

An exploratory study of creative problem solving in lucid dreams: Preliminary findings and methodological considerations

Tadas Stumbrys & Michael Daniels

Liverpool John Moores University, UK

Summary. Both historical accounts and modern research suggest that dreams may contribute to creativity and problem solving, however no research has been done to investigate creative problem solving in lucid dreams – in which the dreamer is aware that he or she is dreaming. This pilot and exploratory study explored the feasibility of such research. It was also hypothesised that dream characters might help the dreamer. Nine lucid dreamers (the experimental group) and nine non-lucid dreamers (the control group), for ten consecutive nights, had either to solve a logical puzzle or to create a metaphor. The preliminary findings suggest that lucid dreams can contribute to problem solving when dealing with more creative rather than logical tasks and that dream characters can provide plausible creative advice to the dreamer. Several methodological considerations were revealed that should be addressed in future studies.

Keywords: lucid dreaming; problem solving; creativity; dream characters

1. Introduction

Throughout history dreams have been a wellspring of inspiration for many. Scientists, inventors, writers, artists found insights and clues to long-awaited answers while dreaming. F.A. Kekulé's discovery of the structure of the benzene molecule; O. Loewi's idea for the Nobel Prize winning experiment with a frog's heart; E. Howe's invention of the sewing machine; R. L. Stevenson's famous novella "The Strange Case of Dr. Jekyll and Mr. Hyde" are just a few famous anecdotal examples of dream-inspired problem solving and creativity (cf. Garfield, 1976). Creative dreaming is not a privilege of a few gifted individuals, it plays an important role in the lives of ordinary people – it has been estimated that about 8% of our dreams provide creative insights to our waking life problems (Schredl & Erlacher, 2007).

Although various dream incubation practices, aiming to receive answers to questions or obtain cures from sickness, existed in many ancient cultures (cf. Garfield, 1976), there is still relatively little known from the scientific point of view. Laboratory studies suggest that sleep loss and deprivation of dreaming, or of REM sleep, impairs creative thought and adaptation to stress (Glaubman et al, 1978; Greenberg, Pillard & Pearlman, 1972; Horne, 1988), however only very few studies have enquired whether dreams can contribute to creative problem solving.

Cartwright (1974) in a laboratory study asked student participants to accomplish three different types of tasks - crossword puzzles, the Remote Associates Tests (RAT), and

Thematic Apperception Test (TAT) story completions. These were done after a period of sleep, which included the REM stage, and after an equivalent period of wakefulness. The only difference between the two conditions was that sleep and dreaming resulted in less positive TAT story endings. However the *quality* of stories was not assessed in this study. Schatzman (1983a, 1983b, 1986) published several brain-teasers in the New Scientist magazine and received a number of dream reports solving these problems. However there is no way to establish the total number of people who actually tried to solve these problems with dream incubation techniques.

Barrett (1993) asked 76 college students to select a problem of personal relevance which had a possible solution and to follow a dream incubation procedure each night for one week or until they had a dream with a solution to the problem. About a half of the participants had a dream related to the problem and a majority of these (70%) were considered by the participants as containing a solution. Independent judges rated half of the problem-related dreams to contain a possible solution.

White and Taytroe (2003) randomly allocated 96 participants into a control and four experimental conditions. Participants were asked to choose between one and eight personal problems and to rate their solvability and level of distress at the beginning and at the end of ten days study, while keeping daily records of their dreams and moods. Experimental participants were asked to review cognitively one particular focal problem each day and to use either a dream incubation technique before going to sleep or after waking in the morning, or to use a relaxation technique before sleep or after awakening. The participants that used night dream incubation technique were more likely to report greater problem solvability, lower level of distress and greater improvement in their focal problem in comparison with the controls. Their daytime anxious and depressed moods also decreased over the period of study.

Corresponding address:
Tadas Stumbrys, MSc
E-mail: t_stumbrys@yahoo.com

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A recent study by Cai et al (2009) investigated the role of REM sleep on creative problem solving, using the Remote Associates Test while manipulating various conditions. In comparison with quiet rest and non-REM sleep, REM sleep was found to enhance the integration of unassociated information for creative problem solving during a nap. REM sleep increased the performance by almost 40%, while there were no improvements in NREM sleep and quiet rest conditions. The authors also established that prior exposure is necessary for creative problem solving and that REM improvements in creative problem solving are not simply the result of improvements in memory. The advantage of REM over NREM sleep in problem solving was also demonstrated by Walker et al (2002). Their participants were awakened after 10 minutes into NREM and REM sleep and were given anagram word puzzles to solve. It was found that awakenings immediately following REM sleep provided a significantly greater number of anagrams solved in comparison with NREM awakenings.

However none of this research has investigated creative problem solving in *lucid dreams* – in which the dreamer is aware that he or she is dreaming and can consciously influence the dream content (LaBerge, 1985). Although lucid dreaming is not widely known or understood, and is considered to be a rare phenomenon, it is estimated that about 58% of the population have experienced a lucid dream at least once in their lifetime and about 21% are having lucid dreams regularly - at least one lucid dream per month (Snyder & Gackenbach, 1988). It is a learnable skill (LaBerge, 1980) and there are a number of techniques suggested for lucid dreaming induction (e.g. Gackenbach, 1985; LaBerge & Levitan, 1995; LaBerge & Rheingold, 1990; Tholey, 1983).

LaBerge and Rheingold (1990) provide an anecdotal account of a computer programmer who used lucid dreams regularly for a computer program design. In his dreams, the programmer discusses the program with a dream character that represents Albert Einstein; they draw some flowcharts on a blackboard until they come up with a solution, which is usually 99% accurate (ibid. pp. 216-217). Tholey (1989) found out that at least some dream characters in lucid dreams are capable of remarkable cognitive achievements – they were able to write and draw, to rhyme, and even to say an unknown word to the dreamer, although they somehow struggled with arithmetic. Experienced lucid dreamers also observe that some dream characters appear as knowledgeable personas that describe themselves as guides and offer assistance or support to the dreamer (Waggoner, 2009). Considering that the content of lucid dreams mostly seems to depend on the dreamer's expectations (LaBerge, 1985; Waggoner, 2009), it seems plausible that knowledgeable-looking figures, such as Albert Einstein or an old wise guru, might provide credible advice to the dreamer.

In this pilot and exploratory study we explored the feasibility of creative problem solving in lucid dreams and enquired whether it might be beneficial for a dreamer to ask a knowledgeable-looking 'guide' or 'guru' dream figure for help with problem solving.

2. Method

2.1. Participants

Nine experienced lucid dreamers were recruited to the study by placing adverts on discussion boards in three lu-

cid dreaming related websites (ld4all.com, mortalmist.com and dreamviews.com). The age range was 18-41 years ($M = 26.2$, $SD = 8.0$). There were four males and five females and all were English speakers (4 native and 5 non-native). The lucid dreamers comprised the experimental group. The control group consisted of nine non-lucid dreamers with a good dream recall. A mixed strategy and purposive sampling procedure was used to match the control group with the demographic characteristics of the experimental group. One participant in the control group was recruited through a lucid dreaming related website, while the others were recruited by sending group emails to a number of people, directly or indirectly known to the researchers, inviting ones with good dream recall to take part in a study about dreams and creative problem solving. Three participants, who were known to have an interest in dreams, were invited to participate because they matched the characteristics of the experimental group. The age range of the control group was 19-41 years ($M = 26.9$, $SD = 6.7$). There were three males and six females and all were English speakers (4 native and 5 non-native).

Participants were recruited from different countries and continents, including Europe, Northern America and Australia. Although some of the participants were not native English speakers, all of them had a good command of the English language. All correspondence between the participants and the researcher was by emails in English. Participation was voluntary and unpaid. The ethical approval for this study was received from Liverpool John Moores University's Research Ethics Committee.

2.2. Procedure

The study was designed as a field experiment. For a period of ten consecutive days, each evening at 9 pm (21:00) their local time, the participants received an email with a task for that particular night to solve. The participants were asked to write down the task on a piece of paper or print it out and, before going to sleep, to read the task several times and try to memorize it *without solving it*.

The lucid dreamers were further advised to attempt to induce a lucid dream using their preferred technique. Once in a lucid dream, they were encouraged to believe that there is someone in their dream who knows answers to many questions and is willing to help the participant. It was suggested that it may be an old wise man or woman, a 'guru' figure or a 'guide'. The participants were asked to find this dream figure or to call him or her to appear. A specific sequence of movements was also suggested which participants could use if they were not able to find such a dream character (to go forward, turn to the left, find a door, open it, go through the door and turn to the right). It was expected that this might increase the expectations of the participants and thus the chances of finding the required dream figure. Once the lucid dreamers had found the guide figure, they were encouraged to ask him or her to solve the problem given to them. Even if the answer provided seemed not to be valid, the participants were asked to thank the 'guide' figure, to wake up themselves and to write down the answer and a description of the dream.

If the lucid dreamers were not successful with the completion of the whole procedure (inducing a lucid dream, finding a dream 'guru' character, obtaining the answer) they were asked to follow the same procedure as the control group: upon awakening in the morning to reflect on their dreams

and to write the first solution which then came to their mind, providing also a description of the most vivid dream of the night. They were also asked to send their report to the researcher on the same day. Participants also indicated in the report whether the answer was provided in the dream or by themselves. The lucid dreamers also specified whether they were able to induce a lucid dream, to find a guide figure, and to obtain an answer from the guide. This was also later verified by the researcher by comparing the dream descriptions provided by the participants.

Participants were not allowed to discuss their tasks with anyone else until after they had sent the report to the researcher. During the whole period of study, they were also prohibited from discussing the tasks, or their dreams and experiences of the study publicly or with people who might also participate in the project (e.g., on dream-related internet forums). At the end of the study, the participants were asked to reflect and share with the researchers their personal experiences, thoughts, and insights during the period of research.

2.3. Tasks

Two different types of tasks were used in the study: the participants had either to solve a logical puzzle or to create a metaphor for a specified situation. Logical tasks were selected from various sources, while metaphor tasks were chosen to reflect an unusual and ambiguous situation in order to avoid possible automatic associations. The order of task presentation was randomized. The tasks are shown in Table 1.

Logical tasks were assessed for their correctness (either correct or not), while the metaphors were evaluated by two judges (University tutors in psychology) who ranked them accordingly to four criteria: originality, aptness, validity and aesthetic fit or “elegance” (cf. Barron, 1969). One judge (Judge 2) was the second author. Both judges were blind to which group participants belonged to, although both judges understood the purpose and protocol of the study. The

judges initially were asked to provide an overall evaluation of the metaphors (considering the four criteria together) and to rank the different answers for each task, assigning the rank 1 to the best answer, 2 to the second best, and so on. Subsequently they were also asked to evaluate the metaphors by each criterion separately, i.e. to rank the answers for originality, aptness, validity and elegance. To avoid possible ambiguity, the distinction between aptness and validity was also clarified for the judges, who were advised to consider aptness as a more subjective measure (how well “it clicks”, or gives the right impression), while validity should be considered as more objective measure (how directly the images corresponded).

If the participant had not provided the answer to a logical task, it was considered as an incorrect answer (fail). A failure to provide an answer to a metaphor task resulted in an automatic assignment of the average lowest rank (e.g. if seven out of 10 participants provided their answers, they were assigned ranks in the range of 1-7, while the other three participants who did not provide their answers were assigned the same average lowest rank of $9 = (8 + 9 + 10) / 3$).

2.4. Statistical testing

Chi-Square analysis (two-tailed) was used to compare the answers to the logical tasks between the two groups. Answers to the logical tasks for all other conditions were compared by employing Fisher’s exact probability test (two-tailed), because sample sizes used were small.

Spearman’s rho coefficient (one-tailed) was calculated to assess the agreement between the two judges’ rankings of the answers to the metaphor tasks. The answers to the metaphor tasks among different conditions were compared by using the Mann-Whitney U test (two-tailed) for the rankings assigned by the two judges.

SPSS 14 software was used for statistical analysis.

Table 1. Tasks given to the participants

Day	Task
Day 1	What is the missing letter in the sequence? W, I, T, M, ?, I, T, S (Answer: L - initial letters of the presented sentence)
Day 2	To create a metaphor for: “Lighthouse in a desert”
Day 3	What is curious about the sentence: “Show this bold Prussian that praises slaughter, slaughter brings rout”? (Answer: without first letters of each word the sentence still makes sense)
Day 4	To create a metaphor for: “Banknote floating in a river”
Day 5	To create a metaphor for: “Child playing in a cemetery”
Day 6	There is an open bottle of beer in the centre of a small rug. The problem is to get the bottle off the rug. But you mustn’t touch the bottle with any part of your body or anything else. And not a drop of beer must be spilled. (Answer: to roll the rug carefully)
Day 7	What is the missing letter? H, Z, X, O, I, S (Answer: N – all these letters look exactly the same when viewed upside down)
Day 8	To create a metaphor for: “Sacrifice on a beach”
Day 9	Consider the letters: H, I, J, K, L, M, N, O. These letters represent one word. What is the word? (Answer: Water [“H to O” - H ₂ O])
Day 10	To create a metaphor for: “A well in an abandoned village”

Table 2. Responses to the logical tasks.

	N	Correct	Incorrect	Percentage Correct
Control group	38	7	31	18.4%
Lucid dreamers	39	6	33	15.4%
Dream guides	11	1	10	9.1%
Other dream characters	6	1	5	16.7%
Participants themselves	22	4	18	22.2%
Lucid dreams	24	2	22	8.3%
Non-lucid dreams	15	4	11	26.6%

3. Results

In total, 163 reports were received: 81 from the lucid dreamers (averaging 9.0 per participant) and 82 from the control group (averaging 9.1 per participant). Three reports were discarded: one lucid dreamer indicated that he solved a logical task while memorising it before sleeping, while two other participants (one lucid dreamer and one non-lucid dreamer) reported that they already knew the answer to the task given. Therefore 160 protocols (79 from the lucid dreamers and 81 from the control group) were used in the analysis.

3.1. Logical tasks

Seventy-seven reports (39 from the lucid dreamers, 38 from the control participants) were received in response to the logical tasks. Only 13 answers (16.9%) provided by the participants were correct (7 in the control group and 6 in the lucid dreamers group). There was no significant difference in the percentage correct between the two groups (18.4% and 15.4% of answers were correct, respectively; $\chi^2(1) = 0.126$, $p = .722$). Dream 'guide' figures provided only one correct answer out of 11 dreams in which such guides were encountered (9.1%). This proportion of correct answers seems to be somewhat lower than the rest of the answers provided by the lucid dreamers (5 out of 28, 17.9%), but these differences were not significant ($p = .655$). Other dream characters, that did not identify themselves as guides, provided one correct answer out of 6 dreams in which only non-guide characters were encountered. In total, therefore, dream characters gave 2 correct answers out of 17 dreams in which such characters appeared (either guide or non-guide). This percentage (11.8%) again was only about

half the proportion of the correct answers provided by non-dream characters, i.e. by the participants themselves, (4 out of 22, 22.2%), but the differences were also not significant ($p = .679$).

Interestingly, after a night with a lucid dream the lucid dreamers seemed to provide a lower number of correct answers than after a night without a lucid dream (8.3% vs. 26.6%), though these differences were not significant ($p = .180$). The answers to the logical tasks are presented in Table 2.

It is perhaps notable that both correct answers provided in lucid dreams for the logical tasks were to the same problem (Day 7) and were the only correct answers to this problem across both groups. However one participant already had an idea about this answer, while in the second case, the answer was provided even without asking the question of the dream character:

I'm back at the school. There's a woman working with one of the kids in the class that I work in. The woman doesn't look particularly old or young, maybe in her 40s or 50s, but she's very beautiful. I ask her if she's a guru and she nods. "What's the missing letter?" I say, "H, X . . . No, Z comes first, H, Z, X, O, I, S?" I simultaneously write the letters on the desk with my finger and they linger and glow. I realize that she's looking at them upside down, which might actually help her if my idea about the puzzle is correct. I hope that I didn't confuse her by saying X before Z at first. "What's the missing letter?" She mumbles some stuff, mostly to herself and then tells me an answer that doesn't make sense. "I think it has to be a letter," I say. She looks scared, like I've found her out for not knowing the answer. "N," she says. That's the answer I was just thinking of! I know that she took it from me. It's the answer I thought of when I was falling asleep. I'm annoyed. (Participant L7)

I managed to make a lucid dream but totally forgot to ask for an answer. So it had nothing to do with the problem to solve. Only after the dream I realized that one of the dream characters told me several times his name is "N". (Participant L11)

Table 3. Correlations between the evaluations of the two judges

Criteria	Spearman's rho	p-value (1-tailed)
Overall	.248	.017
Originality	.484	<.001
Aptness	.211	.036
Validity	.278	.009
Elegance	.225	.028

3.2. Metaphor tasks

In response to the metaphor tasks, 40 reports were received from the lucid dreamers and 43 protocols from the control group (83 protocols in total). The answers to the metaphor

Table 4. Mean (SD) rankings given by the two judges to the metaphor tasks.

	Control Group	Lucid Dreamers						
		All dreams	Dream guides	Not dream guides	All dream characters	Not dream characters	Lucid dreams	Non-lucid dreams
N	43	40	5	35	8	32	21	19
Overall								
(Judge 1)	8.72 ^{*9,17} (4.31)	8.90 (5.37)	4.00 ^{*4,9} (3.74)	9.60 ^{*4} (5.23)	4.88 ^{*11,17} (3.76)	9.91 ^{*11} (5.27)	6.86 ^{*20} (4.54)	11.16 ^{*20} (5.41)
(Judge 2)	8.28 (4.87)	9.18 (4.65)	7.00 (3.94)	9.49 (4.71)	8.63 (3.78)	9.31 (4.89)	8.81 (3.63)	9.58 (5.65)
Originality								
(Judge 1)	8.54 (4.67)	9.10 (5.02)	5.40 ⁷ (3.78)	9.63 ⁷ (4.99)	6.13 ¹² (4.09)	9.84 ¹² (5.00)	7.86 (4.57)	10.47 (5.24)
(Judge 2)	8.67 (4.75)	8.95 (4.95)	7.20 (4.32)	9.20 (5.04)	6.00 ¹⁶ (3.82)	9.69 ¹⁶ (4.87)	8.19 (4.32)	9.79 (5.56)
Aptness								
(Judge 1)	8.86 ¹⁸ (4.49)	8.75 (5.21)	5.40 (4.93)	9.23 (5.13)	5.75 ^{13,18} (4.13)	9.50 ¹³ (5.23)	7.10 ^{*21} (4.27)	10.58 ^{*21} (5.64)
(Judge 2)	7.33 ^{**1} (4.54)	10.40 ^{**1} (4.65)	7.20 ⁸ (3.56)	10.86 ⁸ (4.65)	9.13 (4.22)	10.72 (4.76)	9.91 (4.56)	10.95 (4.81)
Validity								
(Judge 1)	8.86 ¹⁰ (4.37)	8.78 (5.34)	4.80 ^{6,10} (4.44)	9.34 ⁶ (5.26)	6.13 ¹⁴ (4.82)	9.44 ¹⁴ (5.32)	6.76 ^{*22} (4.57)	11.00 ^{*22} (5.34)
(Judge 2)	7.42 ^{**2} (4.62)	10.30 ^{**2} (4.63)	6.40 ^{*5} (2.70)	10.86 ^{*5} (4.60)	8.88 (4.12)	10.66 (4.74)	9.43 (4.68)	11.26 (4.50)
Elegance								
(Judge 1)	8.65 ¹⁹ (4.39)	8.98 (5.29)	5.80 (5.26)	9.43 (5.21)	5.63 ^{15,19} (5.34)	9.81 ¹⁵ (5.02)	7.38 ²³ (4.75)	10.74 ²³ (5.42)
(Judge 2)	7.77 ^{*3} (4.58)	9.93 ^{*3} (4.88)	7.00 (3.81)	10.34 (4.92)	8.25 (4.46)	10.34 (4.95)	9.76 (4.48)	10.11 (5.40)

Note. * $p < .05$; ** $p < .01$; other highlighted pairs $p < .1$; all tests 2-tailed.

tasks were evaluated (ranked) by two blinded judges. However rankings of the two judges were only weakly correlated (Table 3). Originality had the highest level of agreement ($rho = .484, p < .001$). Agreement for validity was somewhat lower ($rho = .278, p < .01$), while agreements on overall evaluation, elegance and aptness, although low, were still statistically significant ($rho = .248, .225$ and $.211$, respectively, $p < .05$). Both judges reported their difficulty in evaluating the metaphors. Because of the differences in the evaluations made by the two judges, the evaluations of each were analysed separately (average ranks were not calculated).

Some examples of the metaphors provided by the participants that both judges agreed were good: 'a condom in the hands of a nun' (for 'lighthouse in a desert'), 'a conveyor belt of wealth' (for 'banknote floating in a river'), 'ignorance is bliss' and 'a flower growing on waste land' (for 'child playing in a cemetery'), 'Poseidon is calm and understanding' (for 'sacrifice on a beach'), and 'an active mind trapped inside someone who is unable to communicate' (for 'a well in an

abandoned village').

The evaluations of answers to the metaphor tasks provided by the judges are presented in Table 4.

In general, the control group achieved slightly better (lower) rankings for the metaphor tasks than the lucid dreamers (Figure 1). The second judge rated their metaphors as more apt ($M = 7.33$ vs. $10.40, z = -2.917, p < .01$)¹, more valid ($M = 7.42$ vs. $10.30, z = -2.734, p < .01$)² and more elegant ($M = 7.77$ vs. $9.93, z = -2.045, p < .05$)³. However there were no differences on these criteria according to the first judge. There were no significant differences in the rankings given to the two groups on overall evaluation or on originality.

Despite the fact that dream 'guide' figures provided only five answers to the metaphor tasks, their answers were significantly better than other answers of the lucid dreamers, according to the first judge ($M = 4.00$ vs. $9.60, z = -2.234, p < .05$)⁴ and their answers were considered to be more valid according to the second judge ($M = 6.40$ vs. $10.86, z = -2.111, p < .05$)⁵ (Figure 2). There were also near-sig-

nificant indications that the answers of the dream 'guides' may be more valid ($M = 4.80$ vs. 9.34 , $z = -1.824$, $p = .068$)⁶ and more original ($M = 5.40$ vs. 9.63 , $z = -1.681$, $p = .093$)⁷ according to the first judge and to be more apt ($M = 7.20$ vs. 10.86 , $z = -1.783$, $p = .075$)⁸ according to the second judge. According to the first judge, the answers provided by the dream 'guides' surpassed the answers of the control group on overall evaluation ($M = 4.00$ vs. 8.72 , $z = -2.216$, $p < .05$)⁹ and also indicated a non-significant tendency for the answers of dream 'guides' to be more valid than the answers of the control group ($M = 4.80$ vs. 8.86 , $z = -1.877$, $p = .060$)¹⁰.

Three answers to the metaphor tasks in the dreams of the lucid dreamers were provided by dream characters who did not claim to be dream 'guides'. Comparing all answers provided by dream characters with the rest of answers of the lucid dreamers (Figure 3), the dream characters' answers were better on overall evaluation according to the first judge ($M = 4.88$ vs. 9.91 , $z = -2.423$, $p < .05$)¹¹ with trends also towards better scoring on all other criteria according to the same judge (originality¹²: $M = 6.13$ vs. 9.84 , $z = -1.830$, $p = .067$; aptness¹³: $M = 5.75$ vs. 9.50 , $z = -1.846$, $p = .065$; validity¹⁴: $M = 6.13$ vs. 9.44 , $z = -1.660$, $p = .097$; elegance¹⁵: $M = 5.63$ vs. 9.81 , $z = -1.915$, $p = .055$). There was also a tendency for the dream characters' answers to be more original according to the second judge ($M = 6.00$ vs. 9.69 , $z = -1.846$, $p = .065$)¹⁶. According to the first judge, the dream characters also provided better answers to the metaphor tasks than the control group ($M = 4.88$ vs. 8.72 , $z = -2.221$, $p < .05$)¹⁷ with non-significant tendencies also for their answers also to be more apt ($M = 5.75$ vs. 8.86 , $z = -1.752$, $p = .080$)¹⁸ and more elegant ($M = 5.63$ vs. 8.65 , $z = -1.830$, $p = .067$)¹⁹.

In contrast to the results from the logical tasks, the occurrence of a lucid dream did contribute in accomplishing the metaphor tasks (Figure 4). The first judge rated lucid dream answers generally better than non-lucid dream answers ($M = 6.86$ vs. 11.16 , $z = -2.443$, $p < .05$)²⁰, as well as more apt ($M = 7.10$ vs. 10.58 , $z = -2.008$, $p < .05$)²¹, and more valid ($M = 6.76$ vs. 11.00 , $z = -2.415$, $p < .05$)²². Results from this judge also indicate a non-significant tendency for greater elegance in the answers from lucid dream nights compared with non-lucid dream nights ($M = 7.38$ vs. 10.74 , $z = -1.955$, $p = .051$)²³.

3.3. Feedback

Feedback was received from eight lucid dreamers and six control participants. In their feedback, some lucid dreamers admitted that they were not expecting much from dream characters before the study but subsequently discovered that they are capable of more:

Not only did I learn that dream characters can be quite unpredictable when you approach them with a question, but they can be very deep and reflective in their answers as well. (Participant L3)

I wasn't expecting them to say anything of the kind or to act like that, so after the experiment discovered I can get far more info than I actually thought from dream characters. (Participant L6)

However some participants retained a sceptical attitude regarding the abilities of dream characters:

I also found that the answers given to me by characters in my dreams were no more insightful than what I could come up with myself. But perhaps this had to do more with my beliefs that characters in my dreams only know what I know. Maybe others who have more spiritual attitudes about their dreams would receive answers that they hadn't previously thought of because of their belief. (Participant L7)

Two lucid dreamers were not able to induce a lucid dream during the period of study and both of them admitted the lack of motivation to solve puzzles:

I did not feel interested in the puzzles ... It would be more interesting if the puzzles would have been things that I really care to find an answer. (Participant L10)

Lucid dreamers are more motivated to go on adventure then solve a task puzzle ... let them go on adventure, create landscapes or let them go back to their childhood to fix things. (Participant L5)

Interestingly enough, on the very next night after the study ended, one of these participants had two lucid dreams.

One lucid dreamer noted that sometimes the answers manifested themselves in non-lucid dreams while trying to induce a lucid dream:

It was not surprising to me that I could indirectly solve a problem in a lucid dream by asking a dream character for the answer ... What was surprising to me is the notion of having a problem statement, briefly thinking about it and memorizing it, and then having that problems' answer manifest in a non-lucid dream. I had several of these. This is a very specific and unusual sort of dream incubation. (Participant L8)

The lucid dreamers also admitted a difficulty in memorizing the task without trying to solve it. Also, although detailed data on sleep disturbance was not collected, some participants in the control group found that their engagement in the study had disturbed their sleep – they woke up more often in the night during the period of study.

4. Discussion

Taken together, these preliminary findings provide some evidence that lucid dreams may contribute to problem solving when dealing with more creative rather than logical tasks. Dream characters, and especially the ones who acknowledged themselves as 'guides', can also provide credible advice relating to more creative tasks. This suggested difference between more creative and more logical tasks to some extent resembles Tholey's (1989) findings: in his study dream characters were also more successful with creative tasks but struggled when doing arithmetic which required rather logical thinking. Lucid dreaming is generally considered to be a REM phenomenon (cf. Erlacher & Schredl, 2008) and it is plausible that during REM sleep associations are made more loosely and creatively (cf. Cai et al, 2009; Stickgold et al, 1999). Some authors (e.g. Green & McCreery, 1994; Piller, 2009) speculate that the right hemisphere might be predominant in lucid dreams and the right hemisphere also seems to activate a broader range of verbal associations than the left hemisphere, including alternate meanings of ambiguous words (Faust & Lavidor, 2003). Furthermore, creative performance and the experience of insight are also

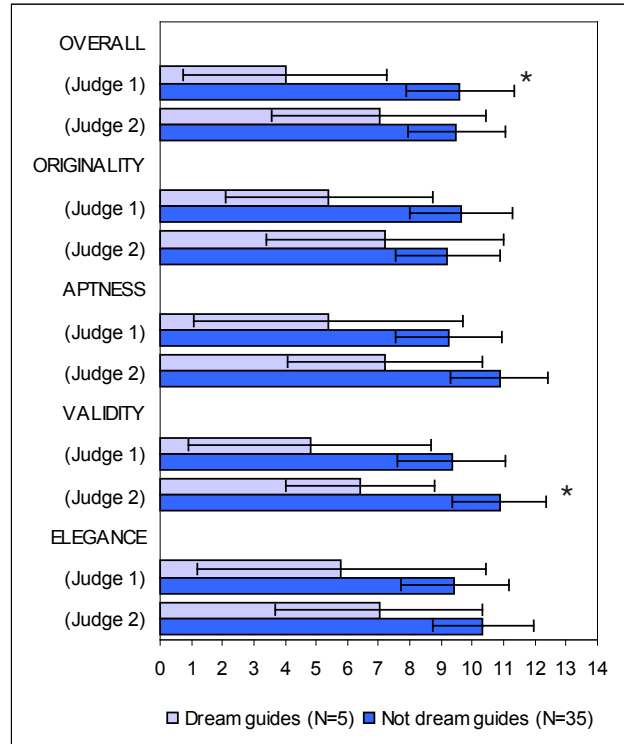
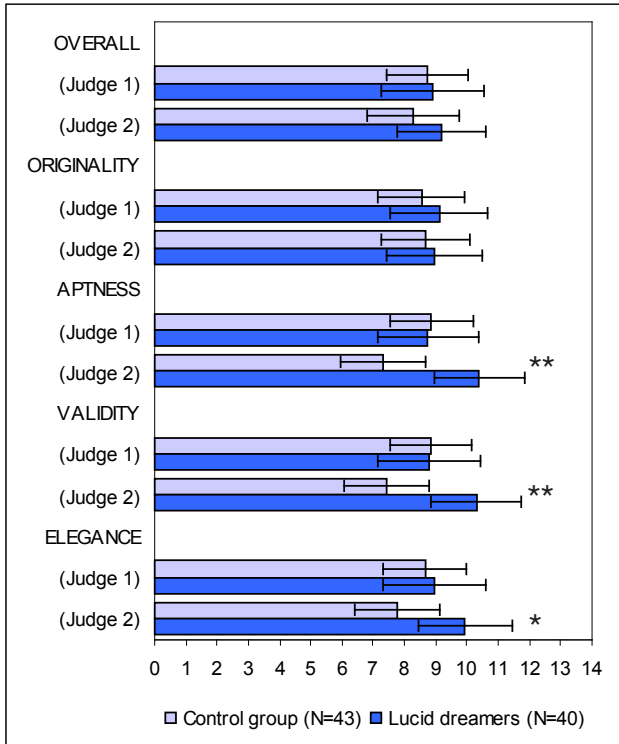


Figure 1. Comparison of the answers to the metaphor tasks (mean rankings with 95% confidence intervals): lucid dreamers vs. control group (* $p < .05$; ** $p < .01$).

Figure 2. Comparison of the answers to the metaphor tasks (mean rankings with 95% confidence intervals): dream guides vs. other answers of the lucid dreamers group (* $p < .05$).

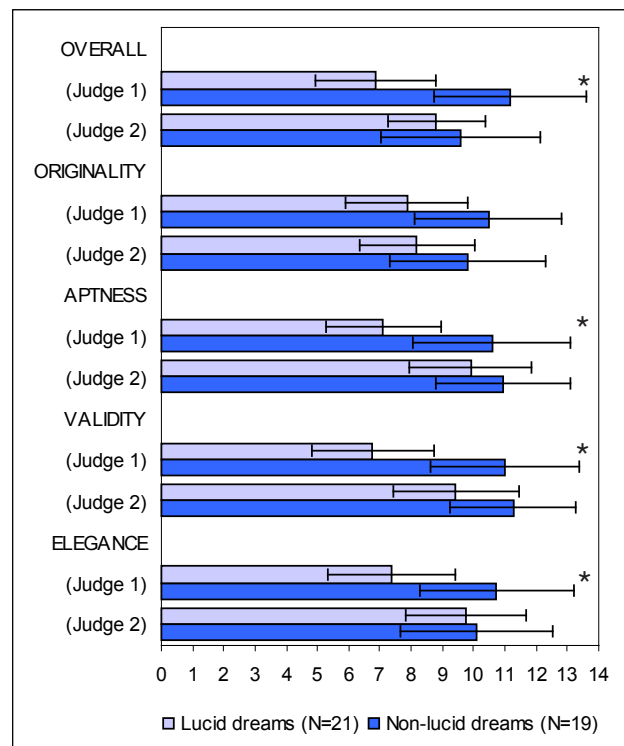
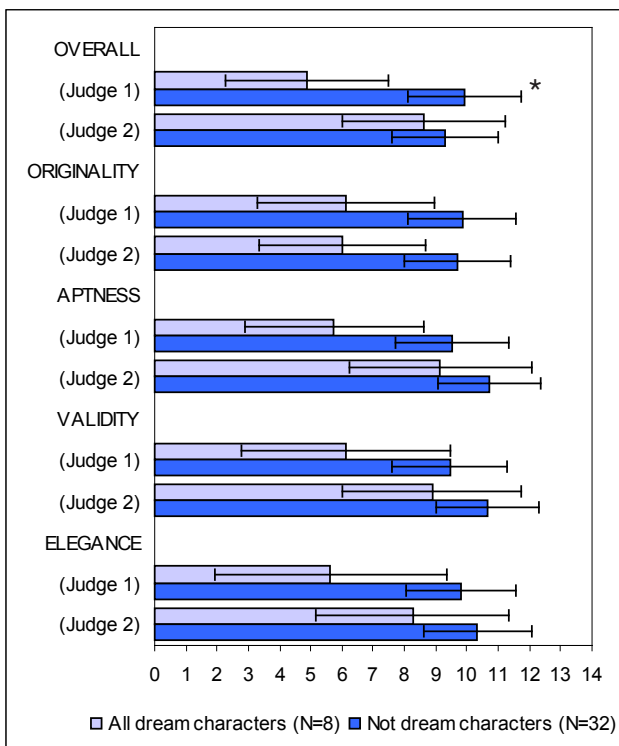


Figure 3. Comparison of the answers to the metaphor tasks (mean rankings with 95% confidence intervals): all dream characters vs. other answers of the lucid dreamers group (* $p < .05$).

Figure 4. Comparison of the answers to the metaphor tasks (mean rankings with 95% confidence intervals): lucid dreamers' answers after a night with a lucid dream vs. without a lucid dream (* $p < .05$).

linked with right hemispheric activity (cf. Bowden & Jung-Beeman, 2003; Jung-Beeman et al, 2004; Martindale et al, 1984). However further evidence from neuroimaging studies is needed, also considering that differences in the lateralisation of brain function exist between men and women, left-handers and right-handers, and other groups (for an overview on brain lateralisation see: Toga & Thompson, 2003).

The lucid dreamers found their dream characters to be far more profound than they were expecting them to be, despite the fact that expectations themselves play a crucial role in lucid dreaming (cf. LaBerge, 1985; Waggoner, 2009) and observed that they can benefit from their interactions with dream characters. McNamara et al (2005) found that social interactions in dreams are more frequent than in waking life and the authors even suggest that dreaming might be specialised for stimulating social interactions. However, interestingly enough, lucid dreams usually have fewer dream characters and fewer friendly verbal interactions than non-lucid dreams (Gackenbach, 1988).

The exploratory approach employed in this study had several limitations and revealed some methodological considerations that need to be addressed in future studies. Firstly, this study was conducted as a field experiment. Although some precautions were taken (e.g. tasks were sent after 9 pm, the participants were asked to follow the protocol precisely, not to discuss the tasks with anyone else, etc.), it was impossible to ensure that the participants were following the protocol as expected. Therefore it would be more appropriate to conduct the study in a sleep laboratory.

Secondly, although the groups were matched by their demographic parameters, they were not matched by their creative and problem-solving abilities. Differences in personality factors may also have an impact, as lucid dreamers generally seem to be more open to new experience, more creative and with a higher "need for cognition" (Blagrove & Hartnell, 2000; Schredl & Erlacher, 2004). The relatively small sample size in this study was another major restriction (e.g. only five answers to the metaphor tasks were obtained from the dream guide figures) which limits the statistical power of many of the analyses.

Thirdly, the tasks themselves were complicated. Participants were able to solve a logical puzzle in only one case out of six and, as Barrett (2007) suggests, such brainteasers may be beyond the ability of many people. Another approach might be to use some personal problems that are relevant to the participants in order to assess their problem solving abilities, although it would be difficult to evaluate their solutions on an objective basis. The assessment of creativity was another issue: the judges experienced difficulties when evaluating the metaphors and their assessments diverged. The images given for the metaphor tasks were fairly ambiguous and it might be that the judges were seeing and emphasising different aspects. Therefore some initial training for the judges on the assessment of creativity might be useful, ensuring that they are evaluating metaphors in the same manner. In future studies it may also be advisable to use a larger number of judges.

Fourthly, language was another issue. Not all participants in this study were native English speakers. Some logical tasks were language-specific (e.g. the tasks for days 1, 2 and 9) and the situation was even more complicated for those lucid dreamers who were able to engage in dialogues with dream characters since these participants reported that they were using their native language or a mixture of their

native language and English. In some cases this completely distorted the tasks. In one case a dream character even answered: "I don't know, it's in English"! The metaphors used might also lose their subtle meaning when translated into another language. Therefore it would be much more appropriate to avoid using any language specific tasks or to provide all tasks in the native language of the participant.

Finally, spreading the study over a longer period (e. g. providing one task every two or three days) might be preferable, as was suggested by some participants. This might help to increase the motivation of participants and provide fewer disturbances to their daily life and their sleeping pattern.

To summarise, this exploratory study demonstrated the feasibility of creative problem solving in lucid dreams and revealed various methodological considerations that should be addressed in future studies. The preliminary findings suggest that lucid dreams can contribute to problem solving when dealing with more creative tasks and dream characters can provide plausible creative advice to the dreamer. Future studies should verify these findings in more controlled conditions and explore further links between REM sleep, lucid dreams and creativity. Brain imaging studies exploring creative performance during REM lucid dreams would be of particular interest.

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