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Practicing a Motor Task in a Lucid Dream Enhances Subsequent Performance: A Pilot Study

Daniel Erlacher
University of Heidelberg

Michael Schredl
Central Institute of Mental Health

Nocturnal dreams can be considered as a kind of simulation of the real world on a higher cognitive level. Within lucid dreams, the dreamer is able to control the ongoing dream content and is free to do what he or she wants. In this pilot study, the possibility of practicing a simple motor task in a lucid dream was studied. Forty participants were assigned to a lucid dream practice group, a physical practice group and a control group. The motor task was to toss 10-cent coins into a cup and hit as many as possible out of 20 tosses. Waking performance was measured in the evening and on the next morning by the participants at home. The 20 volunteers in the lucid dream practice group attempted to carry out the motor task in a lucid dream on a single night. Seven participants succeeded in having a lucid dream and practiced the experimental task. This group of seven showed a significant improvement in performance (from 3.7 to 5.3); the other 13 subjects showed no improvement (from 3.4 to 2.9). Comparing all four groups, the physical practice group demonstrated the highest enhancement in performance followed by the successful lucid dream practice group. Both groups had statistically significant higher improvements in contrast to the nondreaming group and the control group. Even though the experimental design is not able to explain if specific effects (motor learning) or unspecific effects (motivation) caused the improvement, the results of this study showed that rehearsing in a lucid dream enhances subsequent performance in wakefulness. To clarify the factors which increased performance after lucid dream practice and to control for confounding factors, it is suggested that sleep laboratory studies should be conducted in the future. The possibilities of lucid dream practice for professional sports will be discussed.

Sleep has long been seen as a passive state in which the body and brain recovers from daytime activity. In recent years it becomes apparent that the sleeping brain is never inactive; rather, specific brain regions are activated more or less throughout

Erlacher is with the Institute of Sport and Sport Science, University of Heidelberg, Germany. Schredl is with the Central Institute of Mental Health, Mannheim, Germany.

the night (e.g., Hobson & Pace-Schott, 2002). REM (rapid eye movement) sleep is a sleep stage in which the brain has high activation (Dang-Vu et al., 2005). This state occurs in nearly 90–100 min cycles, alternating with four stages of quiescent sleep known as non-REM (NREM) sleep (Rechtschaffen & Kales, 1968). The duration of REM periods get longer during the second half of the night, whereas slow wave sleep is predominant during the first half of the night. The high activation of the brain during REM sleep can be mirrored in the high percentage (70–95%) of vivid dreams which normal subjects report after awakening from REM sleep, whereas only 5–10% of NREM awakenings produce equivalent reports (Dement & Kleitman, 1957a; Dement & Kleitman, 1957b). In contrast to the high activation of the dreaming brain the physical body is nearly paralyzed because the efferent motor commands are actively suppressed by neural structures in the brain stem (Hobson, Pace-Schott & Stickgold, 2000; Jouvet, 1965). This mechanism is important because it keeps the dreamer from actually acting out his or her dream.

REM dreams can be considered as a kind of a simulation of the real world on a higher cognitive level (Erlacher & Schredl, 2008b). Revonsuo (2000), for example, speculates in his threat simulation theory that the biological function of dreaming is to simulate threatening events, and to rehearse threat perception and threat avoidance. This theory implies that dreaming might alter waking performance, a notion which is also discussed within findings about sleep-related memory consolidation processes (e.g., Stickgold, Hobson, Fosse & Fosse, 2001). A special kind of REM dreams are lucid dreams. A lucid dream is defined as a dream in which the dreamer—while dreaming—is aware that he or she is dreaming (LaBerge, 1985; Schredl & Erlacher, 2004). After realizing that they are in the dream state, lucid dreamers are able to remember waking memories (Erlacher, 2009) and consciously influence the action occurring in such dreams (cf. Tholey, 1981). Within lucid dreams the simulated dream world can be controlled by the dreamer and therefore a lucid dreamer could practice motor skills in his or her dreams.

In this paper, the possibility of performing and practicing movements in a lucid dream and the effects on the performance in the waking state will be studied. Practice in lucid dreams will be defined as a type of mental rehearsal, whereby a person is using the dream state to consciously practice specific motor tasks without waking up (cf. Erlacher, 2007). Even though this kind of mental rehearsal is not novel (e.g., Tholey, 1990), it is a rather unknown technique to enhance sport performance. Because the phenomena of lucid dreaming and the results from lucid dream research are in general quite unknown, especially in the area of sports, some aspects about lucid dream research will be briefly described.

Studies from lucid dream research (overview: Erlacher & Schredl, 2008b) demonstrated that lucid dreaming is a REM sleep phenomena. As stated above, the brain is very active and the skeletal muscles are nearly paralyzed in REM sleep (Hobson et al., 2000). One obvious exception of the inactivated body is the eye movements, which in part correspond to the eye movements carried out by the dreamer (scanning hypothesis, cf. Roffwarg, Dement, Muzio & Fischer, 1962). The exception of eye movements from the paralysis of the sleeping body can be used in sleep laboratory studies, whereas lucid dreamers execute preagreed and specific eye movements to mark events in the recordings of the electrooculogram (EOG). The EOG recording is part of the standard sleep recording and monitors the movement of the eyes during sleep. Specific eye movement patterns like a left-right-left-right

can be easily seen in the EOG recording. After awakening, those eye signals can be confirmed in the dream report of the lucid dreamer. With this method, a strong correlation between lucid dreamed actions and physiological measurement (e.g., EEG, EMG, heart rate) was found (see Erlacher & Schredl, 2008b). In the following, two recent sleep laboratory experiments studying motor performance in lucid dreams will be described.

Erlacher, Schredl, and LaBerge (2003) studied the physiological responses to dreamed motor activities in a single lucid dreamer. Electroencephalographic (EEG) alpha power over motor areas was recorded while the participant subsequently performed a motor task (hand clenching) and control task (counting) in his lucid dream. The lucid dreamer signaled those dream events through left-right-left-right eye movement patterns evident in the recorded EOG. The results showed that EEG alpha power over bilateral motor areas decreased while the lucid dreamer executed left or right hand clenching in contrast to dream counting. The decrease in the EEG alpha power (also event-related desynchronization) corresponds to higher activity in the underlying cortex area (cf. Pfurtscheller & Neuper, 1997). In a study by Erlacher and Schredl (2008a), five lucid dreamers were instructed to perform ten deep squats while lucid dreaming. Heart rate and respiration rate were measured continuously. The lucid dreamers were instructed to signal those dream events by left-right-left-right eye movement patterns. The results revealed a small but significant increase in heart rate while performing squats in the lucid dream. The changes for respiration rate were less pronounced but showed the expected higher respiration rates while squatting in the dream. The results of these two studies can be seen as an indicator that motor performance during lucid dreaming involves the same cortical areas as during waking performance (cf. Erlacher & Schredl, 2008b).

Beside the previously discussed sleep laboratory studies there are anecdotal reports (e.g., LaBerge, 1985) and one qualitative study (Tholey, 1981) which investigated the possibility of performing and practicing movements in lucid dreams. In the study by Tholey (1981), lucid dreamers were instructed to perform different complex sport skills in their lucid dreams, like skiing or gymnastics which the participants already knew how to do from waking life. The participants reported that they had no difficulties in performing those complex sport skills during their lucid dreams. Furthermore, the participants reported that the movements were accompanied by a pleasant feeling in the dream and, due to the practice, that the movements improved in both the dream state and the waking state. In sport, it seems that at least some athletes already use lucid dream practice to improve their waking performance (Erlacher, 2007; LaBerge & Rheingold, 1990; Tholey, 1990). LaBerge and Rheingold (1990) reported several amateur athletes who improved their skills during lucid dreams, e.g., a long distance runner who practiced his running technique, a tennis novice who learned his tennis serve and a woman who enhanced her skating skills. Erlacher (2007) reported one female high diver who described that she practiced complex twists and somersaults in her lucid dreams. She reported that the movements felt real, but she could slow down the entire sequence to focus on important details of the dive.

Practice in lucid dreams seems to be similar to mental practice in so far as movements are rehearsed with an imagined body on a cognitive level (cf. Erlacher, 2007). There is convincing evidence that mental practice of motor tasks improves performance (cf. Driskell, Copper & Moran, 1994). Based on past research in the

area of lucid dreaming, along with research on the effects of mental practice, it seems plausible to justify the notion that practice in dreams will lead to increased performance. In contrast to the amount of research on mental practice, the empirical research is rather limited for practice in lucid dreams.

The aim of the current study was to extend the findings about motor learning in lucid dreams from the qualitative study by Tholey (1984). In a prepost design, participants were asked to practice a motor task in their lucid dreams. It was hypothesized that participants who succeeded in practicing the aiming task in their lucid dreams would enhance their waking performance on the next morning. Furthermore, it was expected that the lucid dream practice group would show better results than the participants who could not practice in their dreams as well as a nonpracticing control group. No predictions were made with respect to the improvement compared with a physical practice group.

Method

Participants

Forty participants (19 female, 21 male) volunteered in this study. Their mean age was 27.5 years ($SD = 8.3$), ranging from 17 to 54 years of age. The participants belonged either to the lucid dream practice group ($n = 20$), the physical practice group ($n = 10$) or the control group ($n = 10$). The participants who were assigned to the lucid dream practice group were recruited through an Internet page (http://klartraum.de) about lucid dreaming provided by the first author. The other participants were students from the University of Heidelberg. Participation was unpaid.

Aiming Task

To measure waking performance, the participants had to carry out a simple aiming task. For this task the participants had to toss 10-cent coins (European currency; diameter: 19.75 mm; thickness: 1.93 mm; weight: 4.10 g) into a cup (diameter: 8 cm) which was positioned 2 m away. The pre and post test consisted of 20 tosses. The number of hits out of 20 tosses (0–20 hits) served as the dependent measure.

Procedure

The experiment was conducted as a field experiment, e.g., the participants performed the pre and post test by themselves in a home setting. The participants of the lucid dream practice group downloaded the material for the experiment from the Internet page http://klartraum.de ("Klartraum" is the German term for lucid dream). The material contained 1) a general introduction to the experiment, 2) instructions for the experiment and 3) a protocol to record the results. No instructions were given on how to induce a lucid dream because those participants were familiar with lucid dreaming. The participants of the physical practice group and the control group received the same material, but without any reference to lucid dream practice. The difference in the material for the physical practice group and the control group was that the control group should only perform the pre and post test, whereas the physical practice group should practice the task for six minutes after the pre test. The

practice time of six minutes was taken because the estimated time of practice for the participants in the lucid dream was six minutes on average (see results section).

All participants were instructed to perform the pre test at 9 p.m. For the pre test, the participant had to toss 20 coins in a cup and afterward they had to record the number of hits in the protocol. During the night, the participants of the lucid dream practice group were asked to induce a lucid dream and to practice the aiming task within the lucid dream as long as possible. All dreams and lucid dreams during the night had to be recorded on the protocol. If the participants were successful in inducing a lucid dream, they had to estimate how long they could practice the aiming task in the lucid dream. In the morning at 9 a.m. the participants had to toss 20 throws for the post test and, afterward, they had to record the number of hits in the protocol. After finishing the experiment, the protocol was sent to the first author by e-mail.

Following a quasi-experimental design, the participants of the lucid dream practice group were divided into participants who were able to practice the aiming task in the lucid dream and those participants who were not successful in either inducing a lucid dream or in practicing the aiming task in the lucid dream. The participants for the physical practice group and the control group were randomly assigned.

Statistical Analysis

Because the assumption of a normal distribution of the hit rate was not given in some cases, nonparametrical tests were used for statistical analysis. The improvement for each group in the number of hits was analyzed by Wilcoxon tests. One-tailed tests were applied because the direction of the effect was predicted for the lucid dream practice group. To compare the four groups with respect to their improvement in the motor task a Kruskal-Wallis test was applied. Post hoc analysis was made by Mann-Whitney U tests. The level of significance was $p = .05$. Statistical analyses were carried out with the SPSS for Windows (PASW, Version 17.0.2) software package.

Results

The 20 participants in the lucid dream practice group attempted to carry out the motor task in a lucid dream on a single night. Seven participants succeeded in having a lucid dream and practiced the experimental task. This group of seven showed a significant improvement in performance from 3.7 to 5.3, $z = 2.2$, $p = .01$. The other 13 subjects with no dream practice showed no improvement (from 3.4 to 2.9; no test applied). The physically practicing group showed the highest improvement from 3.4 to 6.4, $z = 2.6$, $p < .01$, whereas the control group did not improve significantly (from 2.9 to 3.0; $z = 0.3$, $p = .79$). All scores for all participants are depicted in Figure 1.

In Figure 2, box plots are depicted with the improvement in hits for each group. Comparing all groups regarding their improvement in the motor task, a statistically significant finding was attained, $\chi^2(3, N = 40) = 17.9$, $p < .001$. Post hoc analysis showed that the physical practice group and the lucid dream practice group differed significantly from the no dream practice group and the control group. No

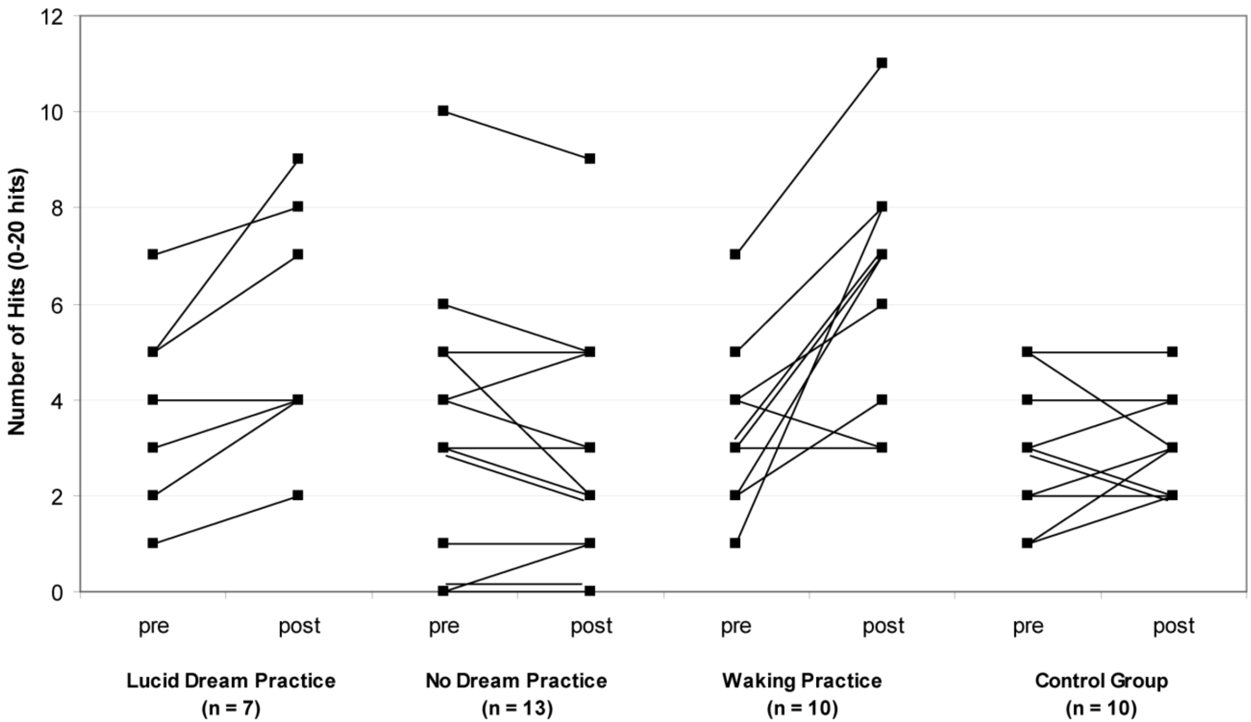

Figure 1 — All scores of all participants for the four groups in the pre and post test. Two identical results are depicted as two parallel lines.

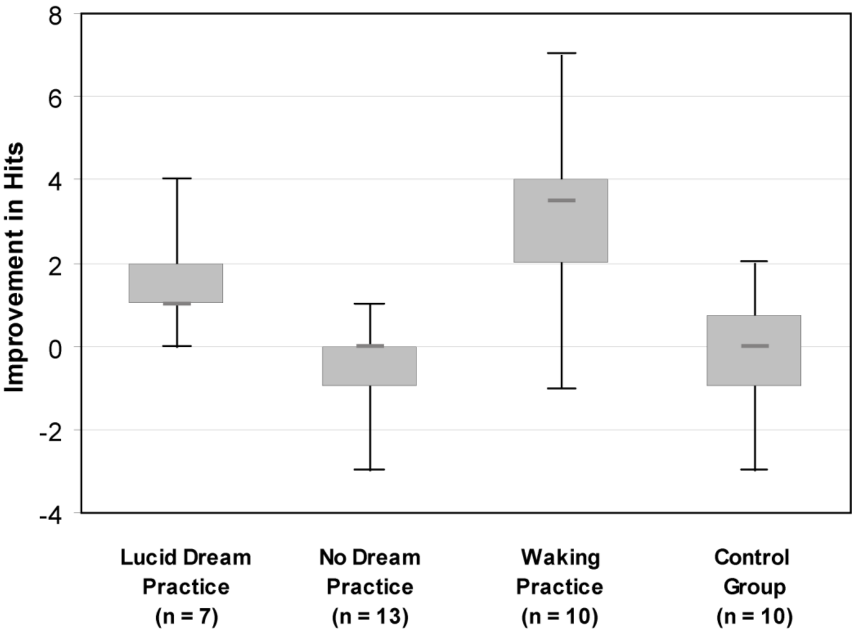

Figure 2 — Box Plots for the improvement in hits for all four groups.

statistically significant findings were found between the physical practice and lucid dream practice group nor for the no dream and control groups.

The seven participants who practiced the motor task in the lucid dream estimated the length of the lucid dreams as being a mean of 11.2 min (5, 6, 8, 10, 18, 5, 15, and 20 min) and the duration of practice in the lucid dream as a mean of 6.0 min (3, 4, 4, 5, 5, 5, and 16 min).

Discussion

The findings of this study indicate that lucid dreamers are able to practice a motor task within their lucid dreams and that the rehearsal in the lucid dream enhances the performance in wakefulness. On average, the lucid dream practice enhanced the hit rate by about 1.6 hits, whereas the hit rate of the nonlucid dream group and the control group did not improve to a statistically significant degree. The physically practicing group showed the highest improvement, but did not differ significantly from the lucid dream practice group. The results therefore support the qualitative findings by Tholey (1981) and underline the possibility of lucid dream practice for professional sports.

Because this was in part a quasi-experimental field study several methodological issues should be discussed. The study was conducted as a field experiment, e.g., the participants received instructions by Internet and conducted the test by

themselves in a home setting. The advantage of the field research is that more lucid dreamers can be reached. In general, the prevalence rate of lucid dreamers in the normal population lies at 26% (Stepansky et al., 1998). This means that 26% experienced a lucid dream at least once in their life, however, within lucid dreamers, the rate of frequent lucid dreamers (frequency equal to or higher than once per month) ranges from 17% to 38% (cf. Snyder & Gackenbach, 1988). For sleep laboratory studies, however, lucid dreamers are necessary who have a high frequency of lucid dreams, because the sleep recordings are usually limited to a few nights. Therefore, it is problematic to recruit a sufficient number of proficient lucid dreamers for sleep laboratory studies. To overcome this limitation, we applied the online experiment which allowed reaching a greater number of participants all over Germany.

The field research, however, has its known disadvantages (cf. Bortz & Döring, 2002). The missing control of the experimental procedure is one disadvantage. Even though we kept the lucid dream task as simple as possible and formulated clear instructions for the participants, we cannot rule out possible errors from participants who did not adhere to the instructions, e.g., it might be possible, that some of the participants did not follow the experimental protocol exactly. In future studies it would be desirable to conduct experiments in a sleep laboratory setting to have a better control of confounding variables. In the sleep laboratory, the lucid dream could also be monitored by using pairs of eye movements (e.g., Erlacher & Schredl, 2008a).

The quasi-experimental research design for the lucid dream group bears the disadvantage that the participants are not randomly assigned to the lucid dream practice group or the nondream control group (cf. Bortz & Döring, 2002). This procedure might lead to a systematic bias within the groups, e.g., lucid dreamers who were not successful in performing the lucid dream task or in inducing a lucid dream might be disappointed and perform the task less accurately in the morning. This bias should be considered for the interpretation of the results. However, to account for this problem, we included a classical control group with no instructions and no practice.

The practice in lucid dreams enhanced the performance in wakefulness; however, the explanation for this increase is still open. The first possible explanation is that the practice in lucid dreams elicited motor learning processes which are similar to mental practice (Heuer, 1985). For both types of mental rehearsal, movements are simulated with an imagined body on a cognitive level. For motor imagery, the positive effects of imagining movements on motor learning suggest a close functional equivalence between motor imagery and motor preparation, because the cognitive processes must interfere at some level (Holmes & Collins, 2001; Jeannerod, 1994). The same holds true for practice in lucid dreams: The enhancement of the performance rate can be explained by the improvement of the neural networks which, in part, is the same for wakefulness and for dreams (cf. Erlacher & Schredl, 2008b).

Another explanation for the increased performance rate might be that the successful practice of coin tossing in the lucid dream led to a higher confidence after awakening and a higher motivation in the post test. Such unspecific effects cannot be excluded by the current study; therefore, it would be desirable to have

a control group in further studies which also have lucid dreams, but perform an unspecific task in their dream. A second possibility to control for unspecific effects would be to use a different motor task which has a higher motor component (e.g., balance task). For such a motor task, motivational and psychological factors have less impact on the learning rate (e.g., Ryan & Simons, 1981).

Practice in lucid dreams seems to be quite similar to mental practice in so far as that movements are rehearsed with an imagined body on a cognitive level; however, in contrast to mental imagery, there is some evidence that (lucid) dreaming is more perception-like than thought-like (LaBerge, 2000; LaBerge & Zimbardo, 2001). LaBerge and Zimbardo (2001) are viewing dreaming as the special case of perception without the constraints of external sensory input. On the basis of this thought, one might speculate that dream practice leads to better results than mental practice (cf. Erlacher, 2007). This hypothesis should be tested in further research comparing lucid dream practice and mental practice.

To provide a new mental rehearsal method, athletes need to have techniques to learn lucid dreaming. Throughout the literature on lucid dreams, a wide variety of techniques are described, however only very few of which have been formally tested. Price and Cohen (1988) categorized those techniques in "lucid awareness training", "intention and suggestion procedures" and "cue-REMinding" techniques. Within "lucid awareness training" a person attempts to promote a particular attitude or state of consciousness during wakefulness. The idea behind this is that once this attitude becomes firmly established while awake, it will be triggered during the dream (Price & Cohen, 1988; Tholey, 1989). Intention and suggestion techniques focus on auto-suggestions (e.g., Garfield, 1976) or posthypnotic suggestion (e.g., Dane & Van de Castel, 1991), whereby a person concentrates on the intention to become lucid or intends, for example, to perform a particular action in the dream which is associated with lucidity before sleep. Within "cue-REMinding" techniques, the goal is to stimulate lucidity by introducing an external stimulus during REM sleep (e.g., LaBerge & Levitan, 1995). So far, a broad range of techniques have been established, although none of these techniques have been verified to induce lucid dreams reliably and consistently. To use lucid dream practice in sports or other areas, such reliable techniques must be established. This is one of the major tasks currently facing lucid dream research.

To summarize, the results of the current study indicate that lucid dreamers are able to practice a simple motor task in their dreams and that this rehearsal improved the performance in wakefulness in comparison with the group without dream practice or a control group. Even though the experimental design is not able to explain if specific effects (motor learning) or unspecific effects (motivation) caused the improvement, the results of this study demonstrated that practice in lucid dreams enhances performance in wakefulness. To clarify the factors which enhance performance after lucid dream practice and to control for confounding factors, it is suggested that sleep laboratory studies be conducted in the future. Even though lucid dream practice might be similarly valuable for professional sports as mental practice, the establishment of this novel technique is dependent on the further development of reliable lucid dream induction techniques.

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