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Improvement of darts performance following lucid dream practice depends on the number of distractions while rehearsing within the dream – a sleep laboratory pilot study

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ABSTRACT

In a lucid dream, the dreamer is aware of the dream state and can deliberately practice motor skills. Two field studies indicated that lucid dream practice can improve waking performance in simple motor tasks. The present pilot study investigated the effect of lucid dream practice in a controlled sleep laboratory setting, using a pre-post design with dart throwing in the evening and morning. The experimental group practiced darts in lucid dreams. Because some participants were distracted during lucid dream practice, the group was divided into lucid dreamers with few (n = 4) and many distractions (n = 5). Change of performance was compared to a physical practice group (n = 9) and a control group (n = 9), showing a significant interaction (P = .013, η^2 = .368). Only the lucid dreamers with few distractions improved (18%) significantly over time (P = .005, d = 3.84). Even though these results have to be considered preliminary, the present study indicates that lucid dream practice can be an effective tool in sports practice if lucid dreamers find ways to minimise distractions during lucid dream practice. Moreover, the study emphasises the necessity to investigate lucid dream practice experiences on a qualitative level.

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KEYWORDS
Lucid dreams; motor learning; lucid dream practice; mental practice; darts

Introduction

In a lucid dream, the dreamer is consciously aware of the dream state and can thus consciously observe the dream state or carry out actions deliberately (Schredl & Erlacher, 2004). Therefore, lucid dreams can be used to rehearse motor skills while dreaming (cf. Erlacher, 2007; Stumbrys, Erlacher, & Schredl, 2016). Lucid dream practice can be conceptualised as a form of mental practice, which is defined as the cognitive rehearsal of motor activity in the absence of overt physical movement (Driskell, Copper, & Moran, 1994). Erlacher and Schredl (2008b) suggest that physically executed and dreamed movements share the same neural mechanisms. Recent findings support this assumption: Correspondences between dreamed and physical movements were found for autonomic responses (Erlacher & Schredl, 2008a), neural activation (Dresler et al., 2011; Erlacher, Schredl, & LaBerge, 2003), and temporal aspects (Erlacher, Schädlich, Stumbrys, & Schredl, 2014). Based on these findings, it can be assumed that lucid dream practice in general could lead to performance enhancement.

Apart from anecdotal accounts of athletes practicing motor skills in lucid dreams (c.f. Erlacher, 2007), there is not much empirical evidence for the effectiveness of lucid dream practice on subsequent performance in wakefulness. Erlacher, Stumbrys, and Schredl (2011–2012) found that out of 840 German athletes practicing different sports 57% reported to have had at least 1 lucid dream in their life, 24% recalled lucid dreams at least once a month. 9% of the lucid dreamers practiced motor skills in lucid dreams and the majority (about 77%) had the impression that their skills improved as a result of lucid dream practice. In a field experiment with a pre-post design, 7 lucid dreamers showed significant improvement after practicing a coin-tossing task in the lucid dream state (Erlacher & Schredl, 2010). In an online experiment, Stumbrys et al. (2016) used a finger-tapping task to compare the performance of lucid dream practice to physical, mental, and no practice. The results show a significant improvement in all 3 practice groups, but no improvement in the control group, demonstrating that lucid dream practice can indeed enhance performance.

However, laboratory studies investigating the effectiveness of lucid dream practice under controlled conditions are still lacking. In addition, polysomnographic recording helps to verify lucid dreams as lucid dreamers can be instructed to perform specific predetermined eye movement patterns during a lucid dream to indicate the onset lucidity or mark specific actions within the dream. These "eye signals" can be detected in the electro-oculogram and can validate the dream reports (cf. Erlacher et al., 2014). This paradigm ensures that lucid dreamers are asleep during lucid dream practice. Furthermore, in a sleep laboratory setting, the examiner can awaken the dreamer to elicit the dream report directly.

The goal of this study is to examine the effect of lucid dream practice in a sleep laboratory setting, using a dart throwing task. We chose darts as a task, because it is a simple

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task, similar to coin-tossing and because several studies showed an effect of mental practice on dart throwing performance (Kremer, Spittle, McNeil, & Shinners, 2009; Mendoza & Wichman, 1978; Straub, 1989). It was expected to find gains in performance in the lucid dream practice group as well as a physical practice group, but not for the control group.

Methods

Participants

Thirty-three individuals spent 1 night in a sleep laboratory. Out of 15 lucid dreamers 9 managed to practice darts in a lucid dream. The final sample consisted of the lucid dream practice group (n = 9), a physical practice group (n = 9), and a control group (n = 9). Experienced lucid dreamers were assigned to the lucid dream practice group; physical practice and control participants were assigned matching age and gender of the lucid dream practice group. Age ranged from 18 to 45 years, with a mean age of 26.6, s = 6.6 years. Group characteristics are depicted in Table 1.

Subjectively estimated darts skills were equal in all 3 groups. Dream recall frequency and lucid dream recall frequency varied significantly over all 3 groups. As expected, the lucid dream practice group showed a significantly higher lucid dream recall frequency than the physical practice group ($P < .001$, $\eta^2 = 0.733$) and control group ($P = .010$, $\eta^2 = 0.392$). In the control group, the lucid dream recall frequency was also significantly higher than in the physical practice group ($P = .030$, $\eta^2 = 0.279$)

Participants were recruited via electronic advertisements, such as forums and online journals on lucid dreaming, posts on social networking sites and via personal contacts. They received 30 € for participation. Additionally, travel expanses of the lucid dreamers were covered, because only a few advanced lucid dreamers lived in the vicinity of Mannheim. The study was approved by the ethics committee of the Medical Faculty Mannheim/Heidelberg University.

Motor task

The pre- and post-test consisted of 21 dart throws in sets of 3 after 9 warm-up throws. Participants had to use their non-dominant hand. If unsure, they were asked to use the hand which they felt less confident with regarding the task. According to the official measurements for steel darts, the dartboard was hung up on a wall with the centre 1.73 m above ground, the oche (white tape) was placed 2.37 m away from the wall. While throwing darts, the participant had placed 1 foot directly in front of the oche. The dartboard measured 42 cm in diameter, displaying 9 concentric rings (alternating in black and white) around the Bull's Eye (red). The Bull's Eye measured 1 cm in diameter, each ring was 2-cm wide. The score for each participant was the average of all 21 throws, the Bull's Eye counting as 10 and the rings from centre to periphery ranging from 9 to 1. If a dart missed the dartboard or hit it in a way that it fell down immediately, it was counted as zero. If a dart hit precisely the line between 2 rings, the higher score was noted down.

Materials

All participants were asked to estimate their darts skills on a Likert scale ranging from 1 – very bad to 7 – very good. Dream recall frequency was assessed on a 7-point Likert scale which showed a high retest reliability (r = .85; Schredl, 2004). The anchors are: 0 – never; 1 – less than once a month; 2 – about once a month; 3 – 2–3 times a month; 4 – about once a week; 5 – several times a week, and 6 – almost every morning. Lucid dream recall frequency was assessed on an 8-point Likert scale which also showed a high retest reliability (r = .89; Stumbrys, Erlacher, & Schredl, 2013), using the anchors: 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, and 7 – several times a week.

Procedure

The participants arrived at the sleep laboratory around 9.30 pm and were shown around by the examiner. They received information about the study, gave their written consent, and completed the questionnaire scales. At 10.00 pm, the pre-test was conducted. Then the participants prepared to go to sleep and electrodes for polysomnography were applied according to AASM criteria (Iber, Ancoli–Israel, Chesson, & Quan, 2007), including electroencephalogram, electro-oculogram, and electromyogram. The lights were switched off between 11.30 pm and midnight, adapting to the participants' sleep habits. Lights were turned on again at 9.30 am. The post-test was

Table 1. Group characteristics (means ± s).

	Lucid dream practice					
	Few distractions (n = 4)	Many distractions (n = 5)	Physical practice (n = 9)	Control (n = 9)	Statistical test	P
Age (years)	25.8 ± 5.6	27.6 ± 8.4	27.6 ± 3.8	26.0 ± 7.5	$F_{3,24} = 0.151$	.928
Male/Female	3/1	2/3	5/4	5/4	$\chi^2_3 = 1.06$	.786
Left hand/right hand[a]	4/0	5/0	9/0	8/1	$\chi^2_3 = 2.00$	.572
Dream recall frequency[b]	6.0 ± 0.0	5.8 ± 0.4	3.8 ± 1.4	5.0 ± 1.0	$\chi^2_3 = 12.88$	.005
Lucid dream recall frequency[c]	6.0 ± 0.8	5.0 ± 1.0	2.2 ± 1.2	3.7 ± 1.4	$\chi^2_3 = 16.35$	.001
Darts skills (subjective)	3.0 ± 1.4	3.2 ± 0.8	3.1 ± 0.9	3.1 ± 1.1	$\chi^2_3 = 0.01$	1.00

[a] Hand used for throwing darts during pre-test, post-test, and practice.
[b] Ordinal scale ranging from 0 to 6.
[c] Ordinal scale ranging from 0 to 7.

performed at 10.00 am. Due to organisational reasons, 4 participants had minor deviations from the time protocol (deviations between 15 and 45 min from the original protocol). The procedures that varied between groups are described separately below.

In all groups, participants were asked not to imagine playing darts at any time of the night and to report any lucid or non-lucid dream that might involve dart throwing. Additionally, the examiner asked the participants after the first awakening as well as at the end of the night if they had dreamed about playing darts or similar movements or tasks in non-lucid dreams.

Lucid dream practice group

In the lucid dream practice group, lucid dreamers were included who had at least 1 lucid dream per month over the last 4 months. Prior to sleep onset, the participants received a handout which described their task for the night step by step: When becoming lucid, they had to perform 3 fast consecutive left–right eye movements (3* left–right). After organising devices for dart throwing the dreamers had to perform a second signal (3* left–right) and throw 30 darts, with a short signal (1* left–right) after every fifth throw. When finished, participants ought to signal the end of the task (6* left–right), try to wake themselves up and to notify the examiner through the intercom system. It was emphasised to use the same hand as in the pre-test. The examiner explained the instructions to the participants and answered questions when necessary.

The Wake-up-Back-To-Bed technique (in lucid dreaming literature often referred to as WBTB, e.g., cf. Stumbrys, Erlacher, Schädlich, & Schredl, 2012) was applied for lucid dream induction. All lucid dreamers were awakened after a rapid eye movement (REM) phase 4–6 h after sleep onset. They sat at a table with the light on and the experimenter asked them to write down the last dream they could remember and to mark so-called dream-signs, i.e., dream features that could make the dreamer realise that they are not awake (cf. LaBerge & Rheingold, 1990). When there was time left, the examiner asked about dream signs in other dreams of the participant. After 30 min, the participants went back to bed. They were told that they might dream about the study or the laboratory and to perform reality checks when they find themselves in such scenes. Furthermore, they were reminded of the motor task again and the experimenter briefly repeated the instructions.

After a lucid dream, the participants awoke or were awakened (after 6* left–right or when no eye signals had occurred for 1 min) via an intercom system. The examiner asked for a detailed dream report, followed by specific questions in order to ensure that the lucid dreamers had managed to carry out the task, that instructions had been followed correctly (hand used for throwing; estimated number of darts thrown, number and time of eye signals) and to assess the conditions of lucid dream practice (estimated distance to the dartboard, features of the board and darts, subjective performance). The dream report and answers were recorded on voice recorder and later transcribed by the examiner.

The dream reports showed that some lucid dreamers were able to accomplish the task without major difficulties, while others had various distracting experiences that led to delays, interruptions, and possibly stress in general. Lucid dream practice sessions that are somewhat disturbed cannot be expected to lead to the same outcome as focused and undisturbed lucid dream practice. In order to distinguish between lucid dreamers who practiced concentrated and those who were distracted, for each participant the total number of *distractions* experienced during lucid dream practice was counted in the dream reports. For the 2 participants who had 2 lucid dreams each, the number of *distractions* was added for both dreams. In order to validate the identification of *distractions*, 3 experienced lucid dreamers, who were not involved in or familiar with the study, were given the instruction sheet for the lucid dream practice task and asked to name difficulties that could occur while performing the task in a lucid dream. A blind judge then developed a manual from these answers and used it to count *distractions* within the dream reports. Inter-rater reliability with the first scorer was $r = 0.773$. In the following, we provide some examples for different kinds of *distractions*:

- Action: The dreamer actively changes objects, the environment or the hand used for throwing (*"I did the first throw with my right hand and then I realised: 'Oh no I have to use my left hand!'"*).
- Adaptation: The dreamer had to adjust to changes in the dream environment or devices. (*"At some point I threw pencils"*).
- Dream characters: Dream characters interfere with the scene (*"The doll kept throwing darts at me"*).
- Stabilisation: The dreamer felt that the dream or lucidity was fading and reacted to it ("*I noticed it was getting somewhat instable ….I performed another eye signal ….I managed three or four more throws and then I woke up*").
- Eye signals: The dreamer thought about the eye signals or realised they had not performed them as instructed ("*And then I realised: 'I forgot the eye signal!' and then performed it quite fast*").

Physical practice group

Physical practice participants were matched to the lucid dreamers regarding gender, time of practice, and number of practice trials as reported by lucid dream practice participants. Two of the 9 lucid dreamers had 2 practice dreams each. In those cases the matched physical practice participants practiced at the time averaging the respective lucid dream times, but threw the total number of darts that had been thrown by the respective lucid dreamer. All physical practice participants were awakened 30 min prior to practice to avoid impairment by sleep inertia (Tassi & Muzet, 2000).

Control group

Control participants did not play darts between pre- and post-test. To create similar sleep conditions as in the other groups, they were awakened in accordance with the Wake-up-Back-To-Bed protocol for the lucid dream practice group (including reporting a dream and checking for dream signs to keep conditions similar).

Statistical analyses

We used IBM SPSS Statistics 21 software for statistical analysis. One-way ANOVA was conducted to compare the groups regarding age. Kruskall–Wallis tests and Mann–Whitney-U tests were used to compare group characteristics for ordinal variables (darts skills, dream recall frequency, and lucid dream recall frequency). A two-way repeated measures ANOVA was conducted to compare the performance between groups from pre-test to post-test. We used pre-planned *t*-tests to compare performance from pre- to post-test for each group. Correlations with interval variables (darts score, number of practice trials, number of *distractions*) were calculated using Pearson's correlation; for ordinal variables (lucid dream recall frequency) Spearman's *rho* correlation was used. G*Power 3.1.9.2 software (Faul, Erdfelder, Buchner, & Lang, 2009) was used for calculating effect sizes *d*. A significance level of alpha = .05 was employed.

Results

Characteristics of lucid dream practice dreams

Altogether, 9 participants managed to practice darts in lucid dreams: Seven lucid dreamers had 1 lucid dream practice dream each, 2 had 2 lucid dream practice dreams each. In all 11 dreams, the examiner noticed the predetermined eye signals and awakened the participants according to the protocol if they had not awakened by themselves. All lucid dreams occurred in REM sleep. None of the lucid dreamers recalled any additional non-lucid or lucid dreams involving darts or similar actions.

Three of the lucid dream practice dreams occurred before and 8 after Wake-up-Back-To-Bed. None of the lucid dreamers managed to perform the eye signals for the purpose of counting correctly and/or clearly visibly. Therefore, we used the number of thrown darts as estimated by each lucid dreamer. The total number of practice trials was in average 20.2 ± 10.0 darts (2 × 7, 1 × 15, 1 × 18, 2 × 20, 2 × 30, 1 × 35). In 3 dreams, the wrong hand was used only for the first (out of 30), first 2 (out of 15), and first 5 (out of 35) throws. In all other dreams, the same hand as in pre- and post test was used.

Because some lucid dreamers experienced multiple *distractions* during lucid dream practice, which are expected to have an influence on a possible effect of practice, the number of *distractions* was counted for each lucid dreamer. The number of *distractions* per dreamer is depicted in Table 2. On average, the lucid dreamers experienced 4.1 ± 2.9 *distractions*. To distinguish lucid dreamers who were able to practice undisturbed from those with many *distractions*, the lucid dream practice group was divided by median split (*few* vs. *many distractions*). The median value of 5 *distractions* was assigned to the *many distractions* group, because the value is closer to the next one in the *many distractions* group (6) than to the *few distractions group* (2). The 4 lucid dreamers of the *few distractions* group experienced 1.3 ± 0.5 *distractions* each; the remaining 5 lucid dreamers had to deal with considerably more *distractions* (6.4 ± 1.1).

Table 2. Number of *distractions* per dream and dreamer.

Participant	Per dream	Per dreamer	Group
2	1	1	Few distractions
4a	2	2	
4b	0		
5	1	1	
6	1	1	
3	5	5	Many distractions
12	7	7	
14	6	6	
19	6	6	
26a	4	8	
26b	4		

Participants No. 4 and No. 26 had 2 lucid dreams each.
The number of *distractions* was added over both dreams.

Effects of practice

None of the participants of the physical practice and control group recalled any darts related dreams or dreams involving similar activities. Change of performance was determined by subtracting the pre-test score from the post-test score. Thus, a positive difference indicates improvement and vice versa. Performance was compared between the 4 groups, i.e., the 2 lucid dream practice groups (*few* vs. *many distractions*), physical practice, and control group. Results show no significant effect of time (pre-test to post-test; $\boldsymbol{F}_{1,23}$ = .170, P = .684, η^2 = .007) or group ($\boldsymbol{F}_{3,23}$ = .160, P = .922, η^2 = .020). Group × time interaction was significant ($\boldsymbol{F}_{3,23}$ = 4.471, P = .013, η^2 = .368), demonstrating that the 4 groups improved differently from pre-test to post-test. In the following, we are looking at performance changes for each group individually. Table 3 shows scores, *t*-test results, and effect sizes for each group. Figure 1 depicts individual score differences in each group. The physical practice group showed a slight improvement of 9% from pre-test to post-test on a descriptive level. However, the lucid dream practice group with *few distractions* significantly improved by 18%, with a large effect size of 3.84, according to Cohen (1992), while the lucid dream practice group with *many distractions* showed a decline of 14% on a descriptive level. The possible influence of the experienced *distractions* during lucid dream practice is also reflected in a strong negative correlation (r = −.742, P = .022, r^2 = .551; Figure 2). The number of *distractions* was not correlated with lucid dream recall frequency (*rho* = −.207, P = .592), the number of practice trials during lucid dream practice (r = .368, P = .329) or the time of practice (r = .068, P = .671).

There was no significant correlation between the number of practice trials and performance within the lucid dream practice groups (*few distractions:* r = .023, P = .977; *many distractions:* r = −.029, P = .963) nor within the physical practice group (r = .062, P = .874). There were also no correlations between the time of practice and performance in the lucid dream practice groups (*few distractions:* r = −.387, P = .613, *many distractions:* r = −.304, P = .619) and physical practice group (r = −.515, P = .156/r = −.503, P = .167). Furthermore, lucid dream recall frequency was not correlated with performance in any of the groups (*few distractions: rho* = .316, P = .684; *many distractions: rho* = −.791, P = .111; physical practice: *rho* = .173, P = .657; control: *rho* = −.398, P = .288).

Concerning the questions about lucid dream practice conditions, which were asked directly after the dream report (estimated distance to the dartboard, features of the board and darts, and subjective performance during lucid dream

Table 3. Effect of practice between groups.

	Darts score[a] Pre-test	Darts score[a] Post-test	Change in %	*t*--test *T*	*P*	Effect size *d*
Lucid dream practice (n = 9)	4.8 ± 1.3	4.8 ± 1.3	0	−.11	.457[b]	−0.03
Few distractions (n = 4)	4.4 ± 1.4	5.2 ± 1.4	+18	7.66	.005[c]	3.84
Many distractions (n = 5)	5.2 ± 1.3	4.5 ± 1.3	−14	−2.22	.091[c]	−0.99
Physical practice (n = 9)	4.3 ± 1.3	4.7 ± 1.4	+9	1.49	.087[b]	0.49
Control (n = 9)	5.0 ± 1.0	4.7 ± 1.1	−6	−1.09	.154[b]	−0.36

[a] Average score on dartboard (0–10 points) over 21 throws.
[b] One-tailed *t*-tests were used because a positive effect on performance was expected.
[c] Two-tailed *t*-tests were used to test post hoc data.

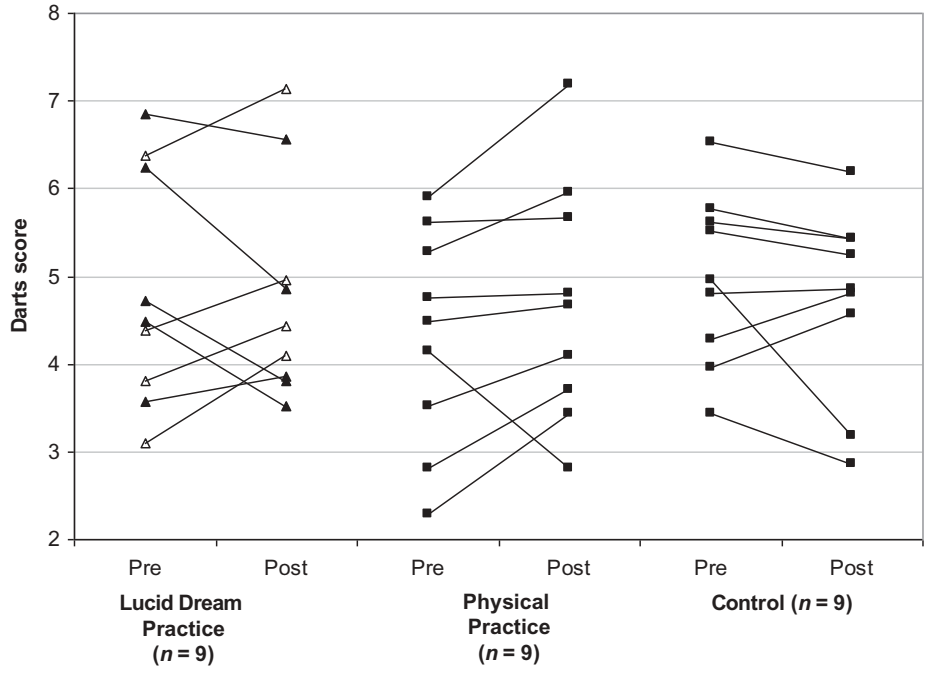

Figure 1. Individual darts scores in pre- and post-test.
Note: Unfilled triangles represent the lucid dreamers with *few distractions*, filled triangles represent lucid dreamers with *many distractions*.

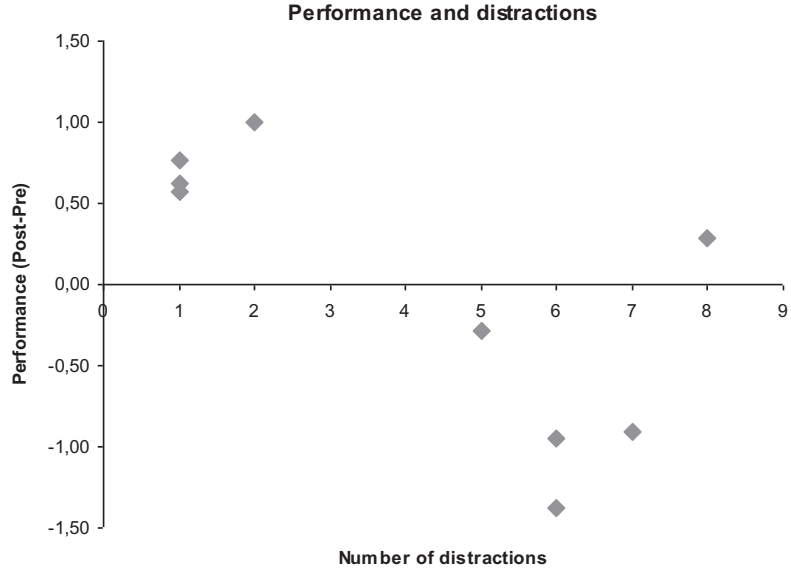

Figure 2. Distribution of performance and dream *distractions* per participant.

practice), none of the variables was correlated with performance.

Discussion

The results of this pilot study indicate that lucid dream practice can be effective when the lucid dreamer does not experience too many *distractions* during rehearsal. It thus supports the results of previous field studies (Erlacher & Schredl, 2010; Stumbrys et al., 2016). Before discussing the implications of these findings, we would like to address some methodological issues.

Firstly, waking performance was only enhanced when the lucid dreamer was not distracted during lucid dream practice. Because the distinction between lucid dreamers with *few* and *many distractions* was not hypothesised but derived from the lucid dreamers dream reports and therefore lacks a strict experimental design, the results of the present pilot study should be interpreted with caution. However, one would generally not expect a practice session that is interrupted and disturbed to be as effective as one that is carried out in a focused way. Thus, the lucid dreamers cannot be investigated as a homogeneous group with regards to lucid dream practice experiences. This finding of distractions during lucid dream practice as a potential influencing factor emphasises that the quantitative approach alone might not be sufficient to explore the lucid dream state as a tool for motor practice. It seems quite challenging to further investigate experimentally the effect of distractions within dreams, because even very frequent lucid dreamers experience distractions in their dreams and secondly, it is unclear how to induce a specific number or intensity of distractions in a lucid dream.

Secondly, although the sample size is rather small, it should be considered that it is a challenge to find many experienced lucid dreamers to participate in a sleep laboratory study. Furthermore, because there is no lucid dream induction technique that guarantees lucidity (cf. Stumbrys et al., 2012), we consider it a great outcome that out of 15 lucid dreamers 9 managed to accomplish the task successfully within a single night. The rather high lucidity rate of 60% cannot be compared directly to the ones found in lucid dream induction studies because, apart from the poor methodological quality of many induction studies (Stumbrys et al., 2012), the sample (untrained vs. experienced), goal (achieving lucidity vs. performing a task), and setting (field vs. laboratory) may vary from the conditions in our study. In studies which use lucid dreaming to explore aspects of the dream state the conditions also vary. For example, it is probably harder to achieve a stable lucid dream in an functional magnetic resonance imaging scanner (e.g., Dresler et al., 2011) compared with a laboratory bed. We assume that in our study the combination of our induction techniques, the experienced lucid dreamers and may be the darts task led to the high lucidity rate.

Thirdly, the reported number of darts thrown during lucid dream practice varied between 7 and 35. However, there was no correlation between the number of dart throws within the lucid dream and performance increases. Originally, we wanted to objectify the number of darts by instructing the lucid dreamers to make a single left–right eye movement after every fifth throw but the instructions were too complex: The lucid dreamers did not perform the counting eye signals as instructed – even though all lucid dreamers managed to perform eye signals to indicate lucidity and the beginning of the task which helped us to verify that the task was performed during REM sleep. Because the instruction for the in-between eye signals did not work, but instead seemed to have caused stress and confusion, it is advisable for future studies to keep instructions simpler.

Finally, the darts task was chosen because it is a simple motor task similar to the coin-tossing task, which showed an effect of lucid dream practice in a field experiment (Erlacher & Schredl, 2010) and because studies on mental practice using darts did show positive effects in subsequent performance (Kremer et al., 2009; Mendoza & Wichman, 1978; Straub, 1989). We did find a slight improvement in the physical practice group on a descriptive level and a significant improvement for the lucid dreamers who experienced *few distractions*. Therefore, the darts task seems a suitable task for lucid dream practice. In future studies, a more complex measurement for the dart positions might be applied additionally to assess performance. In the present study only the distance to the Bull's Eye was used, but one could use the spatial coordinates to look at the distribution of the darts on the board (e.g., Klostermann, Kredel, & Hossner, 2013). It is also noteworthy that all lucid dreamers managed to organise the devices needed to practice the task, showing that *finding* equipment for lucid dream practice is possible. Even though some of the identified *distractions* concerned the devices, this is still a great outcome. After all, none of the participants played darts regularly and they only had 1 night to perform the task.

We shortly want to address the higher lucid dream recall frequency of the control group compared with the physical practice group. Some participants were lucid dreamers but not experienced enough to be assigned to the lucid dream practice group, so they were assigned to the other 2 groups. Coincidentally; more lucid dreamers were assigned to the control group than to the physical practice group. However, considering that participants of both physical practice and control group did not recall any non-lucid or lucid darts dreams and that lucid dream recall frequency did not correlate with performance within any group, our results are not affected by the difference.

The result that *distractions* during lucid dream practice have a negative effect on subsequent performance is plausible, because a *distraction*, such as changing devices or being interrupted by people, would also limit motor learning in the waking state. In 2 previous studies (Erlacher & Schredl, 2010; Stumbrys et al., 2016), distracting events during lucid dream practice have not been analysed, so it cannot be inferred whether the finger-tapping and coin-tossing task are less susceptible to distraction. Based on the positive effect of lucid dream practice in these studies, one might assume that distractions in performing lucid dream practice were minimal. Future studies investigating lucid dream practice should compare different task and analyse the practice within the lucid

dream. It is also possible that the sleep laboratory setting is more stressful for participants than the home setting, which might lead to more distractions. To reduce stress, it could help to conduct an accommodation night in the laboratory. Another approach would be to use several nights for lucid dream practice, based on the assumption that being more familiar with the task would reduce the number of distractions within the dream. It would also be interesting to compare the findings of field studies and laboratory studies using the same task.

It could be speculated that skilled lucid dreamers might benefit more from lucid dream practice. With "skilled" we do not refer to the lucid dream recall frequency (as lucid dream recall frequency was not correlated with the number of distractions); but to the skill to carry out actions as intended and to be able to remain focused in spite of distractions. Other factors could also influence the occurrence and handling of distractions such as personality, motivation, expectancies, waking-life experiences with a certain task as well as attention and mindfulness in wakefulness. Therefore, in future studies, it might be useful to explore previous lucid dream experience and interindividual differences regarding the ability to influence the dream environment as well as other potential influencing factors.

One factor that might have affected the performance in the morning is the motivation to improve motor skills. If a lucid dreamer has managed to accomplish the task within the dream, they might be more motivated in the retest; i.e., it should be clarified how sensitive simple motor tasks are to different levels of motivation. Secondly, a few participants mentioned after the post-test that they had not actually aimed at the centre of the target but were rather focused on performing the throwing itself, counting, and signalling. Therefore, for future studies with similar designs, it might be advisable to place more emphasis on the fact that the motor task is meant to be practice time in order to improve performance. Also, it could be interesting to do single case studies on lucid dreamers who are ambitious about improving their skills.

How can the present findings of successful lucid dream practice be implemented in sports practice? Using the Wake-up-back-to-bed protocol, 60% of lucid dreamers were able to rehearse a motor task within a single night in the laboratory and 45% of those increased their performance by lucid dream practice. The success rate was relatively high, but one has to keep in mind that the participants were frequent lucid dreamers (1 lucid dream or more per month). As there are many techniques to induce lucid dreaming (Stumbrys et al., 2012), it would be interesting to find out whether less frequent lucid dreamers could also perform lucid dream practice by applying specific induction techniques. Keeping in mind that almost a quarter of (German) athletes experience lucid dreams regularly (Erlacher et al., 2011–2012), lucid dream practice can be a valuable tool in sports practice.

To summarise, although the results of the present pilot study are preliminary, they seem to support previous findings of a positive effect of lucid dream practice on subsequent performance. The study also demonstrates the potential of lucid dream practice for athletes. Future studies should also focus on qualitative aspects of lucid dream practice within the dream, as the present findings clearly indicate that it is not only necessary to practice but the conditions (especially concerning distractions) in which the dream practice is carried out are also important.

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