the awakening after about 6 h of sleep (see below). The night procedure was divided into four parts (See **Figure 1**).

First Part of the Night

The first part of the night lasted at least 5 h and 40 min after sleep onset. Then the participants were awakened from the subsequent REM period following 10–15 min of uninterrupted REM sleep. If all subsequent uninterrupted REM sleep was shorter than 10 min, the participant was awakened following the next REM period after 7 h from sleep onset, even if it was shorter than 10 min. Further, if a LRLR signal was observed on the sleep recording, the participant was also awakened (3 epochs after the last signal).

REM Awakening

Via intercom system, the participants were called by their name until responded. Then they were asked to report any mental content that was in their mind before awakening. If the participant did not recall any sleep mentation immediately, he or she was given 2 min to think about it and try to recall it. Further, the participants were asked if in the dream they were aware that they are dreaming (self-rating of lucidity) and if they gave a LRLR eye-signal. All conversations were recorded via a voice recorded.

Wake Period

After awakening the wake period followed. In Experiments 1 and 2, the participants were kept awake for 60 min. During this time period, firstly, the participants were given a dream report sheet and a pen to write down the dream that was just verbally reported (or some vivid earlier dream if nothing was recalled). Then they were given an information sheet about the dream signs (incongruous elements of a dream indicating that this might be a dream, e.g., an odd

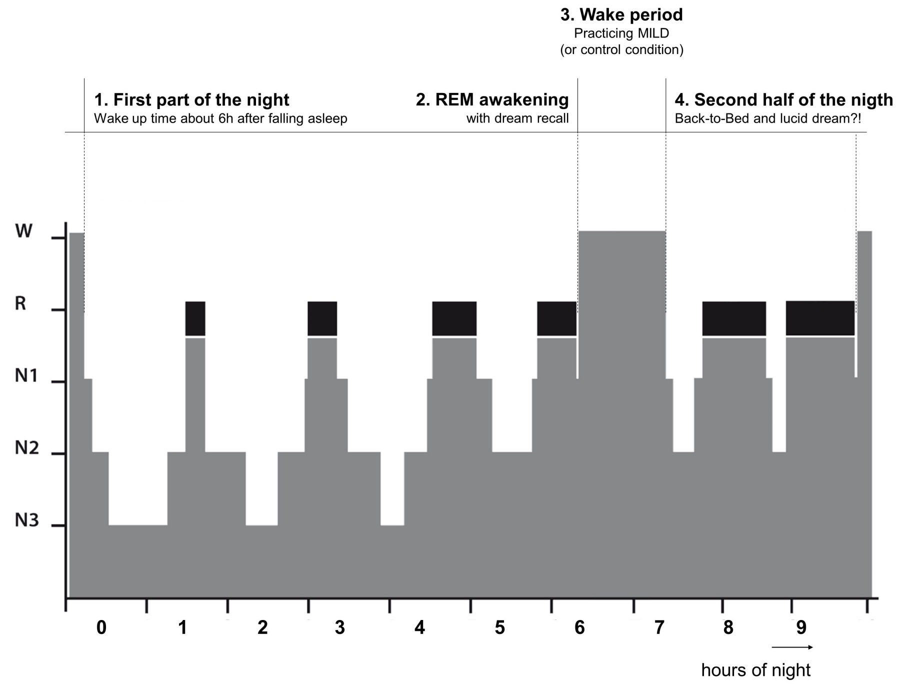

FIGURE 1 | The night procedure divided into two parts.

form, action, context) and asked to go through their dream report and identify all possible dream signs. Lastly, the participants were given a description of MILD technique and asked to practice it with using the present dream report and identified dream signs. To ensure the participants' clear understanding of dream signs and MILD technique, they were asked to explain both the identified dream signs and MILD technique to the experimenter (and corrected if necessary). The participants in Experiment 3 did exactly the same procedure but with a shorter duration (30 min in total; about 10 min for each step).

The participants in Experiment 4 were also kept awake for 60 min and, in a randomized and counterbalanced order, one night were given a book to read for 60 min (fiction, a collection of short stories, "Hauptsache von Herzen" by Brigitte Sinhuber), while on the other night they played a series of Wii video games that involved body balancing (ski-slalom, snowboarding, etc.) for 60 min. After the wake period finished, the participants returned to bed. The participants in Experiments 1–3 were instructed to keep practicing MILD while falling asleep, whereas the participants in Experiment 4 were simply instructed to recognize that they dreaming the next time they dream.

Second Part of the Night (Back-to-Bed)

Upon returning to bed, the participants were further awakened following these conditions: (1) 15 min of uninterrupted REM sleep after 3 h; (2) end of a shorter than 15 min REM period after 4 h; (3) after observing a LRLR eye-signaling on the sleep recording (3 epochs after the last signal). The awakening was made in the same way as before (see above).

All recorded dream reports were transcribed, randomly permutated and scored by a blinded judge for lucidity on a 3-point scale (0 – no evidence of a lucid dream, 1 – possible indications of a lucid dream, 2 – clear indication of a lucid dream), which was shown to have a good interrater agreement (Stumbrys et al., 2013b).

Criterion for Successful Lucid Dream Induction

A successful induction of a lucid dream could be shown by three types of proofs (see also Schmid and Erlacher, 2020): (1) self-rating of lucidity; (2) an external rater judged the dream report as either with clear or possible indications of lucidity; (3) the participant reported LRLR eye signaling and the eye signals can be unambiguously identified on the sleep recording during REM. For the "strict" criterion, all three criteria must be met. For the "loose" criterion, (1) and (2) were considered as sufficient.

Statistical Analysis

Because this was an exploratory study, the main focus is on descriptive statistics.

RESULTS

Sleep Data

The WBTB sleep data for all conditions is provided in **Table 2**. Of all 62 experimental nights in the present study, one participant (Experiment 2) was not able to fall asleep after WBTB. The average WBTB sleep latency for all experimental conditions was

31.5 ± 26.0 min. In 53 occasions (85.5%) the participants had REM sleep with an average latency of 42.1 ± 24.7 min after sleep onset. Notably, one participant (Experiment 2) reported a lucid dream after a nap without REM sleep.

Dream Reports

In total, 115 dream reports were collected during the experimental night: 60 from the first part of the night and 55 from the second part of the night. The dream recall rate for the first part of the night was 95% (from 63 REM awakenings) and for the second part of the night was 76% (from 63 morning naps). The dream reports had an average length of 120.3 ± 121.3 words.

Induction of Lucid Dreams

In total, the participants reported lucid dreams during 20 morning naps following awakening (32.3%). Further, on four occasions (6.5%) they were unsure if they were dreaming or not. On 14 occasions (22.6%) no dreams were recalled and on 24 occasions only non-lucid dreams were reported (38.7%). The judge rated 24 dream reports as without evidence of lucid dreaming (exactly the same ones as the dreamers themselves), 22 dream reports as with clear indications of lucid dreaming (19 of which the participants rated as lucid and 3 as ambiguously lucid) and two dream reports as with possible indications of lucid dreaming (one which was rated by a participant as lucid and one as ambiguously lucid).

Further, on 14 occasions (22.6%) the participants reported that they produced a LRLR eye signal to confirm their lucidity. In nine cases LRLR eye signals were clearly observed on the PSG recording to occur during unequivocal REM sleep; in three cases the signal and/or sleep stage was ambiguous and in two cases there were no signs of prearranged eye-signaling on the sleep recording. On five occasions (8.1%), the participants reported that they are unsure if they produced a LRLR eye signal. In two of those cases there were unequivocal signals during REM sleep observed on the sleep recording, one case was ambiguous and in two other cases no prearranged eye-signaling was observed. On further five occasions (8.1%), the participants reported that they did not give the signal despite the fact that they were aware of dreaming during the dream. The numbers of lucid dreams according to both "strict" and "loose" criteria in different conditions are presented in **Table 3**.

Condition 1 – 60 Minutes Plus MILD

Six out of 11 participants (54.5%) reported to have a lucid dream in the nap following awakening. All these dreams were verified as lucid by an external judge who scored dream reports. Four participants reported that they produced a LRLR signal (three signals were successfully verified on the PSG recording to occur during unambiguous REM sleep; one signal was ambiguous). Two other participants were unsure if they produced a signal (one signal, however, was verified on the PSG; other signal was ambiguous).

Condition 2 – 60 Minutes Plus MILD

Eight out of 15 participants (53.3%) reported a lucid dream during the nap. All these dreams were verified as lucid by an external judge who scored dream reports. Six participants reported that they produced a LRLR signal and four of these signals were successfully verified on the PSG recording. In one case, the signal on the PSG recording was ambiguous, in the other case the signal was absent and there were no REM sleep during the nap period.

Condition 3 – 30 Minutes Plus MILD

Five out of 14 participants (35.7%) reported a lucid dream during the nap and two of them gave a LRLR signal (verified on the sleep recording). Two others did not give a signal and one was awakened on making a signal. One participant reported to make a signal but was uncertain if he was dreaming and corresponding PSG recording showed high EEG alpha levels.

Control Conditions

In the 60 min plus reading condition, only one participant reported a lucid dream, but did not make a LRLR signal. One other participant was uncertain if he was dreaming and made a signal, however, the signal was verified on the PSG recording.

In the 60 min plus Wii condition, two participants were unsure if they had a lucid dream. One of them reported a dream in a dream and told that he made a signal, the other participant was unsure about signaling. No signals were visible on the PSG recording in both cases.

Taken together conditions 1–4, no gender differences were found for successfully induced lucid dreams with respect neither to the loose (Chi2 = 0.80; $p = 0.37$) nor strict criterion (Chi2 = 0.46; $p = 0.50$). Furthermore, successful participants in having a lucid dream (loose criterion) tended to have a higher baseline dream recall frequency and lucid dream recall frequency compared to the unsuccessful participants, however, this tendency was not statistically significant ($p = 0.15$ and $p = 0.10$, respectively).

DISCUSSION

The findings of the present study show that by using a combination of WBTB and MILD techniques, lucid dreams can be effectively induced in people who are not selected for their lucid dream abilities. According to the present results, the most effective approach is to use 1 h WBTB time, during which dreamwork is carried out and MILD is practiced. Under such circumstances, about a half of the participants report a lucid dream and about one out of three participants have a lucid dream which could be objectively verified by volitional eye signaling on the sleep recording. Shorter WBTB durations might be less beneficial, as well as if different activities than dreamwork are used during the WBTB period.

The achieved success rates are quite high, if compared to other sleep laboratory lucid dream induction studies with unselected student samples. For example, in a study by Paul et al. (2014), the success rates for visual and tactile stimulation were only 0–7.4%. Our success rates resemble the ones from WBTB + MILD field studies with lucid dreamers by LaBerge, Levitan and their colleagues (Levitan, 1990b, 1991a,b; Levitan et al., 1992;

TABLE 2 | Sleep data for the second half of the night.

	Study condition					ANOVA	
	1 (60 min + MILD)	2 (60 min + MILD)	3 (30 min + MILD)	4 (60 min + Reading)	4 (60 min + Wii)	*F*	*P*
Total bed time (min)	206.2 ± 34.5	167.9 ± 65.4	190.4 ± 47.5	182.6 ± 23.4	195.3 ± 32.3	1.30	0.28
Total sleep time (min)	162.4 ± 63.5	113.3 ± 64.1	152.9 ± 42.3	151.4 ± 24.5	132.0 ± 55.2	1.86	0.13
Sleep efficiency (%)	76.6 ± 22.5	66.0 ± 22.9	81.0 ± 13.2	83.1 ± 10.0	66.4 ± 23.2	2.21	0.08
Sleep latency (min)	17.0 ± 10.6	43.9 ± 31.2	35.6 ± 35.3	19.3 ± 9.2	37.0 ± 17.2	2.76	0.04
REM latency (min)	35.5 ± 16.7	48.2 ± 18.9	30.1 ± 20.1	34.2 ± 26.2	54.9 ± 39.5	1.97	0.11
REM period count	2.3 ± 1.1	1.0 ± 0.8	2.4 ± 1.0	2.0 ± 1.0	1.7 ± 1.1	4.16	0.01
REM period range	1–4	0–3	1–5	0–4	0–3		
REM total time (min)	36.9 ± 22.6	29.1 ± 33.8	47.8 ± 21.6	35.2 ± 19.0	28.5 ± 20.9	1.34	0.27
REM% SPT	20.1 ± 10.0	20.0 ± 18.8	31.7 ± 11.2	22.7 ± 12.3	17.5 ± 12.1	2.19	0.08
Wake% SPT	13.7 ± 15.6	21.9 ± 26.2	6.2 ± 8.3	8.3 ± 9.7	18.4 ± 18.8	1.93	0.12
Stage 1% SPT	14.6 ± 7.5	17.1 ± 12.4	10.2 ± 7.6	9.0 ± 6.3	10.7 ± 6.1	2.04	0.10
Stage 2% SPT	44.7 ± 13.1	35.9 ± 19.6	44.3 ± 11.6	49.2 ± 8.5	43.5 ± 14.1	1.53	0.21
Stage 3% SPT	2.8 ± 3.9	2.5 ± 4.5	4.7 ± 5.7	8.1 ± 9.3	6.8 ± 6.2	1.95	0.12

TABLE 3 | Number of lucid dreams in different conditions.

	Study condition				
	1 (60 min + MILD)	2 (60 min + MILD)	3 (30 min + MILD)	4[a] (60 min + Reading)	4[a] (60 min + Wii)
N[b] (male/female)	11 (6/5)	15 (9/6)	14 (11/3)	11 (5/6)	
LD (loose)[c] (male/female)	6 (2/4)	8 (4/4)	5 (5/0)	1 (1/0)	0
LD (strict)[c] (male/female)	3 (2/1)	4 (1/3)	2 (2/0)	0	0

[a]Control condition. [b]Number of participants included in the condition. [c]Three types of proofs were used to establish successful induction: (1) self-rating of lucidity, (2) assessment of the dream report by an external judge (3) LRLR eye signals on the sleep recording during REM. For the "strict" criterion, all (1)–(3) had to be met, while for the "loose" criterion only (1) and (2).

LaBerge et al., 1994). While sleep laboratory and field studies can not be directly comparable (for example, in the former, a researcher can awaken the participant from REM sleep to increase the chances for successful dream recall), this suggests that WBTB + MILD can effectively applied not only by frequent lucid dreamers but also by infrequent or non-lucid dreamers. In the first our experiment, out of four participants who never had a lucid dream before, two became lucid in a single night at the sleep laboratory (two out of seven in the second experiment, but four others did not recall any dream content).

The duration of WBTB period seems to be an important factor in the effectiveness of technique. Previous research showed that with MILD, the most efficient periods of WBTB are of 30–120 min (Levitan, 1990a; Levitan et al., 1992; LaBerge et al., 1994). The findings of the present study indicate that WBTB for 1 h might be more efficient than a shorter period of 30 min. The similar finding was reported by LaBerge et al. (1994), which suggests that 1 h of wakefulness might be the most optimal time for this technique.

Two recent sleep laboratory studies applying an acoustic cue during the induction technique of the WBTB-paradigm might shed some light on the timing issue. In the first study lucid dreams were successfully induced in a single nap session by cueing beeping tones with cognitive training (Carr et al., 2020). The session duration was 20 min and performed in the morning either at 7:30 am or 11:00 am. The results showed that 50% of the cued participants produced a signal-verified lucid dream. In the second study a combination of music (e.g., "Boléro" by Maurice Ravel) with reality testing was applied in 1 h session which was embedded in a WBTB-protocol at 4.5 h after sleep onset (Schmid and Erlacher, 2020). In contrast, only 14% of the participants became lucid and none of those lucid dreams were verified by LRLR eye signal. Thus, it seems that not only the duration of the session but also the hours of previous sleep might be important to enhance the chances to experience a lucid dream.

In contrast to the suggestion by LaBerge (1980) that "it is not the particular activity (carried out during the period of wakefulness), but the alert wakefulness that facilitates lucid dreaming during subsequent sleep" (p. 1042), the present findings indicate that the activity does matter. In our fourth study, where two alternative activities for dreamwork were used (reading and a balancing task), the success rates were markedly lower. A previous study by Leslie and Ogilvie (1996) showed that increased vestibular activation can facilitate dream lucidity, however, in the present study we found no difference between the balancing task and the reading condition. In comparison to reading, the balancing exercise had more disturbing effects on subsequent sleep (increased sleep latency and reduced sleep efficiency). While American Academy of Sleep Medicine (AASM, 2014) lists a vigorous exercise close to bedtime as one of the factors that can increase arousal and disturb sleep, empirical findings are inconsistent (e.g., Stutz et al., 2018). From the present findings, dreamwork (writing down the dream, identifying dream signs, practicing MILD) can be recommended as the optimal activity during the WBTB period.

The period of wakefulness in early morning hours did not disturb subsequent sleep: In only one case (1.6%) the participant was not able to fall asleep after WBTB and in most cases (85.5%) the participants had REM sleep. Interestingly, one participant reported a lucid dream after a nap without REM sleep. While there were no eye-signaling in this case, this might have been an NREM lucid dream, which were also infrequently observed before (Stumbrys and Erlacher, 2012). The participants in the Experiment 2 had longer sleep latency than the participants in the same condition in the Experiment 1. This might be explained by the fact that the Experiment 2 participants in contrast to other groups, did not attend the seminar and therefore might have had higher anxiety/stress level (e.g., due to unfamiliar environment, procedures) which might have resulted in poorer their sleep quality. Yet, the participants in the Experiment 2 achieved very similar lucidity success rates as the ones in the Experiment 1, which suggests that the effectiveness of the present induction method was not influenced by the participation in the seminar (e.g., interest in dreams and/or lucid dreams) and the findings might be more generalizable.

Some methodological issues have to be acknowledged. One of the main challenges in all lucid dream induction studies is what to consider a valid criterion for successful induction (see Stumbrys et al., 2012 for further discussion on this point). In the present study, we employed different measures: the dreamer's self-report if he/she was lucid and made a LRLR eye movements and the external ratings for dream lucidity based on the dream report and unambiguous LRLR eye signaling during REM sleep. While in the most cases the self-ratings and the external ratings corresponded, on a few occasions they diverged. On three occasions the judge rated dream as clearly lucid whereas the dreamer was unsure if the dream was lucid or not and on one occasion the judge rated a dream as uncertainly lucid whereas the dreamer considered the dream as lucid. Regarding dream lucidity, in such cases we followed the self-report of the dreamer, as the dream lucidity might not be easily inferred from a dream report if it is not explicitly mentioned (e.g., "I became lucid" or "I realized this is a dream"). Yet, if the dreamer was unsure if he was lucid in a dream or awake or if he/she made a LRLR eye signal, but the signal was unambiguously present during REM sleep, we also considered this as a lucid dream. Our previous research (Stumbrys et al., 2014) showed that lucid dreamers quite often are not able to recall their previous waking intentions in lucid dreams and successfully execute them (most often due to hindrances with the dream environment or a premature awakening). While unambiguous eye-signaling on the sleep recording and confirmatory dream report can be considered as the most valid evidence for the confirmation of lucid dreaming, it might not be appropriate to disqualify completely those dreams in which a person was lucid but, for example, forgot to signal or was awakened during the signaling. The conventional minimal criterion for the definition of lucid dreaming is only awareness of dreaming during dreaming (see Stumbrys et al., 2012), while eye-signaling involves also elements of waking memory retrieval and dream body control. Therefore we think it is useful to introduce two aforementioned types of criteria: loose – for expert-validated self-reported experience, and strict – for its objective external validation.

Some further limitations should be acknowledged. Even though 51 participants were included in the study, the sample sizes across the groups are rather small. Indeed, this is one of the reasons, why the results are of descriptive nature. However, the number of about 50% of participants who successful induced a lucid dream within a single sleep laboratory night provides a good reference to what might be a good induction rate in future studies. Furthermore, it should be mentioned that that only one independent judge rated the dream reports, but this was in high accordance with the self-ratings of the participants. Finally, no adaptation night have been done. Therefore, the so-called first night effect might have possible effects on the REM-NREM sleep cycles, e.g., reducing or delaying REM sleep (Agnew et al., 1966).

To summarize, the present study showed that by using a combination of WBTB and MILD, lucid dreams can be effectively induced in people who are not selected for their lucid dream abilities. Future studies should focus on the time of practicing MILD and on combining WBTB with other cognitive techniques (like reality testing) to check their influence on lucid dream induction.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

Both authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Findings From the International Lucid Dream Induction Study

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The International Lucid Dream Induction Study (ILDIS) investigated and compared the effectiveness of five different combinations of lucid dream induction techniques including reality testing (RT), Wake Back to Bed (WBTB), the Mnemonic Induction of Lucid Dreams (MILD) technique, the Senses Initiated Lucid Dream (SSILD) technique, and a hybrid technique combining elements of both MILD and SSILD. Participants with an interest in lucid dreaming (N = 355) completed a pre-test questionnaire and then a baseline sleep and dream recall logbook for 1 week before practicing the lucid dream induction techniques for another week. Results indicated that the MILD technique and the SSILD technique were similarly effective for inducing lucid dreams. The hybrid technique showed no advantage over MILD or SSILD. Predictors of successful lucid dream induction included superior general dream recall and the ability to fall asleep within 10 min of completing the lucid dream induction techniques. Successful lucid dream induction had no adverse effect on sleep quality. Findings indicated that the techniques were effective regardless of baseline lucid dreaming frequency or prior experience with lucid dreaming techniques. Recommendations for further research on lucid dream induction techniques are provided.

Keywords: lucid dreaming, lucid dream induction techniques, dream recall, reality test, sleep quality

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INTRODUCTION

In a lucid dream, the dreamer is aware that they are dreaming while the dream is still happening (LaBerge, 1985). According to a recent meta-analysis by Saunders et al. (2016), 55% of adults have experienced at least one lucid dream and 23% experience lucid dreams regularly (once per month or more). Recent research indicates that deliberate control is possible in approximately one third of lucid dreams (Soffer-Dudek, 2020). Examples include changing location and deliberately waking up (LaBerge and Rheingold, 1991; LaBerge and DeGracia, 2000; Love, 2013; Mota-Rolim et al., 2013). Lucid dreaming has many potential benefits and applications, such as treatment for nightmares (Spoormaker and Van Den Bout, 2006; Lancee et al., 2010; Holzinger et al., 2015), improvement of physical skills and abilities through dream rehearsal (Erlacher and Schredl, 2010; Stumbrys et al., 2016), creative problem solving (Stumbrys and Daniels, 2010), and research opportunities for exploring mind-body relationships and consciousness (see Hobson, 2009). However, to date the effects reported in most studies have been weak and inconsistent, and more research is needed into the applications of lucid dreaming (Baird et al., 2019; de Macêdo et al., 2019).

Many techniques exist for inducing lucid dreams (see Tholey, 1983; LaBerge and Rheingold, 1991; Stumbrys et al., 2012; Love, 2013). These techniques have been organized by Stumbrys et al. (2012) according to three broad categories. *Cognitive techniques* include mental exercises that increase the likelihood of lucid dreaming. The two most widely researched cognitive techniques are *reality testing* (RT; Tholey, 1983; LaBerge and Rheingold, 1991) and the *Mnemonic Induction of Lucid Dreams* (MILD) technique (LaBerge, 1980; LaBerge and Rheingold, 1991). RT involves examining one's environment and then performing a reliable test that differentiates between waking and dreaming, repeatedly throughout the day. The rationale is that if RT becomes habitual, it will eventually be performed while dreaming, triggering lucidity. The MILD technique involves creating a prospective memory intention to remember that one is dreaming by repeating the phrase "next time I'm dreaming, I will remember I'm dreaming" (or some variation). The MILD technique is performed during a brief awakening after 5 or so hours of sleep. Indeed, waking up after several hours of sleep for the purpose of lucid dream induction is itself a technique, known as *Wake Back to Bed* (WBTB; LaBerge and Rheingold, 1991). When successful, the MILD technique triggers lucidity during subsequent REM sleep. *External stimulation techniques* involve stimuli such as flashing lights presented during REM sleep that can be incorporated into dreams, serving as cues that trigger lucidity. *Miscellaneous techniques* include lucid dream inducing drugs and supplements (see LaBerge, 2004; see also Yuschak, 2006).

Stumbrys et al. (2012) identified 35 empirical studies on lucid dream induction techniques in a systematic review. Most (24) were field studies, with the others conducted in sleep laboratories (11). Stumbrys et al. (2012) evaluated these studies using a methodological quality checklist developed by Downs and Black (1998) and found that most (60%) were of poor methodological quality. The others were classified as moderate quality. More than half of the studies were unpublished Ph.D. dissertations or otherwise not published in peer-reviewed journals. All studies showed poor external validity. Participants were mostly university students or self-selected and highly experienced lucid dreamers. Most lucid dreaming studies are also limited by small sample sizes, lack of random allocation, failure to investigate variables that operationalize the way in which techniques were practiced (e.g., number of technique repetitions), and inconsistent operationalization of lucid dreaming rates (see Aspy et al., 2017 for a more detailed discussion). These widespread limitations are a major impediment to lucid dream research and make it difficult to compare the effectiveness of techniques across studies.

Several additional lucid dream induction studies have been published since the publication of Stumbrys et al. (2012). Taitz (2011) found that daily RT for 2 weeks was ineffective. Poor success rates were reported in laboratory studies of external stimulation (flashing lights and vibration; Franc et al., 2014) and transcranial direct current stimulation (tDCS) to the dorsolateral prefrontal cortex (DLPFC) during REM sleep (Stumbrys et al., 2013). Dyck et al. (2017) found that keeping a dream diary, RT, and a combined WBTB and affirmation technique were ineffective. In a study by Konkoly and Burke (2019), 19 participants performed RT, MILD, and the Wake-Induced Lucid Dream technique (WILD). However, the authors did not provide statistics to indicate how effective this training program was except that 39 lucid dreams were reported. Saunders et al. (2017) found that a greater proportion of participants who practiced several techniques over a 12-week period (including RT, MILD and WBTB) experienced lucid dreaming compared to a control group (45 vs. 6%). However, the frequency of lucid dreaming is unclear. Kumar et al. (2018) reported a low success rate (at most 6% of days had lucid dreams) for Tholey's combined technique, which involves regular reality tests combined with autosuggestion and intention to have a lucid dream (Tholey, 1983). Sparrow et al. (2018) found that the drug Galantamine was effective for inducing lucid dreams. However, results do not permit calculation of lucid dreaming rates. LaBerge et al. (2018) found that lucid dreaming occurred on 42% of nights when participants ingested 8 mg of Galantamine in addition to practicing the MILD technique, and in most cases, using an external stimulation device (flashing light). A success rate of 14% was reported for a control condition involving the same techniques but with placebo pills.

The National Australian Lucid Dream Induction Study (NALDIS; Aspy et al., 2017) provided a thorough investigation into RT, MILD and WBTB using a highly diverse sample of Australian participants (N = 169). During Week 1, participants recorded baseline dream recall rates and were then randomly allocated to one of three experimental groups for Week 2. Because RT, WBTB and MILD are often used in combination, and in the interests of identifying a maximally effective approach to lucid dream induction, an additive approach in which groups involving RT only (*RT only* group), RT and WBTB (*RT + WBTB* group) and RT, WBTB, and MILD (*RT + WBTB + MILD* group) were compared. A significant increase in lucid dreaming was observed in the *RT + WBTB + MILD* group, with lucid dreaming reported on 17.4% of nights in Week 2 compared to 9.4% of nights in Week 1. No significant changes in lucid dreaming frequency were observed in the other two groups. However, although RT was ineffective when practiced in isolation, it remained uncertain whether RT contributed to the significant increase in lucid dreaming rates observed in the *RT + WBTB + MILD* group. This is important because RT is a burdensome practice, and if ineffective, it would be better to simply practice WBTB and MILD. Higher general dream recall was a significant predictor of lucid dreaming following practice of the MILD technique. However, the strongest predictor of lucid dreaming was the amount of time taken to fall back asleep after completing the MILD technique. Lucid dreaming was experienced on 45.8% of occasions when participants completed the MILD technique and then fell asleep within 5 min. A likely explanation is that returning to sleep quickly makes it more likely that the MILD intention will persist into REM sleep and trigger lucidity.

The biggest impediment to research into the potential benefits and applications of lucid dreaming is the lack of effective and reliable lucid dream induction techniques. Despite a reduction of research interest in lucid dream induction over the past few decades (Stumbrys et al., 2012), many promising avenues for research remain. Numerous lucid dream induction techniques have been developed by lucid dreaming enthusiasts but have not been investigated scientifically. One promising example is the cognitive technique known as the *Senses Initiated Lucid Dream* (SSILD) technique (the double "S" in the acronym is intentional; Gary Zhang, 2013). The SSILD technique involves waking up after approximately 5 h of sleep (as with MILD) and then repeatedly shifting one's attention between visual, auditory, and physical sensations before returning to sleep. The International Lucid Dream Induction Study (ILDIS) aimed to investigate the effectiveness of the SSILD technique and address unanswered questions from the NALDIS about the effectiveness of the MILD technique when practiced alone compared to when practiced in combination with RT. The ILDIS also aimed to compare two different types of RT and examine the effectiveness of a hybrid technique combining elements of both MILD and SSILD. Recruitment took place during a media release and subsequent media coverage that occurred when the NALDIS was published. The following hypotheses were tested:

- It was hypothesized that general dream recall rates would be positively correlated with lucid dreaming frequency at both pre-test and during Week 2.
- It was hypothesized that Week 2 lucid dreaming rates would be significantly higher than Week 1 lucid dreaming rates.
- It was hypothesized that lucid dreaming rates would be significantly higher when participants took 5 min or less to fall asleep after practicing lucid dreaming techniques compared to when they took more than 5 min to fall asleep.

MATERIALS AND METHODS

Participants

An initial sample of 1618 participants completed the pre-test questionnaire. A total of 843 participants continued to complete Week 1 of the study and 355 participants completed Week 2. In the final sample there were 190 (53.5%) females, 162 (45.6%) males and 3 (0.9%) "other." Mean age was 35.3 (SD = 12.4, range: 18–84). Most participants (n = 255) were employed non-students (71.8%), with 69 (19.4%) students and 31 (8.7%) unemployed or retired. Just over half of participants (54.9%) reported prior experience with lucid dream induction techniques. Only six participants (1.7%) had participated in prior lucid dreaming research. Participants reported M = 1.1 lucid dreams in the month prior to commencing the study (SD = 2.4, range: 0–28). Participants heard about the study from a wide range of sources that directed them to the present author's website, where they could sign up to participate. Sources included: 183 (51.6%) from Facebook; 83 (23.4%) from other internet sources (e.g., email lists and social media); 40 (11.3%) from newspaper articles; 28 (7.9%) from a friend; 18 (5.1%) from radio interviews; and 3 (0.9%) from a television interview with the author. Country of residence was: 111 in United States (31.3%); 76 in Australia (21.4%); 26 in United Kingdom (7.3%); 25 in Canada (7.0%); 14 in Germany (3.9%); 9 in Mexico (2.5%); and 94 in a wide variety of other countries (26.5%). Participants were excluded from the study if they had been diagnosed with any kind of mental health disorder, sleep disorder, or neurological disorder; suspected they *might* have one of these disorders; were experiencing a traumatic or highly stressful life event that was interfering with their sleep; suffered from persistent insomnia or were unable to keep a regular sleep schedule; had experienced sleep paralysis more than once in the past 6 months; found it unpleasant to think about their dreams; or were under 18 years of age. No material incentive was offered. This study was granted ethics approval by the School of Psychology Human Research Ethics Subcommittee at the University of Adelaide. Participants were given an information sheet and then gave informed consent prior to participating.

Materials

Materials included a pre-test questionnaire, logbooks for Week 1 and Week 2, and technique instructions documents. All pre-test, Week 1 logbook and Week 2 logbook measures were hosted online using the survey management website *Survey Monkey*. Instructions were sent via email. In the present paper, pre-test variables are identified by a capital "P" and logbook variables by a capital "L."

Pre-test Questionnaire

Participants indicated their gender, age, occupation, how they heard about the study, their country of residence, and if they had ever participated in a scientific study on lucid dreaming techniques. Retrospective general dream recall was operationalized as *Dream Recall Frequency* (DRF; the percentage of days on which there was dream recall) and measured by asking "How many days during the last week did you remember your dreams from the previous night?" (*P DRF*). Response options ranged from "0 days" to "7 days." Retrospective lucid dreaming rates were operationalized as *Dream Count* (*L DC Lucid per month*; the number of dreams recalled over the past month) and assessed using a question adapted from Brown and Donderi (1986) *Sleep and Dream Questionnaire* (SDQ): "Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing. For example: 'I was in England talking to my grandfather when I remembered that (in real life) he had died several years ago and that I had never been to England. I concluded that I was dreaming and decided to fly to get a bird's eye view of the countryside. . .' Please estimate the number of lucid dreams you have had in the past month." Response options ranged from 0 to 30 or "more than 30" (scale unit = 1, range: 0–20). Participants were asked "Have you ever tried to have lucid dreams by learning and then practicing a lucid dreaming technique?" (*P Lucid tech prior*; "yes" or "no"). Participants were asked, "How often have you practiced a lucid dreaming technique recently (in the past several months)?" (*P Lucid tech freq*). Response options from Schredl (2004) widely used dream recall measure were used (0 = never; 1 = less than once a month; 2 = about once a month; 3 = two or three times a month; 4 = about once a week; 5 = several times a week; and 6 = almost every morning). Responses were converted to the approximate number of days per week using the following class means: 0 = 0; 1 = 0.125; 2 = 0.25; 3 = 0.625; 4 = 1.0; 5 = 3.5; 6 = 6.5.

Logbooks

Participants wrote the date for each logbook entry. This information was used to calculate the number of days taken to complete all seven logbook entries (*L Days to complete log*). The total number of logbook entries was also counted (*L Total log entries*). Participants reported whether they could recall anything specific about their dreams from the preceding night and provided brief titles for each dream they could recall. Using this information, general dream recall was operationalized as both *Dream Recall Frequency* (*L DRF*; the percentage of days on which there was dream recall) and Dream Count (*L DC per day*; the number of dreams recalled each day). Participants also rated how much content they could recall from each dream according to four categories, operationalizing dream recall as *Dream Quantity* (*L DQ*). The measure was developed by Aspy (2016) and is based on an earlier measure developed by Reed (1973). Category ratings are converted to numerical values ("Fragmentary" = 1, "Partial" = 2, "Majority" = 4, "Whole" = 8) and summed (higher scores indicate superior dream recall). The number values 1, 2, 4, and 8 reflect the proportionate increase in dream content associated with the category labels and descriptions, based on qualitative data collected by Reed (1973). Lucid dreaming was operationalized as DRF (*L DRF Lucid*; the percentage of mornings on which lucid dreaming was reported) using the following question: "Did you have any lucid dreams last night? (Lucid dreams are those in which a person becomes aware of the fact that he or she is dreaming while the dream is still ongoing)" ("yes" or "no"). DRF was used instead of DC because participants were unsure of how many lucid dreams they had in some cases, and in other cases lost and regained lucidity within the same dream.

Participants estimated their total time asleep (*L Time asleep*): "How much time in total do you think you spent sleeping last night? hours, minutes." Participants rated their subjective sleep quality (*L Sleep quality*): "On a scale of 1–5, what was the overall quality of your sleep last night?" (1 = "terrible," 2 = "poor," 3 = "okay," 4 = "good," 5 = "excellent"). Participants indicated how tired they felt on waking when they were finished sleeping (*L Tiredness on waking*): "On a scale of 1–5, how tired do you feel this morning?" (1 = "not at all tired," 2 = "slightly tired," 3 = "somewhat tired," 4 = "quite tired," 5 = "very tired"). Participants indicated their level of sleep deprivation from the previous day (*L Sleep dep yesterday*): "On a scale of 1–5, how sleep deprived were you yesterday?" (1 = "not at all," 2 = "slightly," 3 = "somewhat," 4 = "quite," 5 = "very"). This measure was included to assess any potential effect of sleep deprivation on lucid dream induction, e.g., due to a REM rebound effect.

The Week 2 logbooks included additional measures related to lucid dreaming technique practice. All participants were asked "Did you turn on the light when the alarm woke you up to do the lucid dreaming technique?" (*L Light on when awoke*; "yes" or "no"); "Did you get out of bed (including if you went to the toilet) when the alarm woke you up to do the lucid dreaming technique?" (*L Out of bed when awoke*; "yes" or "no"); "How long (approximately) did you spend on doing the technique? minutes." (*L Technique min*); "Did you fall asleep while you were still trying to do the technique?" ("yes" or "no") (*L Asleep during technique*); and "If you answered "no" to the above question, how long (approximately) did it take for you to get to sleep after you stopped doing the technique? minutes." (*L Min back to sleep*). Participants who practiced RT (Groups 2 and 3) were asked "How many reality tests did you perform yesterday?" (blank space provided) (*L Reality tests*). Participants in Groups 1, 2, 3, and 4 that all involved the MILD technique were asked "How many times (approx.) did you repeat "next time I'm dreaming, I will remember I'm dreaming" after the alarm woke you up?" (*L MILD phrase repetitions*). Participants in Group 5 who practiced the SSILD technique were asked "How many fast and slow cycles did you do? Fast, Slow." (*L Fast cycles* and *L Slow cycles*). Participants in Group 6, which involved the hybrid MILD and SSILD technique, were asked "How many cycles did you do after the alarm woke you up?" (*L Hybrid technique cycles*).

Lucid Dream Induction Technique Documents

All participants were advised to print their lucid dream induction technique instructions, keep them beside the bed, spend a full hour familiarizing themselves with them before commencing the study, practice their techniques at least once during the day to ensure understanding, and to revise the instructions directly before bed each night. All participants were instructed to set an alarm 5 h after going to bed, to place the alarm somewhere that would require getting out of bed to turn it off, and to then practice their assigned "Nighttime Technique" when the alarm went off. Based on findings from the NALDIS, the importance of falling asleep quickly after practicing the techniques was emphasized. Participants were advised that if they were falling asleep too quickly, they could try turning the lights on for a few minutes and reading over the technique instructions to increase wakefulness. They were advised to keep the lights off, put the alarm next to their bed, and use a quieter alarm tone if they had trouble returning to sleep. All participants were given instructions on how to perform an RT if they suspected they were dreaming but were not sure. Participants were told not to practice RT during the day except for participants in Group 2 and Group 3 (see section "Group 2: MILD + WBTB + RT Breath" and section "Group 3: MILD + WBTB + RT Hands"). Participants were also given information and advice about sleep paralysis (see LaBerge and Rheingold, 1991; Sleep Paralysis Information Service, 2013; University of Waterloo, 2013). Instructions that were specific to each group are provided below.

Group 1: MILD + WBTB (No RT)

Participants in this group were given a "Nighttime Lucid Dreaming Technique" document that contained instructions for the MILD technique. This involved recalling a dream from directly prior to waking up (or alternatively, any other recent dream), laying down comfortably, and then repeating the phrase "next time I'm dreaming, I will remember I'm dreaming." The importance of strong intention was emphasized. Participants were told to simultaneously visualize being back in the dream they had recalled and noticing something unusual that causes them to realize they are dreaming. They were advised to continue until they felt their intention was set.

Group 2: MILD + WBTB + RT Breath

These participants were given the same MILD instructions as Group 1. They were also provided with instructions for performing a minimum of 10 inhalation RT per day. This involves closing one's lips and then attempting to inhale through the mouth, which is possible in dreams but not while awake (see Aspy et al., 2017).

Group 3: MILD + WBTB + RT Hands

This group was given a different kind of RT from Group 2, which involves attempting to push the fingers of one hand through the palm of the other. This was chosen because it is one of the most widely practiced RT. The ability to push the fingers through the palm indicates that one is dreaming. Participants were advised to also inspect their hands for anomalies during each test.

Group 4: MILD + WBTB (No RT)

Instructions for this group were the same as the instructions for Group 1, with no modifications. The decision to include a second *MILD + WBTB (no RT)* group in Cohort 2 was based on the fact that some participant sample characteristics changed over time during the recruitment process (see section "Preliminary Analyses"). The inclusion of a second *MILD + WBTB (no RT)* group in Cohort 2 permitted valid comparison of the MILD and SSILD techniques.

Group 5: SSILD + WBTB (No RT)

Instructions for the SSILD technique were designed with consultation from the creator of the technique. It was explained that the technique works by conditioning the mind and body into a subtle state that is optimized for lucid dreams to occur, and that it involves performing several "cycles" that each involve the following three steps:

> *Step 1. Focus on Vision*: Close your eyes and focus all your attention on the darkness behind your closed eyelids. Keep your eyes completely still and totally relaxed. You might see colored dots, complex patterns, images, or maybe nothing at all. It doesn't matter what you can or cannot see – just pay attention in a passive and relaxed manner and don't "try" to see anything.
> *Step 2. Focus on Hearing*: Shift all of your attention to your ears. You might be able to hear the faint sounds of traffic or the wind from outside. You might also be able to hear sounds from within you, such as your own heartbeat or a faint ringing in your ears. It doesn't matter what, if anything, you can hear – just focus all of your attention on your hearing.
> *Step 3. Focus on Bodily Sensations*: Shift all of your attention to sensations from your body. Feel the weight of the blanket, your heartbeat, the temperature of the air, etc. You might also notice some unusual sensations such as tingling, heaviness, lightness, spinning sensations, and so on. If this happens simply relax, observe them passively and try not to get excited.

Participants were instructed to first perform four fast cycles (2 or 3 s on each step) and then four to six slow cycles (approximately 20 s on each step). They were told not to count the number of seconds, and that it is important to complete at least four slow cycles. Participants were instructed to fall asleep as normal after completing six slow cycles.

Group 6: SSILD/MILD Hybrid + WBTB

Participants were asked to do only four to six slow cycles (no fast cycles) and to repeat the MILD phrase "next time I'm dreaming, I will remember I'm dreaming" every time they switched to a new sensory modality. The importance of strong intention was emphasized. Participants were not asked to recall dreams or do any visualization.

Procedure

The ILDIS was conducted entirely via the internet, allowing people from around the world to complete the study at home. Participants were directed to a web page about the ILDIS using a URL included in a range of media items (see section "Participants"), where they read the information sheet and completed the pre-test questionnaire. Participants were sent emails with instructions and web URLs for accessing the Week 1 logbooks hosted on *Survey Monkey*. Participants were instructed to complete each logbook entry immediately upon waking, and to not practice any lucid dreaming techniques during Week 1. Participants were given instructions on how to improve their dream recall during both Week 1 and Week 2. Upon completing Day 7 of the Week 1 logbook, participants were sent further instructions, lucid dream induction technique documents, and additional web URLs to access the Week 2 logbooks. Participants were asked to practice the techniques and make logbook entries on consecutive days if possible, but not to practice the techniques if they were sleep deprived. They were instructed to make up for any skipped days at the end. Once sufficient sample sizes had been achieved for the three groups in Cohort 1 (permitting comparison of MILD practiced with and without two kinds of RT), the author began randomly allocating new participants to the three groups in Cohort 2 (permitting comparison of MILD with SSILD and the SSILD/MILD hybrid technique, all without RT). NALDIS group sizes were used as a guide in determining adequate group sizes in the ILDIS.

RESULTS

Preliminary Analyses

Analyses were conducted using IBM SPSS 26 for Windows. Non-parametric tests were used in all cases because most variables were non-normally distributed. There was no significant difference in the proportions of participants who were employed non-students, students, and unemployed or retired who did and did not complete the full study: $\chi^2(2, N = 1615) = 3.43$, $p = 0.180$, $V = 0.05$. The proportion of participants who reported prior experience with lucid dreaming techniques at pre-test was significantly higher for participants who completed the full study (54.9%) compared to those who did not (43.5%): $\chi^2(1, N = 1615) = 14.59$, $p = 0.001$, $V = 0.10$. Mann-Whitney tests indicated that participants who completed the full study had significantly higher general dream recall rates and *P Lucid tech freq* at pre-test. These findings and descriptive statistics for pre-test variables are presented in **Table 1**.

There were no significant differences between Cohort 1 and Cohort 2 on any pre-test, Week 1 or Week 2 variables except for: *P Age* (Cohort 1 $M = 32.4$, $SD = 10.2$; Cohort 2 $M = 37.2$, $SD = 13.4$; $Z = 3.28$, $p = 0.001$, $r = 0.17$); Week 1 *L Sleep quality* (Cohort 1 $M = 3.6$, $SD = 0.5$; Cohort 2 $M = 3.4$, $SD = 0.5$; $Z = 2.10$, $p = 0.036$, $r = 0.11$); and Week 1 *Days to complete log* (Cohort

TABLE 1 | Descriptive statistics for pre-test variables with Mann-Whitney tests for differences between participants who did and did not complete the full study.

Pre-test variable	Completed full study (*N* = 355)	Did not complete full study (*N* = 1260)	Mann–Whitney test		
	***M* (*SD*)**	***M* (*SD*)**	***Z***	***p***	***r***
P Age	35.3 (12.4)	34.5 (12.1)	1.00	0.318	0.03
P DRF	42.8% (28.5%)	38.4% (28.0%)	2.34	0.019	0.06
P DC Lucid per month	1.1 (2.4)	1.5 (3.7)	0.53	0.593	0.01
P Lucid tech freq	0.4 (1.1)	0.3 (1.0)	2.17	0.030	0.05

P, pre-test variable.

1 $M = 7.8$, $SD = 1.5$; Cohort 2 $M = 7.9$, $SD = 6.8$; $Z = 3.95$, $p = 0.001$, $r = 0.21$). There were no significant differences between the three groups within Cohort 1 or within Cohort 2 on these variables. Non-significant test results are not reported for the sake of brevity. Descriptive statistics and Wilcoxon tests of differences between Week 1 and Week 2 logbook variables are presented in **Table 2**. Results showed that participants reported significantly higher *L Time asleep* and significantly lower general dream recall rates, *L Tiredness on waking* and *L Total log entries* in Week 2 of the study compared to in Week 1.

Relationships With Lucid Dreaming

It was hypothesized that general dream recall rates would be positively correlated with lucid dreaming frequency at both pre-test and during Week 2. Spearman rho non-parametric correlations supported the hypothesis and are presented in **Table 3**. All pre-test general dream recall variables were related to *P DC Lucid per month*. Correlations between pre-test general dream recall variables and Week 2 *L DRF Lucid* were weaker but still significant in all cases. All Week 2 general dream recall variables were significantly correlated with both *P DC Lucid per month* and Week 2 *L DRF Lucid*, with the relationships being stronger with Week 2 *L DRF Lucid* in all cases. This pattern of findings highlights the imperative to not treat retrospective and logbook variables of dream recall as equivalent (see Aspy et al., 2017; see also Aspy, 2016). A weak correlation was observed between *P Lucid tech freq* and *P DC Lucid per month* but not with Week 2 *L DRF Lucid*. Pre-test and Week 2 lucid dreaming rates were positively correlated. *P Age* was weakly correlated with *P DC Lucid per month* but not with *L DRF Lucid*.

TABLE 2 | Descriptive statistics and Wilcoxon tests for differences between week 1 and week 2 logbook variables for participants who completed the full study.

Logbook variable	Week 1 (*N* = 355)	Week 2 (*N* = 355)	Wilcoxon test		
	***M* (*SD*)**	***M* (*SD*)**	***Z***	***p***	***R***
L DRF	85.0% (17.9%)	79.8% (28.1%)	2.73	0.006	0.15
L DC per day	1.9 (1.0)	1.7 (1.1)	4.21	<0.001	0.22
L DQ	5.7 (4.4)	5.6 (5.1)	0.50	0.621	0.03
L Time asleep	7.4 (0.9)	7.7 (1.0)	5.14	<0.001	0.27
L Sleep quality	3.5 (0.5)	3.4 (0.6)	1.44	0.150	0.08
L Tiredness on waking	2.34 (0.6)	2.27 (0.8)	2.09	0.036	0.11
L Sleep dep yesterday	1.9 (0.7)	2.0 (0.8)	0.75	0.456	0.04
L Total log entries	6.9 (0.4)	4.6 (2.2)	13.19	<0.001	0.70
L Days to complete log	7.9 (5.4)	7.7 (5.8)	0.85	0.396	0.05

L, logbook variable.

Lucid Dream Induction

It was hypothesized that Week 2 lucid dreaming rates would be significantly higher than Week 1 lucid dreaming rates. This hypothesis was supported. Dependent samples Wilcoxon tests showed that Week 2 *L DRF Lucid* was significantly higher for all participants combined and for each of the six Week 2 groups, with medium to large effect sizes in all cases. These results are presented in **Table 4**. Logbook day was significantly related to *L DRF Lucid* in both Week 1 [$\chi^2(6) = 13.21$, $N = 2448$, $p = 0.040$, $V = 0.07$] and Week 2 [$\chi^2(6) = 28.51$, $N = 1647$, $p = 0.001$, $V = 0.13$], with the tendency for *L DRF Lucid* to decrease slightly over time. Because of the significant difference in *L Total Log entries* between Week 1 ($M = 6.9$) and Week 2 ($M = 4.6$) noted in section "Preliminary Analyses," there were concerns that the Week 2 *L DRF Lucid* rate may be inflated compared to the Week 1 *L DRF Lucid* rate. To control for this issue, analyses were repeated comparing mean *L DRF Lucid* rates based on only the first four logbook days of Week 1 and Week 2. *L DRF Lucid* was again significantly higher for all participants combined and for participants in all six of the Week 2 groups, confirming the effectiveness of the techniques. Independent samples Kruskal-Wallis tests showed that there were no significant group differences within Cohort 1 ($\chi^2 = 1.51$, $p = 0.471$, $r = 0.06$) or Cohort 2 ($\chi^2 = 4.16$, $p = 0.125$, $r = 0.11$) in Week 2 *L DRF Lucid*. The combined *L DRF Lucid* rate for the

TABLE 3 | Spearman rho non-parametric correlations between pre-test and week 2 lucid dreaming rates and other pre-test and week 2 variables.

	P DC Lucid per month	L DRF Lucid (week 2)
P DC Lucid per month	–	0.38**
P Lucid tech freq	0.18**	–0.06
P Age	0.05*	0.10
P DRF	0.33**	0.14*
L DRF (Week 2)	0.15**	0.22**
L DC per day (Week 2)	0.16**	0.31**
L DQ (Week 2)	0.21**	0.30**

*P, pre-test variable; L, logbook variable. Correlations with pre-test variables and L DRF were calculated using mean Week 2 L DRF Lucid values for each participant. Correlations with all other logbook variables were calculated using individual daily observations and are point-biserial. *p = 0.05, **p = 0.01.*

TABLE 4 | Differences between week 1 and Week 2 lucid dreaming rates for all participants combined and for each of the six week 2 groups.

Week 2 group	L DRF Lucid			Wilcoxon test		
	Week 1 *M* (*SD*) (%)	Week 2 *M* (*SD*) (%)	Improvement (%)	*Z*	*p*	*r*
All participants combined (*N* = 355)	5.3 (13.4)	15.8 (25.2)	199.0	8.37	<0.001	0.44
Group 1: MILD + WBTB (no RT) (*n* = 54)	6.5 (16.4)	18.4 (28.7)	185.7	3.12	0.002	0.42
Group 2: MILD + WBTB + RT Breath (*n* = 44)	1.0 (3.6)	10.8 (14.0)	1006.1	3.74	<0.001	0.56
Group 3: MILD + WBTB + RT Hands (*n* = 44)	5.2 (14.5)	13.4 (25.3)	157.3	2.68	0.007	0.40
Group 4: MILD + WBTB (no RT) (*n* = 64)	6.8 (14.7)	20.2 (27.2)	198.0	3.99	<0.001	0.50
Group 5: SSILD + WBTB (no RT) (*n* = 76)	4.7 (10.8)	16.9 (27.2)	258.9	4.43	<0.001	0.51
Group 6: SSILD/MILD Hybrid + WBTB (*n* = 73)	6.3 (15.0)	13.3 (23.3)	109.6	2.71	0.007	0.32

L, logbook variable.

two MILD + WBTB groups that did RT during the day (n = 88, M = 12.1%, SD = 20.4%) was compared to the combined rate for the two MILD + WBTB groups that did not do RT during the day (n = 118, M = 19.4%, SD = 27.8%). Results from a Mann-Whitney test were non-significant (Z = 1.94, p = 0.052, r = 0.14).

Relationships With Technique Practice Variables

Relationships between *L DRF Lucid* and variables that operationalize the way in which the lucid dreaming techniques were practiced were assessed using Spearman rho non-parametric correlations and are presented with descriptive statistics in **Table 5**. All correlations were non-significant except for a weak correlation between *L Fast cycles* performed by participants in Group 5: SSILD + WBTB (no RT) and *L DRF Lucid*. The results remained non-significant in all cases when correlations were repeated for each group individually, except for a weak negative correlation observed between *L Technique min* and *L DRF Lucid* in Group 5: SSILD + WBTB (no RT) (r_s = -0.16, p = 0.013, n = 256).

Participants turned on the light when they awoke to practice lucid dreaming techniques on 467 occasions (28.7%) as opposed to keeping the light turned off. A 2 × 2 Chi^2 test showed that this was not related to lucid dreaming: χ^2(1, N = 1626) = 0.30, p = 0.582, V = 0.01. Participants got out of bed after the alarm went off and before practicing lucid dreaming techniques on 1140 occasions (70.1%) as opposed to staying in bed. A 2 × 2 Chi^2 test showed that this was not related to lucid dreaming: χ^2 (1, N = 1624) = 1.08, p = 0.298, V = 0.03. Participants fell asleep while performing lucid dreaming techniques on 1162 occasions (70.7%). A 2 × 2 Chi^2 test showed that this was not related to lucid dreaming: χ^2(1, N = 1642) = 0.01, p = 0.966, V = 0.01.

A 2 × 2 Chi^2 test was conducted to assess the hypothesis that lucid dreaming rates would be significantly higher when participants took 5 min or less to fall asleep after practicing lucid dreaming techniques compared to when they took more than 5 min to fall asleep. Mean Week 2 *L DRF Lucid* was 17.5% (SD = 38.1%) for 177 occasions when participants fell asleep within 5 min or less, compared to 13.8% (SD = 34.6%) for 275 occasions when participants took more than 5 min to return to sleep. However, this difference was not significant: χ^2(1, n = 452) = 1.14, p = 0.286, V = 0.05. Therefore, these findings did not support the hypothesis. To further explore the hypothesis, another 2 × 2 Chi^2 test was conducted using the criterion of 10 min or less instead of 5 min or less. Mean *L DRF Lucid* was 18.3% (SD = 38.7%) for 263 occasions when participants fell asleep within 10 min or less, compared to 11.1% (SD = 31.5%) for 189 occasions when participants took more than 10 min to return to sleep. This difference was statistically significant: χ^2(1, n = 452) = 4.33, p = 0.037, V = 0.10. When this test was repeated for each of the six groups individually the results were non-significant in all cases. This may be due to insufficient statistical power.

TABLE 5 | Spearman rho non-parametric correlations between Week 2 lucid dreaming rates and variables that operationalize the way in which the lucid dream induction techniques were practiced.

	M (*SD*)	Correlation (r_s) with L DRF lucid
L Reality tests (Groups 2 and 3)	4.1 (4.4)	−0.04
L MILD phrase repetitions (Groups 1, 2, 3, and 4)	13.6 (11.6)	−0.02
L Fast cycles (Group 5 only)	4.0 (2.2)	−0.11*
L Slow cycles (Group 5 only)	5.1 (4.1)	0.08
L Hybrid technique cycles (Group 6 only)	5.1 (2.9)	0.01
L Technique min (all groups)	8.7 (9.2)	−0.02
L Min back to sleep (all groups)	19.5 (52.0)	−0.05

*L, logbook variable. Group 1 = MILD + WBTB (no RT), Group 2 = MILD + WBTB + RT Breath, Group 3 = MILD + WBTB + RT Hands, Group 4 = MILD + WBTB (no RT), Group 5 = SSILD + WBTB (no RT), Group 6 = SSILD/MILD Hybrid + WBTB. All correlations are point-biserial and based on daily observations. *p = 0.05.*

Additional Exploratory Analyses

Mann-Whitney tests were conducted to further explore factors related to the success rate of the lucid dream induction techniques and are presented in **Table 6**. On nights when participants were successful in inducing lucid dreams, they had significantly better sleep quality and significantly higher general dream recall compared to nights when they failed to induce lucid dreams. Participants in Group 5: SSILD + WBTB (no RT) also did more fast cycles on nights when they had lucid dreams. As noted in section "Relationships With Lucid Dreaming," there was no significant correlation between *P Lucid tech freq* and

TABLE 6 | Mann–Whitney tests for differences in week 2 logbook variables between nights when practice of lucid dream induction techniques was and was not followed by lucid dreaming.

Week 2 Logbook variable	Lucid dreaming reported			No lucid dreaming reported			Mann–Whitney		
	n	*M*	*SD*	*n*	*M*	*SD*	*Z*	*p*	*r*
L Reality tests (Groups 2 and 3)	44	9.8	4.0	350	9.7	4.0	0.48	0.629	0.02
L MILD phrase repetitions (Groups 1, 2, 3, and 4)	177	13.8	13.1	1130	13.5	11.4	0.65	0.514	0.02
L Fast cycles (Group 5 only)	58	4.4	4.1	276	4.0	1.5	2.07	0.039	0.11
L Slow cycles (Group 5 only)	58	6.8	8.0	276	4.7	2.6	1.46	0.145	0.08
L Hybrid technique cycles (Group 6 only)	41	5.5	3.9	293	5.0	2.8	0.19	0.852	0.01
L Technique min (all groups)	235	9.4	11.1	1406	8.6	8.9	0.85	0.398	0.02
L Min back to sleep (all groups)	69	17.8	29.4	383	19.8	55.1	1.05	0.293	0.05
L DC per day (all groups)	236	2.8	1.8	1406	1.7	1.5	9.33	<0.001	0.23
L DQ (all groups)	236	10.2	9.9	1406	5.2	6.5	10.54	<0.001	0.26
L Time asleep (all groups)	236	7.8	1.3	1402	7.7	1.3	0.56	0.576	0.01
L Sleep quality (all groups)	236	3.6	0.9	1405	3.4	0.9	2.08	0.037	0.05
L Tiredness on waking (all groups)	236	2.1	1.0	1405	2.3	1.1	1.81	0.070	0.05
L Sleep dep yesterday (all groups)	236	1.9	1.0	1405	2.0	1.1	1.44	0.150	0.04

L, logbook variable. Group 1 = MILD + WBTB (no RT), Group 2 = MILD + WBTB + RT Breath, Group 3 = MILD + WBTB + RT Hands, Group 4 = MILD + WBTB (no RT), Group 5 = SSILD + WBTB (no RT), Group 6 = SSILD/MILD Hybrid + WBTB.

Week 2 *L DRF Lucid*. Further to this, a Mann-Whitney test showed that there was no difference in Week 2 *L DRF Lucid* between participants who had prior lucid dream induction experience (M = 15.3%, SD = 24.9%) and participants without prior experience (M = 16.4%, SD = 25.7%): $Z(355) = 0.75$, $p = 0.454$, $r = 0.04$.

GENERAL DISCUSSION

Participants of the International Lucid Dream Induction Study (ILDIS; N = 355) completed a pre-test questionnaire, a baseline Week 1 logbook period, and then practiced one of six different combinations of lucid dream induction techniques in Week 2. All six technique combinations were effective.

Lucid Dream Induction Techniques

Reality Testing (RT)

No significant correlations were observed between number of RT performed each day and lucid dreaming incidence. This replicates the lack of significant correlations in the RT only and the RT + WBTB + MILD groups of the NALDIS, and the lack of correlation reported by Konkoly and Burke (2019). There was no significant difference in lucid dreaming rate between the MILD + WBTB groups that did and did not perform RT during the day. These findings are consistent with the NALDIS and studies by LaBerge (1988) and Taitz (2011), in which RT was ineffective. It remains possible that RT is effective over longer periods of time, as found for 3 weeks in studies by Purcell et al. (1986) and Purcell (1988), and 8 weeks in a study by Schlag-Gies (1992). Many participants complained that performing RT was burdensome and difficult to remember. This burden may reduce motivation and compliance with more effective techniques when practiced in combination. Lucid dream induction studies should avoid daytime RT unless this technique is of specific interest. The present author believes that RT is still a valuable technique for confirming whether one is dreaming, and as a specialized lucid dreaming practice for cultivating mindfulness, which is associated with lucid dreaming (Stumbrys et al., 2015).

The Mnemonic Induction of Lucid Dreams (MILD) Technique

The MILD technique was effective in four separate experimental groups, two of which involved performing RT during the day. As discussed above, the addition of RT did not result in higher lucid dreaming rates. The weighted average lucid dreaming rate for the four MILD technique groups was 16.5%. This is close to the success rate reported in the NALDIS of 17.4%. These findings replicate the NALDIS and several other studies that have shown the MILD technique to be effective (LaBerge, 1988; Levitan, 1989, 1990a,b, 1991; Edelstein and LaBerge, 1992; Levitan et al., 1992; LaBerge et al., 1994, 2018; Levitan and LaBerge, 1994; Saunders et al., 2017; Konkoly and Burke, 2019). Although there were no statistically significant differences between the effectiveness of the hybrid SSILD/MILD technique and the other techniques in Cohort 2, results show that the overall lucid dreaming rate in Week 2, the improvement in week 2 compared to Week 1, and the effect size were all lowest for the SSILD/MILD hybrid group.

The Senses Initiated Lucid Dream (SSILD) Technique

The SSILD technique was shown to be effective, with a large effect size and a Week 2 lucid dreaming rate of 16.9%. This rate is almost identical to the weighted average rate for the four groups that practiced the MILD technique (M = 16.5%), as well as the RT + WBTB + MILD group of the NALDIS (M = 17.4%). These findings indicate that the SSILD technique is similarly effective for inducing lucid dreams as the MILD technique. There are several possible explanations for how the SSILD technique may induce lucid dreams. One is that repeatedly focusing attention on the visual, auditory and kinesthetic sensory modalities causes a generally increased awareness of perceptual stimuli that persists into REM sleep, making it more likely that the practitioner will notice that they are dreaming, either through generally increased awareness, or through recognition of anomalies within the dream. This could also occur if repeated sensory modality shifts persist upon entering REM sleep. Indeed, one participant reported: "as I was drifting off to sleep, I found myself continuing to do the technique, even though I wasn't trying to." Another possible explanation is that repeatedly refocusing one's attention on different types of perceptual stimuli causes a general increase in cortical activation that increases the likelihood of lucid dreaming.

Predictors and Effects of Lucid Dream Induction

Prior Technique Experience

There was no relationship between Week 2 lucid dreaming and whether participants had ever practiced a lucid dream induction technique, nor with the frequency of practice for those who did have prior experience. This indicates that MILD and SSILD combined with WBTB can be used successfully regardless of baseline lucid dreaming or prior technique experience.

General Dream Recall

In Week 2, lucid dreaming rates were significantly correlated with general dream recall rates. Pre-test lucid dreaming was also correlated with pre-test general dream recall. Furthermore, participants recalled significantly more dreams on nights when lucid dreaming occurred following technique practice. General dream recall was significantly lower in Week 2 compared to Week 1, indicating that the increased lucid dreaming rates cannot be attributed to simply recalling more dreams of all types. Taken together, these findings provide further support for the theory that superior general dream recall is conducive to lucid dreaming (see Aspy et al., 2017) and that general dream recall is a strong predictor of lucid dreaming (see Erlacher et al., 2014).

Technique Practice Variables

Lucid dreaming was not related to any of the variables that operationalized the way in which the lucid dream induction techniques were practiced, except for a weak correlation with the number of fast cycles in the SSILD + WBTB (no RT) group. The explanation for this correlation is unclear. Type 1 error is a likely possibility ($p = 0.039$).

Time Taken to Return to Sleep

In the NALDIS, lucid dreaming occurred 86.2% more often when participants fell asleep within 5 min of completing the MILD technique. This finding was not replicated in the ILDIS. However, upon further exploration, it was found that lucid dreaming occurred 64.9% more often on nights when participants of the ILDIS fell asleep within 10 min (*L DRF Lucid M* = 18.3%) compared to nights when they took more than 10 min (*L DRF Lucid M* = 11.1%). This effect is weaker than in the NALDIS. A possible explanation is that participants of the ILDIS were able to fall asleep more quickly in general due to being given suggestions for how to do this. Notwithstanding, findings from the ILDIS provide further support that lucid dreaming techniques are more effective when one can return to sleep quickly. For the MILD technique, this probably makes it more likely that the mnemonic intention to remember that one is dreaming will be recalled during REM sleep. For the SSILD technique, it may be due to increased cortical activation and/or increased awareness of perceptual stimuli being more likely to persist into REM sleep.

Effects of Lucid Dream Induction on Sleep

Sleep quality was superior on nights when participants successfully induced lucid dreams compared to nights when they failed to induce lucid dreams. Participants also reported significantly more time asleep and significantly less tiredness on waking in Week 2 compared to Week 1. These findings indicate that sleep quality was not adversely affected by successful induction of lucid dreams but may have been adversely affected by unsuccessful attempts. This would be expected if the probability of success is related to the amount of time taken to return to sleep. These findings are consistent with findings from the NALDIS, whereby successful lucid dream induction using the MILD technique was related to the amount of time taken to return to sleep and did not adversely affect sleep quality. Vallat and Ruby (2019) have recently drawn attention to the fact that increasing the frequency of lucid dreams may have unknown negative impacts on the usual processes that occur during REM sleep, due to the fact that lucid dreaming involves a brain state that is neurologically distinct from non-lucid REM sleep. They also raised concerns about potential negative health impacts of the sleep disruption inherent in many lucid dreaming techniques. Soffer-Dudek (2020) raised similar concerns about the effects of lucid dreaming on sleep as well as potential disruptions to reality-fantasy boundaries, which may be of particular concern to clinical populations with disorders such as pscyhosis. More research is needed to investigate the impacts of lucid dreaming generally, and lucid dreaming training specifically, on sleep quality.

Strengths and Limitations

Strengths include the wide range of measures used, the use of measures that operationalized the way in which lucid dream induction techniques were practiced, the comparison of six different lucid dream induction technique combinations, and the large and highly diverse international sample of participants that were mostly employed non-students (71.8%), with nearly equal proportions of people who did (54.9%) and did not (45.1%) have prior lucid dreaming technique experience. Indeed, the ILDIS is the largest study of lucid dream induction techniques to date. As with the NALDIS, the ILDIS has high ecological validity. Participants practiced the techniques in their own homes using written instructions, which reflects how cognitive lucid dream induction techniques are usually practiced. A limitation of the ILDIS is the high attrition rate from the initial sample that completed the pre-test questionnaire ($N = 1618$) to the final sample ($N = 355$). Findings are likely to be most generalizable to people who are highly motivated to learn lucid dreaming. The use of self-report measures is a potential limitation to the findings that lucid dream induction did not adversely affect sleep quality. This is because the excitement of having a lucid dream may have counteracted feelings of tiredness upon waking. Another limitation is that the large number of statistical tests increases the familywise error rate. Results that are only marginally significant should therefore be interpreted with caution.

Directions for Future Research

Further research is needed to gain a deeper understanding of the mechanisms through which the MILD and SSILD techniques work. This may yield potential avenues for refinement. One approach could be to ask participants to describe in detail exactly how they become lucid in each lucid dream, including whether they thought about or practiced the techniques in their dreams prior to becoming lucid. Sleep laboratory research could investigate whether the SSILD technique causes increased cortical activation and whether this activation is correlated with lucid dreaming. Further research is also needed to investigate the effectiveness of practicing the MILD, SSILD and RT techniques over longer periods of time than the single week used in the present study, and the effects of lucid dreaming training on sleep quality.

Findings provide further evidence that superior general dream recall is conducive to lucid dreaming. Thus, it may be possible to increase the effectiveness of cognitive lucid dream induction techniques using drugs and supplements that enhance dream recall. In a small pilot study by Ebben et al. (2002), ingestion of vitamin B6 (pyridoxine hydrochloride) prior to sleep was found to significantly enhance dream recall compared to placebo. In a larger replication study (Aspy et al., 2018), participants recalled 64.1% more dream content when they took 240 mg of vitamin B6 directly before bed compared to placebo. Future research should compare the effectiveness of cognitive lucid dream induction techniques both with and without vitamin B6 before bed.

Currently, the most evidence-based substance for inducing lucid dreams is Galantamine, a widely used and well-tolerated acetylcholine-esterase inhibitor that influences the REM-on neurotransmitter acetylcholine (LaBerge, 2004; Yuschak, 2006; Sparrow et al., 2016, 2018; LaBerge et al., 2018). In the most recent study by LaBerge et al. (2018), lucid dreaming occurred on 42% of nights when participants ingested 8 mg of Galantamine in addition to practicing the MILD technique and, in most cases, using an external LED light stimulation device. According to Yuschak (2006), Galantamine is more effective when combined with Alpha-GPC, a form of choline that acts as a precursor to acetylcholine. It may be even more effective to take vitamin B6 before bed and then a combination of Galantamine and Alpha-GPC during a WBTB period 5 h after going to sleep, before practicing a cognitive lucid dream induction technique such as MILD or SSILD and then returning to sleep within 5–10 min. An external light stimulation device may further increase the success rate (see Mota-Rolim et al., 2019). This combination of cognitive, pharmacological and external stimulation techniques is currently the most promising approach to lucid dream induction.

Future studies should operationalize the way in which lucid dream induction techniques are practiced, use valid and reliable measures of dream recall, and avoid the many methodological limitations of prior lucid dream induction studies (see Stumbrys et al., 2012; Aspy et al., 2017). These methodological issues – especially the inconsistency in the way that lucid dreaming rates are operationalized – are a major impediment to research progress. The present author implores other researchers to, at minimum, report the *L DRF Lucid* rate based on daily logbook observations in all lucid dream induction studies, so that the effectiveness of techniques can be determined and compared (see section "Materials").

CONCLUSION

Findings provide the strongest evidence to date that the MILD technique is effective for inducing lucid dreams. Findings indicate that the SSILD technique is similarly effective. In contrast, RT appears to be an ineffective lucid dream induction technique – at least for short periods such as 1 week in the present study.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the School of Psychology Human Research Ethics Committee at the University of Adelaide. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

DA was the sole author of this study and was solely responsible for all tasks involved. This includes experiment design, experiment management, data collection, data analysis, literature review, and manuscript authorship.

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OPINION
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Key Concepts in Dream Research: Cognition and Consciousness Are Inherently Linked, but Do No Not Control "Control"!

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INTRODUCTION

Whilst lucid dreaming (LD) is defined as being aware of dreaming whilst dreaming, a misconception exists in the public domain as a referral to controlling dream content and plot (Neuhäusler et al., 2018). This misconception reflects a number of widely-held beliefs about the nature of dreaming, which in part this commentary will seek to explain and rectify.

Furthermore, the aim of this piece is to suggest definitions of key concepts in the study of lucid and non-lucid dreaming concerning control, cognition, and consciousness. Whilst superficially there seems overlap between each of these, independent processes, and associated experiences underpin them.

Dreaming

First it is necessary to identify the parameters of "dreaming." Essentially dreaming refers to the recollection of mental content from sleep. This broad definition recognizes that dreams may be fragmented, brief, non-narrative, thought-like, and/or containing basic sensory-perceptual experiences such as emotions, without necessarily comprising complex plots or activity. It also emphasizes the role of memory in accessing experiences, as there are no valid means by which dreams can be sampled, as neither can individuals report on their activity during sleep nor can we independently validate individuals' experiences. Some scholars use "REM" (rapid eye-movement) sleep and "dreaming" synonymously (e.g., Walker, 2009), recognizing that the majority of spontaneously recalled dream reports emerge from REM sleep, and indeed that REM sleep provides the conditions most typical of dreams, such as bizarreness, clearer dream recall, emotionality and, likely, hyperassociativity (Horton and Malinowski, 2015; Malinowski and Horton, 2015; Horton, 2017), in which several distinct memory sources and images can be simultaneously experienced. However, dreams can be sampled easily from non-REM periods, and REM can exist without dreaming (Solms, 2000), thus is it essential to define the parameters of dreaming relevant to each scientific investigation. For instance, if we are interested in cognition and/or consciousness across different periods of sleep, or even across sleep and wake, then the term "mental content" or "mentation" may be more appropriate than "dream," to aid such comparability (Kahan and LaBerge, 2011). If we are interested in characteristics such as emotional intensity or report length, then we need to clarify whether we should focus upon memory recall from sleep or the underlying features of a conscious state such as neurological correlates of such activity.

Next, for explorations LD, or even mere lucidity, researchers need to define and operationalise LD. An awareness of dreaming during dreaming relies on accurate reality monitoring processes (Johnson et al., 1984) as well as unbiased recall. Reality monitoring is typically impaired during sleep, hence making experiences of lucidity rare and interesting. However, in order to engage

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the frontal faculties sufficiently to warrant accurate reality monitoring, an atypical neurological profile is engaged (Voss et al., 2014). It is therefore important to note that lucidity is infrequent and abnormal (Vallat et al., 2018), and as such likely does not reflect "normal" cognition and consciousness during sleep, particularly when extensive training is necessary in order to create pre-requisite conditions for lucidity to emerge (e.g., Baird et al., 2019). Nevertheless, LD can be reliably measured, in laboratory conditions, by asking trained participants to move their eyes systematically whilst lucid (Mota-Rolim, 2020), and it is recognized that LD may provide insights into the nature of consciousness (Baird et al., 2019), albeit in a more artificial than naturally-occurring environment.

The Elements of Cognition vs. Consciousness

As lucidity during sleep relies on heightened metacognitive activity, we need to understand what is meant by cognition during sleep and during wake. Cognition refers to the capacities and capabilities of function, in this case during sleep, in particular the organization, activation and reactivation of memories or experiences that are either familiar or unfamiliar to the dreamer. These processing capacities are notoriously difficult to study at any time, during sleep or wake, as some are so speedy they are automatic and operate beyond conscious awareness (see also the use of the term "offline processing" insofar as describing non-conscious cognitive activity, e.g., Wamsley, 2014). Consequently, it can be apparently tangible for researchers to focus upon the neural correlates of such behavior, to provide evidence for their functional existence (Baird et al., 2019). However, cognitive scientists need to offer theory for the function of such processes, for instance in relation to sleep-dependent memory consolidation (Payne and Nadel, 2004), rather than merely studying activations without considering functional relevance. In dream science, memory activations and predictable patterns of dreaming of familiar aspects of waking life have largely been explored under the Continuity Hypothesis (Schredl and Hofmann, 2003), as well as being observed in relation to other behaviors, such as personality traits (Schredl and Erlacher, 2004), moods, or subsequent performance on cognitive tasks such as problem solving, insight, creativity (Cai et al., 2009; Lewis et al., 2018), composition or recall (Baylor and Cavallero, 2001). Studies of cognition and metacognition during sleep have found that dreaming is not deficient but rather different in only a few ways to waking cognition (Kahan and LaBerge, 2011), with reality monitoring being one of the key different features. Specifically, during most sleep experiences, people cannot determine that their mental experience is internally- rather than externally-generated, consequently dreams feel real. Only in the cases of LD are individuals aware that they are dreaming. However, often the heightened metacognitive awareness is rousing and awakens the dreamer.

Whilst being aware of an experience as being internally- or externally-oriented can be operationalised in cognitive, or metacognitive terms, the conscious experience of that function may be characterized somewhat differently, although some features may overlap with those of cognition. Consciousness may, here, refer to the more characteristic features of sleep mentation, including experiential elements such as the fluidity, continuity over time, presence of specific features or characters and the more holistic nature of mental content. For instance, we may note that non-REM mentation is typically thought-like and brief, containing day residues and life-like references, whereas REM sampled mentation is typically bizarre, story-like and full of activity (Baylor and Cavallero, 2001; Blagrove et al., 2011). These descriptions of sleep mentation could well-reflect underlying cognitive processes such as memory activation, likely forming memory consolidation processes, but the overriding consciousness is more descriptive. The cognitive interests relate to function, and may be measures in those terms, such as extent of activation, which may also include aspects that are non-conscious at the point of experience.

When considering lucidity, the nature of the consciousness may include sensations of awe at realizing one is dreaming, as well as vivid memories of the dream experience itself. This is commonly associated with increased underlying neurocognitive activity. The underlying *cognition*, or hypothetical function, reflects accurate reality monitoring, metacognition, self-awareness and, typically, arousal (from enjoyment of the experience).

Furthermore, in some studies of LD, participants who achieve lucidity may continue to develop the ability to control their actions during dreaming (LaBerge, 1980). Indeed, several studies aimed to achieve this, rather than studying the mere presence of lucidity in more naturalistic or opportunistic settings. Such studies confuse the concepts of lucidity and control, with the former being more likely to occur naturally, and the latter being rare and artificial experiences. As such scholars should be cautious about inferring the nature of consciousness and/or cognition from artificial control-induction techniques, as this likely differs from the profile of mental content emerging from experiences of lucidity.

LD is unusual, relative to the existence of dreaming which, arguably, occurs the entire time that one is asleep (if the present definition of dreaming is adopted, as consciousness continues, even during sleep). Whilst lucid, or controlled, experiences may offer a therapeutic benefit, for instance by allowing individuals to rehearse actions (Stumbrys et al., 2016) or overcome threats (Putois et al., 2019) during sleep, they are typically fleeting, and estimations of their frequency often rely on self-report and retrospective methods (Vallat et al., 2018). Furthermore, inducing lucidity interrupts sleep, which we know is required to facilitate emotion-regulation and memory consolidation processes, which arguably would be more beneficial than any benefits of lucid dreaming anyway (Vallat and Ruby, 2019).

Control

To operationalise lucidity, researchers should take care not to confuse controlling the dream experience with mere awareness of dreaming. We should then define control carefully for instance as voluntarily changing experience. Superficially control may seem to rely upon both a specific cognitive and consciousness profile, however the conscious awareness of control may only become apparent at the time of recall, rather than during the experience itself, and again scholars should take care to identify any potential additional explanatory information offered to a dream report at the point of reporting it, as being distinct from a description of the original experience.

Caution should be urged when considering whether it may be appropriate to recommend that participants control their dreams, given that doing so increases sleep disturbances via awakenings (however, see LaBerge et al., 2018a, who included data from uninterrupted REM sleep only, but see also LaBerge et al., 2018b, for a paradigm in which participants remained awake for 30 min in the middle of the night, which increased LD recall), and also that controlling dream content is unnatural, therefore it may restrict the activation of memory sources and emotions that may underly sleep-dependent memory consolidation (Wamsley and Stickgold, 2011) and emotion regulation (Walker, 2009) processes. Perhaps only in the case of nightmares causing substantive distress, most typically in sufferers of post-traumatic stress disorder, should the possible benefits of reducing distress from terrifying dreams outweigh the likely negative consequences of changing sleep structure and physiology, by restricting the opportunity for "offline" processing (e.g., Putois et al., 2019).

In the occasions of spontaneous ongoing lucidity, whereby the experience does not awaken the dreamer, either the dreamer attempts to understand, or even "interpret" meaning from the typically bizarre dream narrative in which they find themselves, or they attempt to control it in some form during the dream state. The latter, in the case of LD, can be learned in some cases (LaBerge, 1980). Comparable practices during wakefulness demonstrate the ability for some to being able to gain fuller awareness of some typically more automatic behaviors, as depicted by the rise in popularity of mindfulness.

LD is concerning for a number of reasons, as recently outlined by Vallat and Ruby (2019), whereby training to overcome the mental content spontaneously emerging during sleep-dependent cognition ultimately changes and thwarts those processes. Humans likely need to foster the conditions for those processes to occur in order to benefit from the plethora of advantages of sleep.

It seems surprising that LD has received much attention, when time spent dreaming is far greater. Furthermore, the nature of dreaming and consciousness is fascinating, and may provide insights into the nature and perhaps function of underlying cognitive processes. For instance, dream bizarreness, which typifies REM mentation (Revonsuo and Tarkko, 2002; Payne, 2010) and likely results, at least in part, from hyperassociativity of distinct memory sources during sleep (Horton and Malinowski, 2015) may inform an understanding of the activation, fragmentation and re-organization of memory sources as part of sleep-dependent memory consolidation processes (Horton, 2017). Lucidity, however, is highly atypical and therefore arguably cannot offer so much insight.

DISCUSSION

"Control" within LD inherently unnatural and disrupts sleep. Controlled dreams rarely exist spontaneously, either in typical or atypical cognition. Scholars therefore should have the integrity to consider the impact that studies of control may have not only on participants engaging with such studies, but also the wider community who may be attracted to the idea of controlling their dreams. There is a duty to convey that we should not control, control, but instead promote the benefits of sleeping well (Walker, 2019), to afford the opportunity to dream.

Nevertheless, it is important to consider whether LD may have adaptiveness value, especially in the case of emotion processing and/or when the incidence of LD correlates with pathologies. LD may also provide insights into the nature of dreaming, principally by involving the dreamer during the dream (Zink and Pietrowsky, 2015), rather than just afterwards during recall.

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The author confirms being the sole contributor of this work and has approved it for publication.

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Lucid Dreaming Brain Network Based on Tholey's 7 Klartraum Criteria

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Lucid dreaming refers to a dream state characterized by the dreamers' awareness of being in a dream and being able to volitionally control its content. The aim of this study was to describe and model neurophysiological evidence for the seven awareness criteria of lucid dreaming based on those proposed by Paul Tholey. Each of the awareness criteria was analyzed separately with regard to its underlying neurocircuits. We hypothesized that not one, but several regions are involved in the state of lucid dreaming. Our results have shown a satisfactory overlap of the awareness criteria and the brain regions activated. During lucid dreaming, a brain network seems to emerge, that is something other than the sum of its parts. Further research is needed to understand the psychoneurological underpinnings of lucid dreams.

Keywords: Klartraum, lucid dreaming, pre-lucid, consciousness, free will, self-awareness, choice, brain regions

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INTRODUCTION

Lucid dreaming (LD) is a fascinating research topic and has attracted many enthusiasts. Unfortunately, the scientific field is still lacking a comprehensive definition of LD.

The term "lucid dream" was coined by the Dutch psychiatrist Frederik Willems van Eeden (Holzinger et al., 2006) who reported that in lucid dreams, "the reintegration of the psychic functions is so complete that the sleeper reaches a state of perfect awareness and is able to direct his attention, and to attempt different acts of free volition" (Van Eeden, 1913). The phenomenon of LD is generally understood as the fact that a dreamer is aware that he/she is dreaming while dreaming (LaBerge, 1980; Spoormaker and van den Bout, 2006). Tholey and Utecht (1987) defined additional criteria explaining LD, such as awareness of freedom of decision, memory of the waking state, and full intellectual abilities. Gackenbach and LaBerge (1988) expanded the original definition by requiring the dream to be ongoing, because sometimes the dreamer wakes up upon realising his/her state, and that would be defined as a pre-lucid dream (PLD) instead. Deirdre Barrett (1992) in which the following four criteria were examined: (1) the dreamer is aware that he/she is dreaming, (2) objects disappear after waking, (3) physical laws need not apply in the dream, (4) the dreamer has a clear memory of the waking world.

For now, we preserve the definition according to Tholey (1977) and LaBerge et al. (1981). Lucid dreaming is a dream state characterized by the dreamer's awareness of being in a dream and the awareness of choice (LaBerge, 1980a,b, 1985; LaBerge and Rheingold, 1991; Holzinger et al., 2006). Tholey (1980, 1981) however, being a German Gestalt Theorist, called the lucid dream "Klartraum," or "Dream of Clarity" as Holzinger refers to it (Holzinger, 2009). Upon self-exploration of his dreamlife he described seven criteria of a "Klartraum" to be distinguished from a "Non-Klartraum" (Tholey, 1980, 1981). He declared criteria 1–4 as essential for a "Klartraum," while criteria 5–7 are optional and do not make a "Klartraum" by themselves.

1. Clarity that one is dreaming.
2. Clarity about the freedom of choice (for experiments on the topic see: Libet et al., 1983; Fried et al., 1991; Haggard and Eimer, 1999; Soon et al., 2008; Liljenström, 2015; Liljenström and Nazir, 2016; for an overview see: Baumeister et al., 2010; Caruso, 2012).
3. Clarity of consciousness.
4. Clarity about the waking life.
5. Clarity of perception.
6. Clarity about the meaning of the dream.
7. Clarity recollecting the dream.

The seven criteria used in this article are based on Tholey's, however, we used an adapted version (Holzinger, 2014) that fits the Gestalt theory terminology better (Yontef, 1993). We suggest these criteria are more closely related to newer neurophysiological findings and reportings of lucid dreaming experiences. Awareness being a lasting state seems to describe the process of a lucid dream better, compared to a moment of clarity which tends to be momentary. Nevertheless, the following criteria are in its core the same as those proposed by Tholey.

1. Awareness of (spatial) orientation.
2. Awareness of the capacity of choice.
3. Awareness of (intense) concentration – (awareness of "flow" Csikszentmihalyi et al., 2014).
4. Awareness of identity (the "I").
5. Awareness of the dreaming environment.
6. Awareness of the meaning of the dream.
7. Awareness of memory.

Criteria 1 refers to the self-reflective capacity to appreciate the dream as a dream, by recognizing the dream environment and localizing oneself in it. As Tholey stated, the consciousness of being in a dream (or in our case orientation) is not sufficient for a dream to become lucid. The capacity of choice is what changes a dream (Tholey, 1980). Therefore, we suggest that awareness criteria 1 and 2 are crucial for the experience of LD. If only 1 awareness criteria applies, we should be speaking of a PLD (Green, 1968) since all imply some level of self-reflective capacity which in turn can lead to further cognitive capacities. Awareness criteria 5–7 are not essential for the definition for the PLD, LD and "Klartraum," but can be part of a PLD (distinguishing the PLD from the non-lucid dream), the LD and the "Klartraum" (Holzinger, 2004), describing this extraordinary state and its potential. The definition of LD is still a work in progress and we hope that the discussion about the definition of a pre-lucid, a lucid dream and Klartraum will gain momentum in the scientific community.

Additionally, we would like to propose the value of the seven awareness criteria of LD/ "Klartraum," tracing back to Tholey (1977, 1980, 1981) in another field of research regarding lucid dreaming, namely the search for correlations of the LD state with specific cortex activation patterns of the brain. Our proposition here is that the "lucid" experience requires changes not in one but several areas of the cortex, and consequently the emergence of a brain network. Lewes (1875) defines emergence as follows: "The emergent is unlike its components insofar as these are incommensurable, and it cannot be reduced to their sum or their difference" (p. 413). It therefore occurs when an entity is observed to have properties its parts do not have on their own and in this case, the brain network is the new entity. Therefore, we assume a model of brain activation on the basis of the seven awareness criteria first described by Paul Tholey, and call it the "lucid brain model," trying to integrate the varying results of research projects within the last decades.

First, former findings regarding the general difference in brain activity during REM sleep and LD will be discussed, the matter of consciousness in LD will be introduced, and finally neuroscientific evidence for each of our seven proposed awareness criteria will be presented.

A BRAIN NETWORK IN LUCID DREAMING

From a Non-lucid to Lucid Dreaming Network

There has been a great deal of speculation about the nature of changes during sleep in the known networks identified by fMRI resting state functional connectivity studies (for an overview see Raichle et al., 2001; for reviews see Fox et al., 2013; Picchioni et al., 2013; Pace-Schott and Picchioni, 2017; Baird et al., 2019). Although the review by Baird et al. (2019) is the only one dealing directly with lucid dreaming, other studies, particularly those examining REM (Fox et al., 2013) have relevance to network-based theories on what is happening during lucidity.

During REM sleep, neural activity in the *brain stem*, *thalamus*, *amygdala*, and *extrastriate temporo-occipital cortices* increases, while other structures such as the *dorsolateral prefrontal cortex* and the *precuneus* show deactivation (Dresler et al., 2012). Hobson and Pace-Schott (2002) have theorized that this activity pattern might reflect visual hallucinations, emotional intensifications, and cognitive abnormalities typically experienced in dreams (Dresler et al., 2012). Deeper areas of the brain (limbic system, memory structures, arousal system) continue to play a role during the lucid dream state but will not be discussed in this article. We focus on those areas reactivated during LD in contrast to non-lucid REM sleep, especially frontal brain regions (Hobson and Pace-Schott, 2002). This recovery of reflective cognitive capabilities is likely to be the hallmark of LD (Dresler et al., 2012). Lucid dreamers report being in possession of all their cognitive faculties (Carskadon, 1995) and recent quantitative EEG data findings support the theory that the "wake-like intellectual clarity is paralleled by neural activations in frontal and frontolateral regions" (Dresler et al., 2012). Voss et al. (2018) found that lucidity was accompanied by an increased activation of the *frontal lobes* compared to regular REM-sleep dreams, regarding both synchronicity and consciousness-related frequencies (40 Hz). PET data also shows cognitive control in dreams to be associated with an activation of certain *frontal cortex* components (Shapiro et al., 1995). However, this does not imply that non-lucid dreams completely lack activation in *frontal regions*. Siclari et al. (2017) found that high-frequency frontal EEG activity (20–50 Hz) is higher in dreams that involve "thinking" rather than "perceiving" – which should be more often the case in LDs compared to non-lucid dreams, while parietal activation is higher in "perceiving" dreams. *Frontal lobe* functions include various tasks such as future planning, self-management and decision making, the integration of information from various sources, processing thoughts into words, voluntary movement, categorizing and making sense, forming memories, manage attention, impulse control, personality and empathy. Koch et al. (2016) on the other hand suggest that while frontal brain regions might be involved in directing attention or monitoring and co-vary with consciousness, the conscious experience itself relies on a temporo-parietal-occipital cortical "hot zone." Therefore, increased activation of the frontal brain regions and temporo-parietal-occipital regions during LD compared to non-LD seem to have numerous effects on conscious awareness, influencing all seven components.

Conscious Awareness During Lucid Dreaming

At this point, we would also like to emphasize the notion of consciousness in sleep regarding the understanding and the consequent definition of LD as Harry Hunt did in 1995 (Hunt, 1995) and Jennifer Windt in 2011 (Windt and Noreika, 2011).

Consciousness during regular dreams is thought to be mostly primary, or "characterized by a primitive, animistic style of thinking" (Carhart-Harris and Friston, 2010; Hobson and Voss, 2010). William James claimed that reflective awareness is an immanent part of the waking state while dreaming on the other hand lacks this capacity (James, 1981) and other influential dream researchers supported this theory (Freud, 1960; Hobson, 1988). However, newer findings suggest that rational thinking can be part of non-lucid dreaming as well (Cavallero and Foulkes, 1993) and dreams may be accompanied by a varying degree of insight and subjective control (Voss et al., 2018). Dresler et al. (2014) found that experienced volition was significantly higher during waking state and LD compared to non-lucid dreaming, and that the expression of different aspects of consciousness varies across states: while planning ability was most pronounced during wakefulness, intention enactment was most pronounced during LD, and self-determination most pronounced during both wakefulness and LD. Currently, there is no consensus whether dreaming cognition differs greatly from waking cognition, however, even during a mind wandering waking state, executive *prefrontal cortex* (PFC) regions are significantly more activated than during REM-sleep dreams (Fox et al., 2013).

We do suspect different stages of consciousness and a lucid dreamer does show higher cognitive abilities and reflective awareness than a non-lucid dreamer overall. Empirical data supports the assumption that LD may be defined as a hybrid state, which is still partially ruled by lower level consciousness (Voss et al., 2009; Dresler et al., 2012; Voss et al., 2018). This might be the reason that lucid dreams are "happening" as a result of the subconscious, instead of being "created" in the first place. Like all dreams, they are a reflection of ourselves and our lives. Both lucid and non-lucid dreams may involve a "thinking" dimension as well as a "perceiving" or "experiencing" dimension.

Two brain networks have been proposed in the study of consciousness, which seem to anti-correlate and cause a shift between externally and internally directed awareness (Fox and Raichle, 2007): the *Default Mode Network* (DMN; Raichle et al., 2001) and the *Dorsal Attention Network* (DAN; Corbetta et al., 2000). When the attention system is more active the organism's attention is shifted to external stimuli, and conversely, when the DMN is more active the attention shifts inwards, e.g., to mental imagery (memory reprocessing or future imagination). Paradoxically, the inward shift of attention does not imply an increase in interoceptive sensations (e.g., taste, smell, digestion, pain) but only a shift to imagined visual and auditory content relative to actual empirical content (Pace-Schott et al., 2019). Recently, a third network has been introduced which could explain the emergence of lucidity, the *Frontoparietal Control System*, which seems to integrate information from DMN and DAN (Vincent et al., 2008). The DMN includes the *precuneus*, the *medial prefrontal cortex* (mPFC), and the *left and right inferior parietal cortices* (Raichle et al., 2001) while the DAN is comprised of the intraparietal sulci and frontal eye fields. The LD state seems to arise when DMN and executive functions are active at the same time. The *executive control network* (ECN) including *dorsolateral PFC*, *intra-parietal sulcus*, the salience network (*anterior insula* and *orbitofrontal cortex*), and the cingulo-opercular network (including *anterior cingulate* and *frontal operculum*) is a structure responsible for executive functions and might play a role in LD (Dosenbach et al., 2006).

Awareness of (Spatial) Orientation

High frequency activity in the *right posterior parietal cortex*, a region active during spatial perception and visuospatial attention, was associated with the report of a spatial setting in dreams (Siclari et al., 2017). Dream experience in which the dreamer reports a sense of movement were shown to be associated with an increase in high-frequency activity in the area of the *right superior temporal sulcus* (Siclari et al., 2017). This region is involved in the perception of motion and in viewing body movements. Dresler et al. (2012) found activation in the *bilateral cuneus* and *occipitotemporal cortices* during LD. These areas are part of the ventral stream of visual processing, which is involved in several aspects of conscious awareness in visual perception (Rees et al., 2002). According to Dresler et al. (2012) these findings support an exceptional brightness and visual clarity of the dream scenery which have been reported by lucid dreamers. Furthermore, Holzinger et al. (2006) found increased *parietal beta activity* during LD. One specific part, the *temporo-parietal* *area*, integrates visual, tactile, proprioceptive and vestibular information, and therefore contributes to self-consciousness and own-body imagery (Blanke and Mohr, 2005). If this region is disrupted during waking with magnetic or electrical stimulation, out-of-body experiences can be induced, which are defined as a subjective sensation of being outside one's own body and may occur with or without viewing the own body (Blackmore, 1982; Blanke and Mohr, 2005). These results, together with the higher activation of meta-cognitive brain areas, possibly supply evidence for the awareness of spatial orientation, the awareness of the dream environment, and the option to navigate in it. This includes the awareness of being in a dream – which is Tholey's first criteria but is also inherent to our first awareness criteria.

Awareness of the Capacity of Choice/Deciding/Expectation/of Being in Charge

Lucid dreamers are often able to act voluntarily within the dream upon reflection or in accordance with plans decided upon before sleep (Carskadon, 1995). However, Stumbrys et al. (2014) have shown that lucid dreamers are only able to remember their intentions half of the time, with half of those remembered intentions being successfully executed. The *right dorsolateral PFC* has been associated with self-focused metacognitive evaluation (Schmitz et al., 2004). Metacognition in this case refers to the "awareness of the awareness," or higher order consciousness, which is present in LD (Sinclair, 1922; Voss et al., 2018). This might explain the capability of making choices. Furthermore, meta-cognitive evaluation might be the reason for being aware of one's identity and metacognition includes metamemory, the awareness of one's memory. The increased activation of the *right dorsolateral PFC* during LD compared to non-LD could be essential for lucidity and has been documented in empirical studies (Nofzinger et al., 1997; Voss et al., 2009; Dresler et al., 2012). Dresler et al. (2012) further observed that *bilateral frontopolar areas* are activated during LD. The *frontopolar cortex* (FPC) has been related to the processing of internal states, e.g., the evaluation of one's own thoughts and feelings (Christoff et al., 2003; McCaig et al., 2011). While emotionality in normal REM sleep dreams usually resembles "unconscious affect," referring to "valenced good/bad reactions that occur in the absence of conscious awareness" (Winkielman and Berridge, 2004) the *ventrolateral PFC* is reactivated during lucid dreams and seems to increase self-conscious emotions and a down-regulation of unconscious affect (Clore and Ketelaar, 1997) resulting in reduced negative (and perhaps overall) emotionality compared to normal dreams (Voss et al., 2018). These findings might explain why lucid dreamers are willing to change dream content. Since they become aware of the negative feelings a dream provokes, they try to change it into something more cheerful. FPC activity has also been correlated with a diverse range of other cognitive processes, including multitasking, implementing task sets, future thinking and prospective memory, exploratory decision making, deferring goals and cognitive "branching," episodic memory retrieval and detailed recollection, evaluating counterfactual choice and facing uncertainty or conflict, complex relational and abstract reasoning, integrating outcomes of multiple cognitive operations, coordinating internal and external influences on cognition, evaluating self-generated information (Boschin et al., 2015). The possible activation of all these cognitive processes during LD might explain the awareness of the option to make sound choices based on thoughts, emotions and memories and individual preferences.

Awareness of (Intense) Concentration – A State of "Flow"

Lucid dreaming is characterized by a reflection on one's own state of mind and not driven by the attention to the external dream scenery, which might lead to a state of more intense concentration or even "flow experience." Like in an awake flow state, the dreamer is completely absorbed in their current activity, and has a sense of personal control or agency over the situation or activity, as compared to a state of confusion or semiconsciousness (Tholey, 1981). Additionally, Voss et al. (2018) found that LD differs from non-lucid dreams regarding the positivity of emotions, which might be relevant since the "flow" state is experienced as a very positive one. The flow experience as well as LD are accompanied by hormonal reactions, including norepinephrine, acetylcholine, dopamine, and serotonine (Yuschak, 2006). Acetylcholine has been shown to enhance cognitive function and learning ability and can also enhance LD (Bazzari, 2018; LaBerge et al., 2018). It seems to do so by allowing you to move directly from the waking state into a vivid dream state without losing consciousness (Yuschak, 2006). Dopamine plays an important role in dream recall for REM-dreams (De Gennaro et al., 2016) and might increase the control that a dreamer has within a lucid dream by substantially increasing confidence and motivation levels (Mohebi et al., 2019; Yuschak, 2006). Together with norepinephrine it boosts focus, increases the ability to connect and integrate information, facilitates pattern recognition and problem solving – in case of LD, it might also enhance the ability to recall details and memories from waking life while within the dream (Yuschak, 2006). This allows maintaining constant attention on accomplishing any goals, experiments, or other assignments that you have prepared for the dream. Yoshida et al. (2014) found that during a flow state, the concentration of oxygenated hemoglobin (oxy-Hb) was significantly increased in the *right* and *left ventrolateral PFC*. They also found a significant increase in oxy-Hb concentration in the *right* and *left dorsolateral PFC*, *right and left frontopolar areas*, and *left ventrolateral PFC* while participants were filling out the flow state scale after performing a task in the flow condition. These areas have been found to show increased activation during LD, which supports the LD-flow hypothesis. In conclusion, flow is associated with activity of the PFC, and may therefore be associated with functions such as cognition, emotion, maintenance of internal goals, and reward processing. Therefore, the flow experience shares many characteristics with the LD state.

Awareness of Identity – The "I" Without Which There Would Be No Dialogue

Studies have found that lucidity is related to a change on the degree of self-related processing and the type of self-presentation (Metzinger, 2004; Windt and Metzinger, 2007). Self-awareness is thought to be supported by the DMN, its activation leads to an inward shift of attention and has been found to be a hallmark of the REM dreaming state. Accordingly, Dresler et al. (2012) found that the strongest increase in activation during lucid compared to non-lucid REM sleep happened in the *precuneus*. This brain region is also a part of self-referential processing, such as first-person perspective and experience of agency (Cavanna and Trimble, 2006). Holzinger et al. (1998) found that the *left parietal lobe* was also more activated during LD, that area of the brain being related to semantic understanding and self-awareness. The *insula* is another relevant brain structure that lays between frontal, parietal and temporal cortex. Its functions are still investigated, but seem to include control of conscious awareness, motor control, perception and self-awareness (Craig and Craig, 2009). We suggest that this area of the brain might also play a role in LD, however, this is only speculative and requires further exploring. The awareness of the "I" is of course closely related to the awareness of memory, explained in section "Awareness of Memory," which determines to a great part what the dreamer might decide, wish for or act upon when able to take control of the dream.

Awareness of the Dreaming Environment

The awareness and memory of a spatial dreaming environment can be part of non-lucid dreams as well, and is associated with high frequency activity in the *right posterior parietal cortex* (Siclari et al., 2017). However, while regular REM-sleep dreams usually involve an activation of the DMN and not the DAN, during LD, a higher connectivity between those networks evolves and the *Frontoparietal Control System* starts to integrate information from both. Awareness of the environment may be supported by this collaboration of DAN and ECN and the connectivity between frontal and parietal nodes in DAN, DMN, and ECN seems to reflect consciousness that is required for information integration (Picchioni et al., 2013). Together with those findings discussed in section "Awareness of (Spatial) Orientation," the awareness of the dreaming environment during LD might be explained.

Awareness of the Meaning of the Dream

General frontal activation might be the reason for the ability to add meaning to a dream by integrating memory, identity and the dreaming environment into a whole. Based on empirical and theoretical findings, we suggest that a dream becomes meaningful by an integration of emotional content (limbic system), memory (hippothalamus and related structures) and brain structures involved in identity (see section "Awareness of Identity—the "I" Without Which There Would Be No Dialogue"). This might be possible due to an activation of the DMN and executive functions returning when accessing the state of LD compared to non-LD.

Furthermore, meaning is typically added to something by using words, categories and logical thought. Several areas of the *parietal lobe*, which is more active during LD, are important in language processing. The left *parietal-temporal* areas have been found to be relevant for verbal memory and the ability to recall strings of digits (Warrington and Weiskrantz, 1978). *Insula* activity increases in case of unclear images and perceptive input (Lamichhane et al., 2016). We suggest that the *insula* might enable the lucid dreamer to make sense of the dream images. Furthermore, the *insular cortex* plays a role in developing a sense of the physiological condition of the entire body (introception) by collecting internal cues such as the beating of the heart, and related signals provide a basis for time perception (Craig, 2009). Üstün et al. (2017) found activity in the *right dorsolateral prefrontal* and *right intraparietal* cortical networks, together with *the anterior cingulate cortex* (ACC), *anterior insula* and *basal ganglia* during time perception. Meta-cognitive abilities, language processing, as well as time perception might play a role when adding meaning to a dream.

Awareness of Memory

Lucid dreamers are often able to remember previous LD experiences as well as the conditions of their waking life (Holzinger et al., 2015). Dresler et al. (2012) found the *dorsolateral prefrontal cortex* and *parietal lobules* to be active during LD, which may reflect working memory demands (Smith and Jonides, 1998). In normal dreams, on the contrary, working memory is strongly impaired (Hobson and Pace-Schott, 2002). The activation of the working memory could allow lucid dreamers to analyze the dream content in relation to their identity, memory and dream environment and decide and plan behaviors according to individual preferences. Ogilvie et al. (1978) found a global increase in the percentage of alpha band (8–12 Hz). This supports the hypothesis that LD is an intermediate stage between REM-sleep and waking. Alpha waves are typical for a state of relaxation and focus and are ideal for learning and memory retention (Makada et al., 2016). In this case, however, follow-up EEG studies found no significant differences in alpha power (LaBerge, 1988) or that only PLDs differed in alpha-power (Tyson et al., 1984).

DISCUSSION

For each of the seven awareness criteria of lucid dreaming proposed, neurological evidence was collected. A visualization of our results can be seen in **Figure 1**. The most prominent feature of LD is the reactivation of brain areas that are inactive during regular REM-sleep dreams, which seem to explain the recovered awareness and consciousness of lucid dreamers. Awareness criteria nos. 1 and 2, the awareness of orientation and the awareness of being in charge, were considered essential for the experience of LD and accordingly, activation of relevant brain areas seems to exist. As Koch et al. (2016) suggested, multiple brain areas are involved in conscious experience, which include several frontal areas and a "posterior cortical hot zone." The suggested emergence of a cortical network also points to brain plasticity and the fact that lucid dreaming can be learned and made easier by practicing. However, the findings presented above are not definite and should be further explored in the future. We do not want to imply that this attempt of explaining the underlying network of LD is the only or the best approach. Most studies used for reference have relied on small sample sizes, show low statistical power, discrepant results, and electrode montages

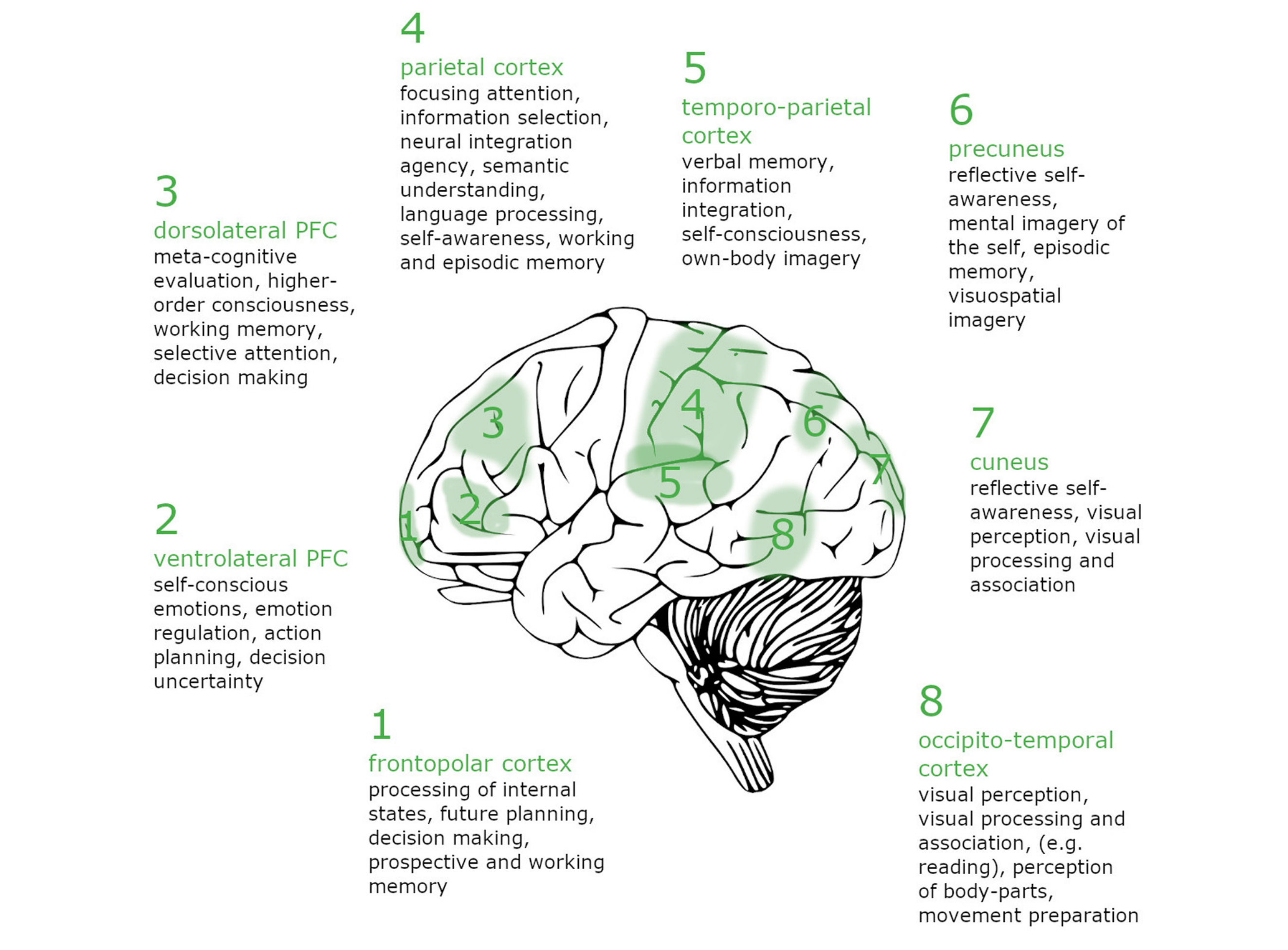

FIGURE 1 | Brain regions showing increased activity during lucid REM sleep contrasted with non-lucid REM sleep. Assignment of awareness criteria to brain regions: (1) Awareness of (spatial) orientation: 4, 5, 7, and 8; (2) Awareness of the capacity of choice: 1, 2, and 3; (3) Awareness of (intense) concentration – awareness of "flow": 1, 2, and 3; (4) Awareness of identity (the "I") : 4 and 6; (5) Awareness of the dreaming environment : 3, 4, 5, 7, and 8; (6) Awareness of the meaning of the dream : 1, 3, 4, and 5; Awareness of memory: 1, 3, 4, 5, and 6.

in EEG studies were limited. Mota-Rolim et al. (2010) suggest that different subjective experiences and contents during lucid dreams might show different neurological activation. Changes in EEG might also depend on the LD experience of the dreamer and the vividness of a dream, individual working memory, emotionality, self-consciousness, as well as levels of attention and insight (Baird et al., 2019). As preliminary findings suggest, part of the observed activation of regions of *anterior prefrontal*, *parietal* and *temporal cortex* might not result from LD itself, but from the eye-signaling and hand-clenching task performed to signal lucidity, which also requires task-switching and sustained attention. Finally, we want to raise awareness for possible risks that might arise when practicing LD. While lucid dreaming can be a helpful tool in treating nightmares, depression or anxiety (Reynolds et al., 2006; Spoormaker and van den Bout, 2006; Doll et al., 2009; Holzinger et al., 2015) lucid dreams are also related to dissociative states, and phenomena like sleep paralysis, nightmares, or even psychosis or psychosis-like states might emerge in some cases (Holzinger, 2014; Aviram and Soffer-Dudek, 2018).

CONCLUSION

Lucid dreaming has the ability to increase awareness and control of the dreamer. Neurological evidence seems to support the seven awareness criteria suggested by Holzinger. During LD, not a single brain structure, but a whole network of brain regions is activated. In this study, we hypothesize that the awareness criteria of LD proposed by Holzinger can be supported by empirical data. However, we want to make clear that we do not claim that this theory has already been proven, we merely use former findings to form our theory. Instead, we wish to push along further research based on Tholey's theoretical concept. We think that theoretical and practical works regarding lucid dreaming make this approach very promising. Lucid dreaming shows potential as a methodology in the cognitive neuroscience of consciousness as well as psychotherapy (Zadra and Pihl, 1997; Holzinger, 2014; De Macedo et al., 2019). However, there is still substantial disagreement with regard to the brain regions and frequency bands most activated during lucid dreaming and how they correlate with the theoretical base of lucid dreams. Further research is needed.

AUTHOR CONTRIBUTIONS

BH and LM conducted the literature search, selected the eligible studies, and drafted the manuscript. Both authors confirm being the only contributors of this work and approved it for publication.

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BRIEF RESEARCH REPORT
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Cognitions in Sleep: Lucid Dreaming as an Intervention for Nightmares in Patients With Posttraumatic Stress Disorder

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About 80% of posttraumatic stress disorder (PTSD) patients suffer from nightmares or dysphoric dreams that cause major distress and impact nighttime or daytime functioning. Lucid dreaming (LD) is a learnable and effective strategy to cope with nightmares and has positive effects on other sleep variables. In LDs, the dreamer is aware of the dreaming state and able to control the dream content. The aim of this study is to evaluate the effectiveness of lucid dreaming therapy (LDT) in patients suffering from PTSD. We suggest that learning a technique that enables the affected subjects to regulate the occurrence and content of nightmares autonomously increases the chance of coping with the complex symptoms of PTSD and can reduce suffering. Sleep quality (PSQI, Pittsburgh Sleep Quality Index), daytime sleepiness (ESS, Epworth Sleepiness Scale), quality of life (MQLI, Multicultural Quality of Life Index), psychological distress (SCL-90-R, Symptom Checklist 90-Revised), distress caused by traumatic events (IE-S, Impact of Events Scale), anxiety (SAS, Self-Rating Anxiety Scale), depression (SDS, Self-Rating Depression Scale), and nightmare severity were assessed in a self-rating questionnaire before and after the intervention. LDT had no effect on the investigated sleep variables. No correlation between reduction of nightmare severity and changes in PTSD-profile (IE-S) was found. Nevertheless, levels of anxiety and depression decreased significantly in the course of therapy. LDT could provide an alternate or complementary treatment option for nightmares in PTSD, specifically for symptoms of anxiety and depression.

Keywords: sleep quality, therapy, anxiety, depression, posttraumatic stress disorder, lucid dreaming

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INTRODUCTION

Nightmares are vivid dream experiences loaded with anxiety or fear, which typically occur during rapid eye movement (REM) sleep and less commonly during N2 sleep (American Academy of Sleep Medicine, 2014). Common themes include failure and helplessness, physical aggression, accidents, being chased, health-related concerns and death, and interpersonal conflicts (Robert and Zadra, 2014; Schredl and Göritz, 2018). If these dysphoric dreams recur with enough frequency, cause major distress and impact nighttime or daytime functioning, they may be classified as nightmare disorder (American Academy of Sleep Medicine, 2014). According to the International Classification of Sleep Disorders, Third Edition (American Academy of Sleep Medicine, 2014), minimal diagnostic criteria are as follows: (1) the patient suffers from repeated episodes of extended, extremely dysphoric, and well-remembered dreams that usually involve threats to survival, security, or physical integrity; (2) on awakening from the dysphoric dreams, the person rapidly becomes oriented and alert; and (3) the dream experience itself or the sleep disorder resulting from it causes significant distress or impairment in social, occupational, or other important areas of functioning. Thorough diagnosis is necessary to assess potential comorbidities like depression and other psychiatric disorders or contributing factors such as medications, substances, and recent or past stressful life events.

Affecting about 4% of the adult population (Levin and Nielsen, 2007) and up to 20% of children and adolescents (American Academy of Sleep Medicine, 2014), frequent nightmares are quite common and have a big impact on quality of life, daytime sleepiness, fatigue, and anxiety. Nightmare distress can lead to problems at work, social and cognitive impairments and was even associated with a higher suicide risk (Nadorff et al., 2018).

Zadra and Donderi (2000) and Robert and Zadra (2014) explain the formation of nightmares as a combination of a certain affect load and the disposition to experience heightened distress and negative affect. With respect to brain physiology, nightmares are suggested to be a result of heightened amygdala and hippocampus activation and a failure of prefrontal regions to dampen this activation of the limbic system (Levin and Nielsen, 2007). This activity pattern is typical for REM sleep and might reflect visual hallucinations, emotional intensifications, and cognitive abnormalities (Hobson and Pace-Schott, 2002). Whereas REM sleep is characterized by wake-like high-frequency electroencephalographic activity (Siclari et al., 2017), reports of dream experiences are also associated with a decrease in low-frequency EEG in posterior cortical regions in both REM and NREM sleep (Siclari et al., 2017).

Nightmares are more prevalent during periods of stress and can emerge in association with traumatic experiences, as in posttraumatic stress disorder (PTSD; Zak et al., 2019). PTSD is the delayed and protracted reaction to a traumatic event or situation, which is likely to cause pervasive distress in almost anyone (World Health Organization, 1992). About 80% of the general population experiences at least one relevant trauma throughout their lives (NIH, 2012), and lifetime prevalence of PTSD is considered to be 7.4%. The disorder is defined by a tendency to avoid people, places, memories, and other stimuli related to the traumatic event, as well as recurrent distressing memories of the event and alterations in mood and hyperarousal (American Psychiatric Association, 2013). Additionally, about 80% of PTSD patients suffer from nightmares (Morgenthaler et al., 2018) which are often emotionally related to the original trauma (Nadorff et al., 2014). Nightmares related to PTSD are equally likely to arise during N1/N2 and REM sleep (Phelps et al., 2018).

Since nightmares represent a chronic and persistent symptom of PTSD and cause major distress by themselves, various treatment options have been discussed. The American Academy of Sleep Medicine listed six cognitive behavioral therapy (CBT) methods as suitable for the treatment of nightmares: imagery rehearsal therapy (IRT), systematic desensitization, lucid dreaming therapy (LDT), exposure, relaxation, and rescripting therapy (ERRT), sleep dynamic therapy, and self-exposure therapy (Aurora et al., 2010). Although each therapy approaches the treatment for nightmares differently, they all conceptualize nightmares as a learned response that can be modified by specific cognitive and behavioral strategies. Hypnosis has also been found to provide fast and effective help by addressing the underlying issue of nightmares (e.g., Eichelman, 1985). Pharmacological approaches to control nightmares include prazosin and selective serotonin reuptake inhibitors. All non-pharmacological techniques target the nightmare's content during wakefulness, with the exception of LDT, which enables the dreamer to modify the dream content while dreaming.

Lucid Dreaming Therapy

Lucid dreaming (LD) is defined as the awareness of being in a dream and the ability to volitionally control its content (Holzinger, 2008). LD is characterized by a recovery of reflective cognitive capabilities associated with the reactivation of frontal and frontolateral brain regions (Dresler et al., 2012).

LDT can be summarized as a cognitive-restructuring method which can be applied in the state of dreaming. By learning this technique, the dreamer becomes aware and able to actively influence the dream's content. This approach delivers a new access on how to cope with nightmares, as LDT allows to alter the story line of the nightmare during the dream phase. LDT has been shown to be effective in narcoleptic patients suffering from PTSD (for a review, see Schiappa et al., 2018). Harb et al. (2016) investigated the relationship between posttraumatic nightmares and the effects of LD, when included in an IRT. In a group of military veterans, they found that the increase of dream content control, as an aspect of LD, led to a reduction in nightmare distress and consequently seemed to contribute to the therapeutic change with IRT. Zadra (1997) and Spoormaker and van den Bout (2006) found that, compared to baseline and waiting-list conditions, not only did the frequency of nightmares decrease significantly, but the quality of sleep increased and PTSD symptoms were alleviated (Krakow et al., 2001), suggesting that LDT may be a helpful therapy. LD has been investigated in adults (Schredl et al., 2012) but studies that examine nightmares under psychological and physiological aspects at the same time are scarce. This can be explained on the one hand by the high costs of polysomnographic recording and on the other hand through the lack of nightmare exploration in sleep laboratory studies. Several studies have demonstrated the positive effects of LDT on nightmare frequency (Spoormaker and van den Bout, 2006) and improvement of quality of sleep (Holzinger et al., 2015). Unfortunately, it often remains unclear which of several investigated variables caused this effect or if there are interactions between them. For example, some participants reported having fewer nightmares although they never became lucid (Gavie and Revonsuo, 2010). Furthermore, the number of participants is often small and may not be representative due to drop-outs, recruitment practices, or similar. On a side note, caution should be taken when dealing with psychotic patients, since there seems to be a risk of LD empowering deliria and hallucinations (Mota et al., 2016). Aside from these exceptions, LD could provide a useful tool for people affected by nightmares, since it could activate self-responsibility and self-control in a frightening situation. In this respect, it presents an advantage over traditional therapeutic treatments as it can be applied in the situation itself, while the nightmare is happening, and not afterwards (Holzinger, 2014) Furthermore, it is theorized that treating nightmares with LD might lead to more ego strength, disappearance of anxiety and obsessive-compulsive symptoms, and increased confidence, emotional safety and balance (Tholey, 1988). These effects have yet to be fully investigated.

The aim of the present study was to (i) evaluate LDT in patients with PTSD with nightmares and (ii) if LDT leads to a sustainable reduction of nightmares. The secondary goal was to investigate the efficiency and sustainability in the reduction of nightmare frequency.

MATERIALS AND METHODS

Participants and Procedure

The final sample included 31 adults suffering from nightmares from an acute stressful situation according to the Impact of Events Scale-Revised (IES-R; Weiss and Marmar, 1997) and seeking treatment. Participants were recruited across Lower Austria *via* an in-patient treatment center for psychiatric patients located in Ybbs. Interested patients were informed of the study's purpose and returned written informed consents. Subsequently, subjects were medically examined prior to the study, and substance use was common. However, medical history of the participants and descriptions of which substances were used cannot be given here. Subjects were randomly assigned to LDT (n = 20, 10 females) or a credible active comparison condition (n = 11, eight females) for the treatment of nightmares.

All 31 subjects kept a sleep diary for the 6 weeks of treatment and completed all of the measures shown in **Figure 1**. Controls in the active comparison condition did not receive any kind of treatment but were instructed to keep a sleep diary over the course of 6 weeks. Those participants assigned to LDT additionally received one 60-min group session each of the 6 weeks. Follow-up surveys consisted of voluntary returns of the questionnaires and happened 6 weeks after the end of the intervention. Unfortunately, due to comorbid substance use disorder, drop-out rates were high and sample sizes of the LDT group varied between measures (baseline n = 9–17, end of therapy n = 4–13).

The study was approved by the Ethics Committee of the Medical University of Vienna and Vienna General Hospital (AKH).

Lucid Dream Therapy Sessions

The 60-min group sessions were held weekly for a total of 6 weeks and took place at the in-patient treatment center in Ybbs, Lower Austria. Sessions were led by two therapists, a doctoral clinical psychologist and the resident clinical psychologist at the center. Due to reasons of documentation and confirmability of LD activity, all sessions were audio-taped. The procedure was applied as follows: the first half-an-hour was designated to the weekly reports of what the participants experienced since the last meeting regarding sleep, dreaming, and LD. Participants shared their dreams in detailed verbal reports. Those dreams were discussed. The group shared their ideas about in which dream scenes the dreamer could have become aware of the dream state and how the dreamer could have changed the dream plot in the dream. The following half-an-hour was used to teach the theoretical background of LD and how to apply self-hypnosis for LD.

Measurements and Questionnaires

Symptom Checklist 90-Revised

The Symptom Checklist 90-Revised (SCL-90-R; Derogatis, 2000; German Version: Franke, 1995) is a 90-item self-report measure to evaluate nine primary symptom dimensions (somatization, obsessive-compulsive, interpersonal sensitivity, depression, anxiety,

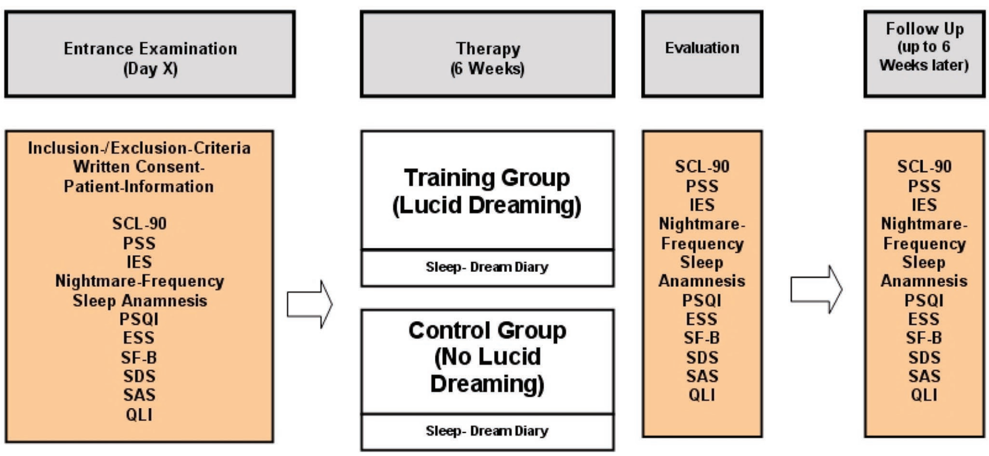

FIGURE 1 | Study design for treatment group and controls.

hostility, phobic anxiety, paranoid ideation, and psychoticism) within the last week. The Global Severity Index indicates the overall psychological distress. Answers are given on a five-point rating scale and completion time is about 12–15 min. The internal consistency coefficient rating ranges from 0.90 for depression and 0.77 for psychoticism. Test-retest reliability has been reported at 0.80–0.90 with a time interval of 1 week.

Impact of Events Scale

The IES-R (Weiss and Marmar, 1997) is a 22-item self-report measure that assesses subjective distress caused by traumatic events and asks for the occurrence of symptoms within the past 7 days. Dimensions measured by the IES-R are avoidance, intrusions, and hyperarousal, and items are rated on a five-point scale ranging from 0 ("not at all") to 4 ("extremely"). Weiss and Marmar (1997) showed that the reliability rates of the subscales are very high with Cronbach's α ranging from 0.79 to 0.92.

Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) is a 19-item self-report measure of sleep quality and disturbances during the past month, creating seven component scores for sleep quality, latency, duration, habitual efficiency, disturbance, use of sleep medication, and daytime dysfunction. Each item is weighted on a 0–3 interval scale, creating an overall score from 0 to 21 with scores above 5 indicating poor sleep quality (Buysse et al., 1989). Backhaus et al. (2002) showed that the PSQI has a high test-retest reliability with a coefficient of 0.87 and good validity (sensitivity 98.7 and specificity 84.4).

Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS; Johns, 1991) is a self-administered questionnaire with eight questions assessing the general level of daytime sleepiness. A total score between 0 and 24 is calculated. The threshold for increased diurnal fatigue is a total score above 10. The test has high internal consistency (Cronbach's α = 0.88–0.74) and reliability (r = 0.82).

Multicultural Quality of Life Index

The Multicultural Quality of Life Index (MQLI; Mezzich et al., 2011; German version: Katschnig et al., 2003) is a self-rating instrument that measures the subjective quality of life using 10 items that cover concepts from physical well-being to spiritual fulfillment. It is a very economical instrument (mean time of completion under 3 min, Mezzich et al., 2011) with high test-retest reliability (r = 0.87) and high internal consistency (Cronbach's α = 0.92).

Self-Rating Anxiety Scale

The Self-rating Anxiety Scale (SAS; Zung, 1971) is a 20-item self-report assessment device that measures state and trait anxiety. The total score can range from 20 to 80. Levels from 20 to 44 are considered normal, 45 to 49 indicate mild to moderate anxiety, 60 to 74 indicate severe anxiety, and 75 to 80 indicate extreme anxiety. Ramirez and Lukenbill (2008) found a high internal consistency with a coefficient of 0.80 and convergent validity ranging from 0.21 to 0.60. for the adapted version of the SAS, the SAS-ID (intellectual disabilities).

Self-Rating Depression Scale

The Self-rating Depression Scale (SDS; Zung, 1965) consists of 20 statements that have to be rated on a four-point scale (1 = *a little of time* and 4 = *most of the time*). The SDS score is the sum of all responses, and the SDS index is derived by dividing the total score by 80 and multiplying it by 100. A score between 25 and 43 is considered normal, 44 and 49 indicates borderline depression, 50 and 59 mild depression, 60 and 69 moderate to severe depression, and above 70 counts as severe depression (Zung, 1965). The Zung SDS has been shown to have good discriminant validity (Zung, 1965).

Perceived Stress Scale

The Perceived Stress Scale (PSS; Cohen et al., 1983) measures the degree to which situations in one´s life are appraised as stressful. The questionnaire comprises ten items, rated on a five-point scale from 0 = *never* to 4 = *very often*.

Sleep/Dream Checklist

Participants completed a sleep and dream rating scale daily during intervention phase and reported their dreams during the weekly meetings. To assess nightmare severity, subjects rated their nightmares on a severity scale from 0 = *not severe* to 5 = *very severe*. Additionally, participants were asked how much the nightmares were interfering with their quality of life and with their daytime functioning, both on a scale from 0 = *no interference* to 100 = *very interfering*. Nightmare frequency was also assessed.

The efficiency of LDT was obtained by comparing nightmare frequency at baseline with the nightmare frequency at end of therapy. We expected a decrease of PTSD symptoms due to reduction of nightmare frequency. The extent of improvement of the initial disturbance by nightmares until the end of therapy was assessed by concomitant psychological tests.

Data Analysis

All analyses were performed after the end of the data collection. For statistical analysis, results at *end of therapy* and *follow-up* were combined due to missing data. Baseline results and *end of therapy/follow-up* results were compared using Mann-Whitney U-test. Wilcoxon tests were used for the longitudinal comparison of baseline and *end of treatment/follow-up* for LDT and control group. The threshold for the rejection of the null hypothesis was set to 0.05. All statistical analyses were performed using the IBM SPSS Statistics for Windows, version 24.0 (IBM, 2016).

RESULTS

The total sample (N = 31) included 18 females and 13 males between 27 and 59 years (M_{age} = 41.58 years). The high drop-out rate can be explained due to the high number of participants with a comorbid substance use disorder. This is also the reason for varying sample sizes for each of the measures (**Table 1**).

Results at Baseline (Beginning of Therapy)

The LDT group (n = 20, 10 females) was 41.58 years on average (SD = 8.49). The average body weight was 169.16 lbs (SD = 42.66)

TABLE 1 | Longitudinal differences in results of lucid dreaming therapy (LDT) group at beginning and end of therapy.

Measure	n	Baseline		End of therapy		p
		M	SD	M	SD	
Pittsburgh Sleep Quality Index (PSQI)	12	11.33	3.33	8.79	3.93	0.149
Epworth Sleepiness Scale (ESS)	4	10.63	4.62	7.00	4.49	0.109
Perceived Stress Scale (PSS)	8	22.00	12.91	25.38	11.81	0.465
Symptom Checklist 90-Revised (SCL-90-R)	12	73.12	9.30	72.83	9.60	0.225
Impact of Events Scale (IE-S)	6	48.31	14.69	39.29	21.48	0.728
Self-rating Anxiety Scale (SAS)	12	46.56	9.59	41.42	9.56	0.012
Self-Rating Depression Scale (SDS)	12	50.93	8.71	45.08	10.92	0.043
Multicultural Quality of Life Index (MQLI)	11	5.07	1.63	5.73	1.85	0.401
Quality of life	12	60.50	30.18	48.63	21.70	0.091
Daily functioning	12	65.00	28.76	63.42	21.38	0.116
Nightmare frequency	13	Several/Month		Several/Month		0.865

and average height was 5.70 ft. The average number of nightmares was 3.20 (*SD* = 1.70) per week. Controls (*n* = 11, eight females) were on average 45.38 (*SD* = 10.93) years old, had an average body weight of 156.09 lbs (*SD* = 26.61) and an average height of 5.65 ft.

Means and SDs were calculated for each of the measures; however, sample sizes were different for each one and differ from those found in **Table 1**: PSQI *n* = 15, ESS *n* = 16, PSS *n* = 9, SCL-90-R *n* = 17, IES *n* = 14, SAS *n* = 16, SDS *n* = 15, MQLI *n* = 14, quality of life *n* = 16, daily functioning *n* = 15, and nightmare frequency *n* = 16. All numbers presented here are of those attending the LDT treatment. The mean score at baseline for sleep quality (PSQI global score) was *M* = 11.80 (*SD* = 3.83), for daytime sleepiness (ESS) it was *M* = 6.50 (*SD* = 3.21), for trauma severity (Items 22–38) it was *M* = 30.40 (*SD* = 9.71), for the Symptom Checklist (SCL-90-R) it was *M* = 73.12 (*SD* = 10.60), for the IE-S (global score) it was *M* = 54.20 (*SD* = 12.07), for anxiety (SAS) it was *M* = 41.00 (*SD* = 8.20), for depression (SDS global score) it was *M* = 51.40 (*SD* = 6.43), for quality of life (MQLI) it was *M* = 5.86 (*SD* = 1.54), for the interference of nightmares with quality of life it was *M* = 60.80 (max. 100), for the interference of nightmares with daily functioning it was *M* = 72.00 (max. 100), and for nightmare frequency it was *M* = 4 (max. 5).

No significant group differences between LDT and controls at baseline except the ESS score (*p* = 0.049; Mann-Whitney U-test) could be found. In summary, both groups (controls and lucid dreamers) demonstrated high levels of daytime sleepiness, with poor sleep quality, severe traumatization and showed symptoms of psychologically distress, anxiety, and depression.

Results at the End of Therapy

Results for the comparison of baseline and end of therapy scores for those in the LDT condition are presented in **Table 1**.

In the LDT group, anxiety (*p* = 0.012) and depression (*p* = 0.043) levels decreased significantly as indicated by reduced SAS and SDS scores at the beginning and the end of therapy. However, no hypotheses confirmation on the effectiveness of LDT could be found. There was no significant nightmare reduction, comparing the nightmare frequency at initiation to end of therapy. Ratings of the interference of nightmares on quality of life and daily functioning did not change. Moreover, no changes in PTSD-profile were found. Sleep quality, daytime sleepiness, and severity of symptoms did not improve significantly. There were no significant differences regarding the parameters listed in **Table 1** between the LDT group and controls.

DISCUSSION

Our findings show that anxiety and depression levels significantly decreased during treatment. All other parameters such as the interference of nightmares on daily functioning, and on quality of life (MQLI) in general, the severity of trauma (IE-S), daytime sleepiness, and sleep quality did not show any significant changes. These results are not surprising considering that the course of PTSD is complex and long lasting and 3 months (the time from baseline to follow-up) of treatment might be too short to cause any positive group effects. Our findings provide some support on the effectiveness of LDT in the treatment of nightmares, especially when it comes to patients with psychological disorders.

Limitations

In this study, there was a high drop-out rate and many of the returned questionnaires were incomplete and could not be included in the statistical analyses. Therefore, sample size was quite small. Although subjects were continuously motivated to participate in the group therapy sessions, they found it difficult under their strong medication to maintain concentration which is required for LD. Although two participants reported lucid dreams and being capable of changing the dream's content while asleep, for most subjects, LD remained novel. Because of this, conclusions drawn from differences between LDT group and controls must be assessed carefully. Although one of the inclusion criteria was "to have at least several nightmares per week," most participants reported only several nightmares per month on average at baseline. The short treatment period might pose another relevant methodological issue which limits the ability to draw conclusions.

Aside the numerous omissions in the data set, also a high inhomogeneity within the sample was observed, even though recruitment of subjects, distribution and collection of the questionnaires were controlled. The majority of the subjects had a comorbid substance use disorder which could have had an influence on the reliability of the completion of the questionnaires as well. Low levels of resilience among subjects could be observed when offering them a polysomnographic screening in a sleep laboratory of which only two participants made use of.

All of the above indicate that single case studies should be applied and further qualitative analyses are needed.

Future Perspectives

As positive effects of LDT on nightmares could be obtained previously (Spoormaker and van den Bout, 2006; Holzinger et al., 2015) and it is reasonable to believe that part of this study's results are not significant due to methodological shortcomings, it is necessary to further research positive effects of LDT. With nightmares being present as symptoms in various psychological disorders, such as eating disorders, schizophrenia, depression, personality disorders, borderline disorder, substance use disorder (esp. alcohol; Fiss, 1980), and diverse organic diseases (Holzinger and Stefani, 2020), LDT is worth investigating, for it can provide a helpful tool for the ones affected. To address this, Gavie and Revonsuo (2010) propose more intense lucidity interventions over longer time periods and with larger sample sizes. Despite of the limitation due to the small sample size, the study has its strength in a naturalistic design and hot spot recruitment, reporting real word data in order so reach higher external validity and some generalizability. Therefore, the decrease in symptoms (anxiety or depression) is interesting. It has to be taken into account that LDT as an intervention technique belongs to the factors or variables that in general explain 10–15% of the variance of the therapy outcome. Taking the whole situation into consideration, other factors may also contribute to the outcome: common factors (e.g., therapeutic relationship and alliance) explaining 30%, patient variables explaining 40% of the variance, and the therapist variable explaining about 20% of the variance in therapy outcome (Lambert, 2013). Concerning further designs naturalistic studies, as well as randomized controlled trials (RCTs) should be conducted as they explain different amounts of variance, e.g., for the therapist variable the overall variance ranges from 5% in controlled studies to 17% in naturalistic studies. In this current investigation, the variables therapeutic alliance (group therapy) and patient factors (e.g., substance use disorder and dependency) might also considered having a possible influence on the symptom reduction of anxiety and depression. Further investigations are needed to investigate these moderators and mediators.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available in order to maintain confidentiality on behalf of the patients and their sensitive data.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BH funding acquisition; BH and GK: conceptualization and methodology; data aquisition and data management; BH, GK, and BS: data analysis and first draft of the result section; BH, GK, and BS original draft preparation and finalization of the article. All authors contributed to the article and approved the submitted version.

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The Dream of God: How Do Religion and Science See Lucid Dreaming and Other Conscious States During Sleep?

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Lucid dreaming (LD) began to be scientifically studied in the last century, but various religions have highlighted the importance of LD in their doctrines for a much longer period. Hindus' manuscripts dating back over 2,000 years ago, for example, divide consciousness in waking, dreaming (including LD), and deep sleep. In the Buddhist tradition, Tibetan monks have been practicing the "Dream Yoga," a meditation technique that instructs dreamers to recognize the dream, overcome all fears when lucid, and control the oneiric content. In the Islamic sacred scriptures, LD is regarded as a mental state of great value, and a special way for the initiated to reach mystical experiences. The Christian theologian Augustine of Hippo (354–430 AD) mentions LD as a kind of preview of the afterlife, when the soul separates from the body. In the nineteenth century, some branches of the Spiritism religion argue that LD precedes out-of-body experiences during sleep. Here we reviewed how these religions interpret dreams, LD and other conscious states during sleep. We observed that while Abrahamic monotheisms (Judaism, Christianity, and Islam) recognize dreams as a way to communicate with God to understand the present and predict the future, the traditional Indian religions (Buddhism and Hinduism) are more engaged in cultivating self-awareness, thus developed specific techniques to induce LD and witnessing sleep. Teachings from religious traditions around the world offer important insights for scientific researchers today who want to understand the full range of LD phenomenology as it has emerged through history.

Keywords: dreams, religion, meditation, lucid dream, out of body experiences

> *"Myths are public dreams, dreams are private myths"*
>
> Joseph Campbell—The power of myth (1988)

> *"In the dream . . . we have the source of all metaphysic. Without the dream, men would never have been incited to an analysis of the world. Even the distinction between soul and body is wholly due to the primitive conception of the dream, as also the hypothesis of the embodied soul, whence the development of all superstition, and also, probably, the belief in god. 'The dead still live: for they appear to the living in dreams.' So reasoned mankind at one time, and through many thousands of years"*
>
> Friedrich Nietzsche—Human, all too human (1878)

INTRODUCTION

The term "lucid dreaming" (LD) was coined by Van Eeden (1913), to describe a kind of dream during which "the reintegration of the psychic functions is so complete that the sleeper remembers day-life and his own condition, reaches a state of perfect awareness, and is able to direct his attention, and to attempt different acts of free volition" (Van Eeden, 1913, p. 446). According to LaBerge et al. (1986), LD would be simply "dreaming while being conscious that one is dreaming". LD started to be objectively studied by the work of Hearne (1978) and LaBerge (1980a,b), who developed a technique that consists of instructing dreamers to move the eyes voluntarily to indicate that they became lucid. Despite these first scientific accounts being recent, LD have been described by various religions for a much longer time. In this opinion article, we review how Hinduism, Buddhism, Judaism, Christianity, Islam and Spiritism interpret dreams, LD and other conscious states during sleep.

HINDUISM

Hinduism has its origins in India approximately 3,500 years ago, and is called Sanâtana Dharma (in Sanskrit: सनातनधर्म), which means "The eternal law." Like most ancient societies, Hindus saw dreaming as divine and prophetic, and one of the most reliable sources of insight (Freud, 1900; Ribeiro, 2019). Hindus interpret dreams and the whole world as illusions made by a God named Vishnu (Shulman and Stroumsa, 1999). In the mystical texts known as the Upanishads, dreaming becomes a personal experiential path toward the realization of the illusory nature of the self and all reality.

Interestingly, Hindus divide consciousness into waking, dreaming, and deep sleep, and believe that both dreaming and deep sleep are more important than waking. This is the opposite of Western culture, which considers waking as the main state–a synonym of "real," sleep as just a complementary state, and dreaming as "unreal" (Bulkeley, 2008). Some Hindu practitioners believe that only in deep sleep can we be completely free from thoughts, but not during waking and dreaming. They also consider that there is a form of consciousness during deep sleep, but that it was not possible to have LD in this state (Sharma, 2006). In fact, studies have found that LD–objectively indicated by the eye movements technique (Hearne, 1978; LaBerge, 1980a,b; Mota-Rolim, 2020)–was already described during sleep onset (N1 stage), light sleep (N2), and rapid eye movement (REM) sleep, but not during deep sleep (N3) (LaBerge et al., 1981a,b; Stumbrys and Erlacher, 2012; Mota-Rolim et al., 2015; Baird et al., 2019). However, this is still debatable, especially when we consider the Hindu tradition of spiritual sleep: Yoga Nidra. Contemporary texts consider Yoga Nidra a kind of LD state, in which dream imagery takes place for the practitioner, who do not identify or become attached to them, remaining as an objective observer (Miller, 2005; Hoye and Reddy, 2016).

Also known as "Yogic Sleep," the Yoga Nidra (Sanskrit: योगनिद्रा) means "blissful relaxation" and is considered one path to achieve the state of Samâdhi or self-realization (Saraswati and Hiti, 1984). The Yoga Nidra is first mentioned in the Upanishads, which are part of the Vedas—the ancient Sanskrit texts that contain the oldest scriptures of Hinduism (Desai, 2017). Interestingly, the Yoga mantra OM/AUM refers to different consciousness states: "A" (awakening), "U" (dreaming), "M" (deep sleep). The fourth state, Turiya or the Transcendental state, is represented by the combination AUM (Sharma, 2018). In the Bhagavad Gita, one of the most sacred and revered Hindu texts, the God Krishna is in Yoga Nidra when the prince Arjuna first meets him: half-awake.

The founder of the modern practice of Yoga Nidra, divided it into eight steps that basically consist of paying attention to different parts of the body, to breath and to do visualizations while lying on the floor in shavasana (the corpse pose) to observe your mind reaction (Saraswati and Hiti, 1984). Actually, one of these steps called "rotation of consciousness" is a variation of the ancient Tantric practice of "Nyasa," which means "to take the mind to that point" (Rani et al., 2011). However, there are also other ways of practicing Yoga Nidra, such as one described in the Himalayan tradition, which consists of using your breath to concentrate your attention on the Ajna (point between eyebrows), Vishuddha (throat), and Anahata (heart) chakras. It is said to be preceded by two preparatory practices called Shavyatra and Shitalikarana. In the first one, the attention travels through the body in 61 points. The term "shava" means "corpse" and "yatra," "journey." In the second, the breath travels from different parts of the body in a specific way. The term "shitalikarana" comes from the Sanskrit verb "shitalikaroti," which means, "to cool or calm." The Yoga Nidra is also considered the state of consciousness during the deep sleep, which is believed to lead to self-realization (Grouven, 2018).

One of the major debates in classical Indian philosophy is whether consciousness is present or not in deep sleep. The philosophical schools of Advaita Vedânta and Yoga affirm that consciousness is present in dreamless sleep, whereas the Nyâya School says it is not (Thompson, 2015). The term "witnessing sleep," on the other hand, describes the co-existence of transcendental consciousness and sleep. According to Alexander (1988) and Travis (1994) there are three types of consciousness in sleep: LD; witnessing dreaming–an experience of quiet, peaceful inner awareness or wakefulness completely separate from the dream; or witnessing deep sleep–an experience of quiet, peaceful, inner state of awareness during dreamless sleep. Recent works also consider that there is a form of consciousness in dreamless sleep (Windt et al., 2016; Siclari et al., 2017). In one study with the yogi Swami Rama, scientists found that he would remember everything that had happened to him while in a state of Yogic Sleep–in which the EEG showed 40% of delta wave activity, which resembles deep sleep. He was able to recite 9 of the 10 sentences given to him while in that state (Ancoli et al., 2012), supporting the observation that information can affect us even when we are in an "unconscious" state (Ruch and Henke, 2020).

Another study obtained a similar result with a different technique called Transcendental Meditation, which uses mantras (Woolfolk, 1975) and shares the same goal with Yoga Nidra (Cranson et al., 1991). The authors found that 11 long-term practitioners were able to report being aware during sleep when compared to 9 short-term practitioners and 11 non-practitioners. EEG recordings showed that during deep sleep, the experimental group (long-term meditators) had greater theta-alpha activity simultaneously with delta activity and lower muscular tonus, when compared to the other groups (short-term and non-practitioners). The authors suggested that transcendental consciousness during sleep is distinct from LD, since the last one occurs almost exclusively during phasic REM and more often during later REM periods (Mason et al., 1997; Baird et al., 2019). Finally, studies on Mindfulness Meditation practices also provide empirical support for the possibility of a kind of consciousness in deep sleep (Tang et al., 2015). According to Thompson (2015), proficient meditators occasionally report "witnessing sleep," when they experience no specific thought contents or imagery. These participants had differences in EEG activity during sleep when compared to non-meditators and inexperienced meditators, such as enhanced gamma-band activity (Mason et al., 1997; Ferrarelli et al., 2013; Dentico et al., 2016; Maruthai et al., 2016).

Another study found that the high-lucidity group disclosed increased gray matter volume in the frontopolar cortex (BA9/10) when compared with the low-lucidity group. Additionally, the blood oxygen level-dependent signal increased in this brain area during thought monitoring in both groups, and even more in the high-lucidity group. The authors suggest that metacognitive practices and LD share neural systems, in particular in the domain of thought monitoring (Filevich et al., 2015). It was also reported that the frequency of LD is more positively related to mindful presence state rather than to acceptance mind state. However, it remains unclear whether the relationship between mindfulness and LD is influenced by actual meditation practice other than individual predispositions (Stumbrys et al., 2015).

BUDDHISM

Buddhism originated around 2,500 years ago in India, and today is divided in three branches: Theravada (The School of the Elders), Mahayana (The Great Vehicle), and Vajrayana (The Diamond Vehicle). The Vajrayana School was established in Tibet during the eighth century and gave origin to Tibetan Buddhism, which practices the Dream Yoga, in Sanskrit स्वप्रदर्शन–a meditation technique focused on developing awareness during the dream state. Curiously, Buddha himself is known as "The Awakened" or "The Enlightened," both related to the word "lucid," as in LD (Rosch, 2014).

The dream yoga practice has four stages. However, before practicing the dream yoga, LaBerge (2003) describes two preparatory techniques. In the first one, the dreamer must recognize the dream as it unfolds, and some techniques such as meditating about it before going to sleep can help (LaBerge, 1980b). Then, the dreamer must try to overcome all possible fears when becoming lucid, aiming to prevent awakening–a common undesired outcome, especially in inexperienced lucid dreamers (Mota-Rolim et al., 2013). After these preparatory techniques, the dreamer can start the first stage, in which one must contemplate the dream, and reflect on how it is or not similar to real life, since both are illusions in constant changing, a fundamental concept of Buddhism. By this previous insight, the dreamer must then try to control the oneiric content. This stage is especially important to those who suffer from recurrent nightmares, because by becoming lucid during the nightmare the dreamer may learn not to be afraid, since nothing can cause real physical harm inside the dream. Other possibilities include transforming the nightmare in a good dream, or simply waking up (Mota-Rolim and Araujo, 2013; Macêdo et al., 2019). In the third stage, the dreamer must recognize that the dream body has not a material substance, and the same idea could be applied to other people or objects in the dream. Finally, in the fourth and last stage, the dreamer should try do visualize the deities, such as Buda, and then a revelation would happen (LaBerge, 2003).

There is a relation between the occurrence of LD and meditation practice (Gackenbach, 1981, 1990; Hunt, 1991; Mota-Rolim et al., 2013; Sparrow et al., 2018). One possible explanation is that experienced meditators have an increased density of rapid eye movements during REM sleep (Mason et al., 1997). This may enhance LD frequency because LD is related to phasic (activated) REM sleep, i.e., REM sleep periods with rapid eye movements (LaBerge, 1980a; LaBerge et al., 1981b, 1986). The neuropsychological mechanisms that underlie this finding is not yet clear, but may have to do with the fact that phasic REM sleep has an autonomic activation that resembles waking, and that LD seems to be a mixture (Voss et al., 2009) or a transition phase (Mota-Rolim, 2020) between REM sleep and waking. Another explanation is that LD increases alpha band (8–12 Hz) power (Ogilvie et al., 1982; Tyson et al., 1984; Mota-Rolim et al., 2008), as also observed in a relaxed wake state with eyes closed (Berger, 1929; Adrian and Matthews, 1934) and during meditation (Varela et al., 1945). Furthermore, meditative states of "focused attention" (Himalayan Yoga), "open monitoring" (Vipassana), and "open awareness" (Isha Shoonya Yoga), show increased global coherence in the gamma band (Vivot et al., 2020), as also observed during LD (Mota-Rolim et al., 2008; Voss et al., 2009). Greater capacity for mental control emerges in both experienced meditation practitioners and frequent lucid dreamers (Blagrove and Tucker, 1994; Blagrove and Hartnell, 2000). Finally, a connection between meditation and LD is through the development of metacognitive abilities, such as mindfulness (Filevich et al., 2015; Stumbrys et al., 2015). These various alternative explanations are not necessarily mutually exclusive.

The leader of Tibetan Buddhism today, Tenzin Gyatso, the fourteenth Dalai Lama, has supported western research on LD as a potential bridge between modern science and ancient religious wisdom. When asked to describe his views of LD, the Dalai Lama replied:

> "There is said to be a relationship between dreaming, on the one hand, and the gross and subtle levels of the body, on the other. But it is also said that there is such a thing as a "special dream state." In that state, the "special dream body" is created from the mind and from vital energy (prana) within the body. This special dream body is able to dissociate entirely from the gross physical body and travel elsewhere. One way of developing this special dream body is, first of

all, to recognize the dream as a dream when it occurs. Then, you find that the dream is malleable, and you make efforts to gain control over it. Gradually, you become very skilled in this, increasing your ability to control the contents of the dream so that it accords to your own desires. Eventually it is possible to dissociate your dream body from your gross physical body".

Another relevant Tibetan Buddhist yoga addresses useful techniques to achieve LD. In the so-called Tibetan sleep yoga, both witnessing sleep and LD are used to develop mind flexibility. Mind flexibility is, according to Wangyal and Dahlby (1998) a crucial characteristic to relativize the way things are in this world, and thus to better administer our feelings and attachment to things. As a consequence, cultivation of sleep witnessing in the beginning and LD at the end of the night may lead to favor paving the path to enlightenment. Thus, according to Wangyal, sleep yoga practitioners can collect useful fruits for enlightenment with this practice, being a reasonable alternative in relation to practices with no related emphasis and with no cultivation of special dreams. The advantage of these practices is emphasized in the way that the practitioner can train a transforming mind yoga technique even when you are in bed for sleep. In this way, Tibetan Yogis developed a specific classification of dreams, as: (1) ordinary dreaming (both lucid and non-lucid), (2) dreams of clarity (both lucid and non-lucid), and (3) clear light dreams (only appearing as LD). As reported by Wangyal and Dahlby (1998), dreams of clarity differences in relation to ordinary dreams rest on more stability of the practitioner, and on the rising of special images and traces that "present available knowledge directly from consciousness below the level of conventional self." Finally, clear light dreams are a specific kind of dream which "occurs when one is far along the path." This dream appears when the practitioner experiences non-dualistic mind states, and is also a non-dualistic dream: the practitioner "does not reconstitute as an observing subject in relation to the dream as an object, nor as a subject in the world of the dream," integrated with the non-dual state.

In order to cultivate those lucid and non-lucid dream states, the practitioner is oriented to perform diverse yoga techniques, which include calm abiding meditation, mind flexibility routines during the day (such as imagination of the world and his/herself as a dream), awareness and remembrance of dreams and, during the sleep, visualization of Tibetan symbols (tingles), and syllables associated to parts of the body at four different moments during the night (Wangyal and Dahlby, 1998). Lucid dreams, in this tradition, are supposed to arise specially in the last part of the night, in a clear coincidence with the classical physiological occurrence of more robust REM episodes.

In this context, we argue that he scientific study of Tibetan sleep yoga practices could address relevant questions in neuroscience. With the use of EEG and functional anatomy scans, we may better understand the neural dynamics of these states in experienced practitioners, as well as in beginners. We may address each of the four visualization practices of this Tibetan sleep yoga during sleep, and get the comprehension of their neural signatures. Also, we may better understand in which way LD-related practices can influence neuroplasticity and if they can work as a mitigation technique for anxiety and depression states, or if it can be a useful tool in modern societies to develop a better emotional stability and self-control. As occurred with classical mindfulness techniques, which re-emerged from ancient Asian traditions to be adopted for lay practice in this turbulent twenty-first century world, a similar adaptation of Tibetan sleep and dream yogas (with possible neuroplasticity effects demonstrated by neuroscience studies), could add additional muscle to prevent the widespread occurrence of mental diseases in our present times.

These experimental approaches to dreaming, treating it as a realm of consciousness capable of being actively explored and intentionally cultivated, is very different from the approach developed in the traditional Abrahamic religions, as the next sections will show.

JUDAISM AND CHRISTIANITY

Judaism originated approximately 3,800 years ago, when Abraham established a covenant with God. Christianity has its origins from the Judaism, about 2,000 years ago. Judaism and Christianity are monotheistic, and share common origins in the Old Testament. Judaism Signals of God can be obtained by visions, through voices, and, of course, through dreams. The approach of dreams in Judaism and Christianity is clearly distinct from those of the two traditional Indian religions mentioned above. In both Buddhism and Hinduism, dreams are used as tools for the expansion of consciousness and gain in self-control, as part of the path toward enlightenment, or mastering of body and mind (LaBerge, 1980b; Saraswati and Hiti, 1984). In Judaism and Christianity, dreaming serves primarily as a means of communication between humans and God. The dreams can take many forms—visual images, auditory commands, frightening nightmares—but the common feature is a revelatory message from the divine to the dreamer.

In the Old and the New Testaments, the word "dream" appears over a hundred times. Hebrews, Babylonians and ancient Egyptians shared traditions of dream interpretation. As exemplified in the interpretation of the Egyptian pharaoh's dreams by Joseph (Gen 1–41), and in the interpretation of Nebuchadnezzar' dream by Daniel (Daniel 2:43–45), the Jewish people were extremely successful in obtaining the grace of foreign rulers through the mastering of dream interpretation, with an impact on public policies. In Egypt, Joseph interpreted a dream report of seven fat cows eaten by seven gaunt cows as predictive of 7 years of abundance followed by 7 years of famine; and recommended the construction of silos to stock grains. In Babylon, Daniel interpreted the king's dream about a huge statue hit by a stone, as a precognitive description of the future generations and kingdoms. However, despite the critical importance of dreams in biblical texts, we found no direct allusion to a LD.

The same is true of the references to dreams in the New Testament, which are fewer than in the Old Testament but convey the same basic theme of human-divine communication.

In this theological context, LD appears less relevant because God's messages can be effectively delivered in non-lucid dreams. Higher levels of consciousness within the dream state do not really matter; what matters is remembering the dream upon awakening and properly interpreting its divine significance. For example, in Numbers 12:6: "And he said, hear now my words: If there be a prophet among you, I the Lord will make myself known unto him in a vision, and will speak unto him in a dream."

This difference is illustrated by the early Christian theologian Augustine of Hippo (354–430 AD) in a letter in which he mentions the LD experience of a friend who was doubting the doctrine of the eternal soul. In his dream an angelic young man appears and brings him to a state of lucid awareness:

> "As while you are asleep and lying on your bed these eyes of your body are now unemployed and doing nothing, and yet you have eyes with which you behold me, and enjoy this vision, so, after your death, while your bodily eyes shall be wholly inactive, thee shall be in you a life by which you shall still live, and a faculty of perception by which you shall still perceive. Beware, therefore, after this of harboring doubts as to whether the life of man shall continue after death." (quoted in Bulkeley, 2008, p. 181)

Augustine clearly recognizes the phenomenon of LD, of conscious self-awareness within sleep, and yet in his religious worldview it has a very different significance from the Hindu and Buddhist perspective. For Augustine, LD is a kind of preview of the afterlife, when the soul becomes completely separated from the body. The experience of LD confirms what Christians should already know. There is no interest here in exploring LD beyond those theological limits and probably this is why there is a lack of scientific works on these experiences in Christianity/Judaism.

ISLAM

Members of the Islamic faith believe that the word of God (Allah) was revealed to humanity by the Prophet Muhammed in 610 AD, continuing and completing the revelations that begun in the Jewish and Christian religions. Importantly, this happened after the visit of the archangel Gabriel to Muhammed in what many believe was a dream (Hermansen, 2001). Moreover, before this first revelation, it is believed that Muhammed experienced many dreams full of spiritual meaning, which induced him to begin his preaching. In the *Qur'an*, the sacred book of Islam as recited by the Prophet, dreams work as a way by which God communicates with humans, as also happens in the Jewish Torah and the Christian New Testament. Dreams are also cited in some *Qur'an* passages, and in spite of appearing considerably less than in the Bible, their application rely on the ability to interpret correctly their metaphoric content, depending on the personal and circumstantial knowledge of the dreamer (Bulkeley, 2002), as highlighted by Freud (1900) and recognized by contemporary neuroscience (Ribeiro, 2019). As the Prophet said, a dream will take effect according to how it is interpreted, and a dream rests on the feathers of a bird and will not take effect unless it is related to someone. On the other hand, there are dreams that are more directly and need no interpretation, such as the famous one in which Allah tells Abraham to sacrifice his son (Bulkeley, 2002). In addition, there are strategies suggested to incubate good dreams. For example, *hadith* texts encourage practitioners to try to sleep in a state of ritual purity in order to have good dreams.

Thus, in Islam, dreams have a similar use as in biblical texts: to be interpreted, or as direct messages. In addition, in some Islamic traditions, discussions about dreams containing clear bad or "unpleasant contents" are not encouraged, because these dreams are interpreted as caused by Satan. Facing a bad dream, the dreamer is encouraged to recite the *Qŕan* and perform donations to get rid of this bad dream content, instead of discussing them with other people.

There are some references to LD in the Islamic tradition, which were made mainly by the Sufi master Ibn El-Arabi (1165–1240). El-Arabi claimed to have a strong lucid imagination and plenty of visionary experiences, such as the one in which he saw the angel Gabriel, as also happened to Muhammed. El-Arabi divided dreams into three basic types. The first are the "ordinary" dreams, which are produced by the imagination based on daily life experiences, but with symbolic content that represents our wishes, very similar to the psychoanalytic view (Jung, 1957; Freud, 1900). The second type of dream is much more important and reflects the "Universal Soul"–a kind of abstract reasoning that would reveal fundamental truths about reality, but that were also distorted by human imagination, and thus requires interpretation to unveil what the symbolic images really mean. The last type of dream involves a clear vision of divine truth with no distortions or symbolisms (Bulkeley, 2002). Regarding LD, El-Arabi believed they were also very important, and once said: "A person must control his thoughts in a dream. The training of this alertness (. . .) will produce great benefits for the individual. Everyone should apply himself to the attainment of this ability of such great value" (Gackenbach and LaBerge, 1988).

According to Hermansen (1997, p. 27), "The Sufi tradition specifically cultivated the preservation of some "observer faculties" during the stage of sleep by means of techniques of physical deprivation such as fasting and remaining awake throughout the night, and by exercises such as self-remembering." A great deal of LD training has also been developed by Indian Sufi orders that migrated to the West. According to Pior Vialat Khan, the dreamer who can maintain focus and lucidity is able to work with the symbols of the World of Images, and participate with awareness in her own process of spiritual development (Khan, 1991). Another movement, the Golden Sufi center inspired by the spiritual leader Llewellyn Vaughan-Lee (1990, 1991), has incorporated dream work in their traditions. The practices involve both sharing and collective interpretation of dreams, as well as the induction of LD. There are even earlier roots of LD in Sufism, going back to medieval Islamic cultural traditions which had some contact with Hindu teachings and practices. There are certainly parallels between aspects of Hinduism and the Sufi quest to cultivate extraordinary states of consciousness, in both waking and dreaming, with the ultimate goal of a direct encounter with the deepest powers of the divine. Unfortunately, there is a lack of scientific works about these Islamic experiences.

SPIRITISM

The three main Abrahamic religions are, in chronological order of foundation, Judaism, Christianity and Islam, as pointed before. However, out of these three well-known religions, there are a number of relatively minor ones, such as Spiritism, which is a Christian-based religion that was created by Allan Kardec in 1857, in France. Spiritism is found nowadays mainly in Brazil, due to the work of the "mediums" Chico Xavier, Waldo Vieira and many others. Mediums are those who can make the contact between the living ones and the spirits of the dead. Spiritism states that the human soul (or spirit) can "leave the physical body," as in out-of-body experiences (OBE), and perform "astral projections" (Blackmore, 1982). The OBE is usually triggered by the "autoscopy" experience, whose etymology is "observing oneself." OBE can be defined as the sight of a look-alike, that is, another self that is less real than the original self (Blackmore, 1982), or the experience of seeing one's own body in an extra-personal space (Blanke et al., 2004).

Based on reports of autoscopy experiences during sleep, especially those in which dreamers see themselves laying on bed and sleeping, Spiritism claims that the spirit naturally detaches from the body during sleep, which would explain several aspects of dreams phenomenology. The irrational and confused aspect of dreams, for example, would be the remembrance of what the Spirit saw, but its coarse physical body would not retain the impressions grasped by the Spirit, which would explain the enormous memory gaps in dream reports. In addition, Spiritism believers claim that–during sleep–our spirit communicates with other spirits, in addition to being able to visit other worlds and have glimpses of the past and the future (de Sá and Mota-Rolim, 2015). Interestingly, some Spiritism branches affirm that LD would be the final stage before this experience of "leaving the physical body." However, for those who believe in Spiritism, the LD would not be "real" because it is only a dream, in comparison to the astral projection. Another difference is that during LD it is possible to have control (with various degrees) over the oneiric content, which would not happen in the "true" OBE that occurs during sleep (Vieira, 2002).

Modern research has confirmed that OBE can occur during the awake state (Ehrsson, 2007), sleep (Blackmore, 1982), or dreaming (Irwin, 1988; LaBerge et al., 1988; de Sá and Mota-Rolim, 2016). According to Levitan et al. (1999), OBE can also happen during some LD, and both may share some features, such as sleep paralysis, vibrations and a sensation of floating out of body. These authors investigated the relation between OBE and LD in two studies. In the first one, the authors analyzed the content of the dream, and observed that from 107 LD episodes recorded on the lab, 10 (9.3%) were qualified as OBE. In the second study, Levitan and colleagues conducted a survey in 604 subjects, and observed that frequency of OBE was similar to that observed in the first study, which support an association between OBE and LD. The authors believe that any state that combines a high level of cortical activation with low awareness of the body has the potential to induce an OBE (Levitan et al., 1999).

OBEs are related to the function of the temporo-parietal junction, a multimodal brain region that integrates visual, tactile, proprioceptive, auditory and vestibular information (processed by occipital, parietal and temporal cortices), contributing to self-consciousness and body internal imagery (Blanke and Mohr, 2005). OBEs can be artificially induced by disrupting the temporo-parietal region with magnetic (Blanke et al., 2005) or electric (De Ridder et al., 2007) stimulation. A much simpler way to induce an OBE was developed by Ehrsson (2007), who used a glass that showed to participants the image from a camera that was positioned on their back. Standing behind the participant, Ehrsson manipulated two plastic sticks, one of which touched the participant's chest and the other made a similar movement in front of the cameras, directing the stick to a place below them. Such synchronous movement induced a sort of cognitive dissonance, or misinterpretation: the participants felt as if their "illusory body"–created by the cameras–was their real body, thus reporting an OBE. It is very likely that OBE are involved in the practice of Spiritism.

Research like this highlights what can be learned by applying scientific methods to the study of dreaming in religious contexts. This is especially true when we look beyond the major world religions of Hinduism, Buddhism, Judaism, Christianity, and Islam. For smaller religious movements like Spiritism, dreams are a very appealing resource. Dreaming can provide a direct, deeply personalized means of accessing powerful spiritual energies and modes of higher awareness. The anthropology of dreaming offers evidence of LD in small-scale societies and indigenous communities around the world (Lohmann, 2003). In these traditions the emphasis of LD practice is often the shamanic work of healing, prophecy, and spiritual empowerment. During shamanic rituals, it is often observed the use of substances that alter the consciousness, such as Ayahuasca, and there is a close phenomenological relationship between dreams, specially LD, and the psychedelic experience (Kraehenmann, 2017). This active, purposeful approach to dreaming is closer to Hinduism and Buddhism than to the Abrahamic faiths, but with less interest in metaphysics and more in the pragmatic challenges of this world.

CONCLUSION AND PERSPECTIVES

In the three Abrahamic monotheisms–i.e., Judaism, Christianity, and Islam–the focus is mainly on the interpretation of dreams to understand the present and predict the future. On the other hand, in traditional Indian religions such as Buddhism and Hinduism, there are specific and well-documented techniques to induce LD. This suggests that while the monotheistic religions are related to understanding the will of God, in the polytheistic or atheistic beliefs from India there is a focus on the cultivation of self-awareness. In indigenous cultures and smaller religious traditions like Spiritism, the approach to LD tends to be less abstract and more focused on responding to personal and communal challenges. In light of these differences, it would be interesting to investigate whether people's religious beliefs and practices correlate with their frequency of LD. Based on the foregoing historical review, we could hypothesize that members of Abrahamic traditions have fewer

LD experiences, and members of traditions like Hinduism, Buddhism, and Spiritism have more LD. However, to pursue this line of investigation would also require accounting for the considerable number of people who do not affiliate with any religious tradition. The non-religious constitute a sizable portion of the population in modern societies, and it is possible that LD frequencies are higher among non-religious people than among those who are part of a formal religious tradition.

This historical review makes clear that LD is not a modern invention. Human awareness of, and experimentation with, LD goes back thousands of years. This evidence supports the idea that LD is a natural, though somewhat rare, feature of the human sleep cycle. This review also highlights the cross-cultural fact that LD regularly elicits spiritual responses, even among people who are not formally religious. There is something about the appearance of consciousness in dreaming that almost automatically stimulates feelings of deep wonder about the fundamental nature of mind and cosmos. People today continue to express similar feelings about their experiences of LD. One of the challenges for contemporary scientific researchers is how to explain the powerful impact of LD at the highest levels of conceptual thought, from the beginnings of history right into the present day.

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