An investigation of a dual-processing hypothesis of lucid dreaming

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Summary. Neuroimaging research has isolated the dorsolateral prefrontal cortex (DLPFC) as a brain structure associated with lucid dreaming, indicating that higher-order executive functions are involved in the onset of lucid dreaming. The DLPFC has also been implicated in the onset of type 2 thinking. As such, a hypothetical link exists between type 2 thinking and lucid dreaming, moderated by DLPFC activity. The present study investigated this potential link, hypothesising that lucid dreaming frequency would be related to type 2 thinking. In study 1, participants (N=103) reported their lucid dream frequency (LDF) retrospectively, and completed the Cognitive Reflections Test (CRT), which measures type 2 thinking, as well as several other measures that have previously been found to correlate with LDF. Since retrospective estimates may be prone to memory errors and biases, a second study investigating LDF using prospective measures was conducted. In study 2, participants (N=30) retrospectively estimated their LDF and also prospectively reported their LDF using dream diaries for 1 month; these participants also completed the CRT, a syllogisms test, and several other measures that have previously been found to correlate with LDF. No evidence was found for a dual-processing hypothesis of lucid dreaming: In study 1, CRT scores did not correlate with retrospective LDF, and in study 2, neither prospective nor retrospective LDF correlated with either CRT or syllogisms test scores. Significant relationships were found, however, between previously identified correlates of LDF: dream recall frequency, the personality trait "openness to experience", and internal locus of control. It was additionally found that retrospective and prospective estimates of LDF correlated very highly, indicating that the retrospective estimate of LDF is a valid measure.

Keywords: lucid dreams, dream recall, locus of control, openness to experience, dual-processing theory, Cognitive Reflections Test, syllogisms, Type 2 thinking

1. Introduction

Lucid dreaming is characterised by the awareness that one is dreaming, and may be followed by the capacity to consciously influence the content of the dream (LaBerge, 1980). Thus, the lucid dreamer may be able to make conscious decisions and even change the dream narrative (Tholey, 1989). In a student population, the percentage of people who have experienced this phenomenon at least once in their lifetime is as high as 82% (Schredl & Erlacher, 2004), while people who are considered spontaneous lucid dreamers varies between 19% (Erlacher, Schredl, Watanabe, Yamana, & Gantzert, 2008) and 37% (Schredl & Erlacher, 2004). A recent meta-analysis found that for the general population, the percentage is 23% (Saunders, Roe, Smith & Gregg, 2016). Studies successfully verified the existence of lucid dreams in laboratories in the late 1970s (LaBerge, 1990). Recent fMRI data have associated lucid dreaming with a reactivation of the dorsolateral prefrontal cortex (DLPFC), which is usually deactivated during REM sleep, thus potentially explaining the return of the reflective cognitive abilities (Johnson, 2002; Dresler, Wehrle, Spoormaker, Koch, Holsboer, Steiger, Obrig, Samann & Czisch, 2012; Stumbrys, Erlacher & Schredl, 2013), although such a conclusion is preliminary as the studies rely on small sample sizes.

The ability to experience lucid dreams is related to particular cognitive strengths from waking life, as well as to certain personality traits, and other factors. For instance, dream recall frequency has been found to correlate with lucid dream frequency (Blackmore, 1982; Watson, 2003; Schredl & Erlacher, 2004; Schredl & Erlacher, 2011). In terms of personality traits, small significant correlations between openness to experience and lucid dream frequency have been found by several studies (Schredl & Erlacher, 2004; Schredl, Henley-Einion & Blagrove, 2016; Hess, Schredl & Goritz, 2016). Similarly, studies have been conducted found that lucid dreamers have an internal locus of control, scored on Levenson's (1973) internal locus of control as well as on Rotter's (1966) locus of control (Blagrove & Hartnell, 2000; Blagrove & Tucker, 1994). Additionally, frequent gamers experience a higher frequency of lucid dreams than individuals who do not play games at all (Gackenbach, 2006, 2009).

The further development in our understanding of lucid dreaming requires that new factors are analysed against lucid dreaming frequency. In the search for factors that predict this capacity to distinguish dream from waking reality, little to no attention has yet been paid to reflective reasoning abilities in the context of the dual-processing theory of reasoning (see Evans, 2010, for an overview of the theory). Since ancient times, many authors from various fields have attested the existence of two types of cognition, implicit

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and explicit (Evans & Stanovich, 2013). The two processing mechanisms have many different properties, with the first type characterised as fast, non-logical, automatic, unconscious and high capacity while the second type is slow, logical, controlled, conscious and low capacity (Evans, 2003). The type 2 processing mechanism is believed to be uniquely human as it allows sophisticated reasoning capacities different from those seen in animals (Stanovich, 1999). Furthermore, it is thought to require decontextualized processing which tends to reject knowledge or belief-based biases.

When confronted with a problem, some people may come up with quick and plausible judgement, while others may discard the immediate response and engage in further reflection (Frederick, 2005). One proposed explanation suggests that people tend to neglect information in their thinking, mostly because the type 1 processing mechanism is used by default due to its low computational expense (Evans, 2008). This strong bias to default to the least expensive computational mechanism results in humans being less than rational (Toplak, West & Stanovich, 2014). Individuals who rely on their type 1 processing mechanism and neglect relevant information are considered cognitive misers (Baumeister and Bushman, 2008).

The fMRI studies available provide support for the qualitative distinction between belief- and reason-based response, with activation in different regions of the brain for the two instances (De Neys, Vartanian, & Goel, 2008; Goel & Dolan, 2003; Tsujii & Watanabee, 2009). In addition, Greene, Nystrom, Engell, Darley and Cohen (2004) found neuroimaging evidence of type 2 processing system overwriting the type 1 processing system that was coming from the emotion centres, thus concluding that the main area responsible for overwriting an emotional response is the dorsolateral prefrontal cortex. The sudden insight that one experiences at the beginning of a lucid dream could be attributed to the activation of the rational type 2 processing system that overwrites the dominant emotional type 1 system.

The dorsolateral prefrontal cortex, which is normally deactivated during REM sleep (Miller & Cummings, 1999), shows activation during lucid dreaming (Voss et al., 2009). The same area is thought to be involved mainly in linking the information stored in our short-term memory to the organisation of forthcoming actions (Fuster, 1997). Thus, this particular area of the brain that activates during lucid dreams loads heavily on working memory while supporting theoretical thinking which is necessary for the planning of future events. These attributes have been found as defining features of the type 2 processing system (Evans & Stanovich, 2013). Moreover, the evolution of this rational second system can be seen as a precursor and requirement for the manifestation of lucid dreams because they require conscious rationality. There seem to be a connection between the workings of the second system and lucid dreaming mediated by the activity in the dorsolateral prefrontal cortex. Thus, it is worth investigating the dual-processing theory of reasoning as a possible explanation for the emergence of lucid dreams.

The prime measure for rational reflection that is a property of type 2 processing system is the Cognitive Reflection Test (Frederick, 2005) which was constructed to measure an individual's ability to override an intuitive, spontaneous response to a problem and engage in further reflection which might lead to the correct answer (Frederick, 2005). The Cognitive Reflection Test (CRT) differs from well-known insight problems where individuals have to spend a lot of time and cognitive resources and still fail to answer because no viable solution comes to mind. The questions used in the CRT trigger an attractive alternative response, thus it is a measure of rational thought, rather than a measure of an underlying ability that supports rational thought (Toplak, West & Stanovich, 2014). In a dream state, individuals who overwrite their first instinctive assumption about reality become aware of the fact that they are dreaming thus enabling control over the dream through rationality. Although rationality seems to occur even in non-lucid dreams, the "rational thought" bar is set higher in lucid dreams where individuals see through the illusion of the dream and further thought operates from this premise (Hurd & Belkeley, 2014).

Another measure for the type 2 processing system can be derived from syllogistic reasoning tasks (Evans, 2008). Syllogisms are arguments that apply deductive reasoning, which is a property of type 2 processing system, to reach a conclusion based on two propositions that are assumed to be true. Furthermore, deductive reasoning can be seen as a fundamental cognitive skill as well as one of the cornerstones of logical thought. Generally, individuals use this type of reasoning in their daily lives in order to reach a conclusion from a set of information. An essential component of good deductive reasoning skills is the ability to reason only with relevant information and ignore beliefs. Instead, there is a tendency of individuals to allow for prior beliefs and knowledge to cloud their judgement and reach a wrong conclusion. This common fallacy is called a belief bias and it is more likely for people to judge a conclusion as valid when it is believable (Evans, Barston & Pollard, 1983; Thompson, 1996; Evans & Over, 2004).

It can be hypothesised, then, that individuals who activate the type 2 processing system during REM sleep might show cognitive strengths while awake, particularly those related to rationality by overcoming belief bias and rational reflection which are properties of the type 2 processing system. A lateral/dorsolateral prefrontal cortex modulation caused by syllogism content was noticed in a study conducted by Brunetti et al (2014) when looking at the influence of emotions on reasoning abilities. This is the area that is deactivated during REM sleep, but active during lucid dreaming; thus providing more evidence of the connection between dual-processing theory and lucid dreaming, more precisely the activation of type 2 processing system that corresponds to the sudden realisation that one is dreaming. As far as causality is concerned, it makes sense to assume that the activation of type 2 processing system coincides with the onset of a lucid dream.

The aim of this study, then, was to test the dual-processing hypothesis of lucid dreaming, as well as attempt to replicate previous lucid dreaming correlate findings, for the purpose of furthering our understanding of the mechanisms involved in lucid dreaming as well as understand why some people experience this phenomenon more than others. By linking the existing body of knowledge on lucid dreaming with two measures of dual-processing theory, the cognitive reflective test and a syllogistic reasoning task, we expect to gain new insights into the workings of the human mind, i.e. how waking life rational and reflective rationalities are related to the rationality experienced during REM sleep by lucid dreamers.

A secondary purpose of the study was to investigate whether prospective and retrospective measures of lucid

dreaming frequency are correlated. Response biases and memory failures may emerge when retrospective measures of dream frequency are used (Beaulieu-Prevost & Zadra, 2005). One study comparing nightmare and bad dream frequency data acquired using prospective and retrospective estimates found that retrospective measures underestimate nightmare and bad dream frequency (Robert & Zadra, 2008). As such, we conducted two studies, one in which retrospective estimates were taken, and a second in which both retrospective and prospective measures were taken for comparison.

For study 1, it was hypothesised that there would be a positive correlation between retrospective measures of lucid dream frequency and internal locus of control, dream recall frequency, openness to experience, video game play, and Cognitive Reflection Test scores. For study 2, it was also hypothesised that high frequency lucid dreamers (measured both retrospectively and prospectively) would score higher on the CRT, syllogisms test, internal locus of control, dream recall frequency, and openness to experience. Finally, it was hypothesised that there would be a positive correlation between retrospective and prospective measures of lucid dream frequency.

2. Study 1 Method

2.1. Participants

One hundred and three participants (52 males and 51 females), with ages ranging from 16 to 65 (M = 24.39, SD = 6.97), were recruited using convenience sampling via posters and fliers from the University of Bedfordshire. Psychology students were asked not to participate because they were familiar with the Cognitive ReflectionsTest and this would have compromised the results.

2.2. Materials

The questionnaire, which was hosted online on Qualtrics, consisted of the following:

Levenson's (1973) internal Locus of Control scale, measuring the extent to which individuals believe that they control events affecting them, which included 7 items (α=.51) responded to on a 6-point Likert scale (-3 = strongly disagree to +3 = strongly agree), e.g. "I am usually able to protect my personal interests.".

Schredl and Erlacher's (2004) Lucid Dreaming Frequency scale which contains 2 items measured on an eight-point rating scale (0 = never, 7 = several times a week), e.g. "How often do you experience so-called lucid dreams?" and "How often do you remember your dreams?". In order to eliminate confusion regarding Lucid Dream Frequency, a definition was formulated and given to the participants: "Lucid dreams are dreams in which the dreaming individual becomes aware of being in a dream and intentionally changes certain elements". A re-test reliability r = .89 (p < .001) for the lucid dream frequency scale supports its consistency (Schredl & Erlacher, 2004).

Schredl and Erlacher's (2004) Dream Recall Frequency scale measured by a 7-point rating scale (0 – never; 1 - less than once a month; 2 - about once a month; 3 – twice or three times a month; 4 - about once a week; 5 – several times a week; 6 – almost every morning).

A Video Game Play measure consisting of 2 items measuring the frequency of gaming activities as well as the frequency of immersive gaming activities on an 8-point rating scale (0 – never, 1 – less than once a year, 2- less than once a month, 3- once a month, 5 – 2-3 times a month, 5- once a week, 6 – 2-3 times a week, 7 – daily); e.g. "How often do you play video games?" and "How often do you play immersive video games?"; also, immersive video games were defined to the participants in order to eliminate confusion: "An artificial, interactive, computer created scene or 'world' within which a user feels involved." A single score for game playing was calculated from the mean of the two items.

John and Srivastava's (1999) Openness to Experience measure from the Big Five Factors of Personality (Goldberg, 1993) which measures an individual's active imagination, preference for variety, intellectual curiosity, aesthetic sensitivity and attentiveness to inner feelings; it contains 8 items (α=0.45) measured on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree), e.g. "I see myself as someone who is inventive"

An expanded version of the Cognitive Reflection Test developed by Toplak, West and Stanovich (2014) which measures the reflective reasoning abilities and contains 7 questions (α=0.72) designed to measure one's ability to overwrite an initial instinctive answer using rational thought, e.g.: "A bat and a ball cost 1.10$ in total. The bat costs 1.00$ more than the ball. How much does the ball cost?". Participants received a score out of seven, with each point denoting a correct answer.

2.3. Procedure

The study received ethical approval from the University of Bedfordshire prior to the collection of data. Participants were recruited from the University of Bedfordshire via posters and fliers. The study was internet-based and required that participants give their consent in order to start the questionnaire. Participants were informed about the nature of the study prior to the completion of the questionnaire and were also asked not to consult any outside source of information while completing the questionnaire. The study was conducted on Qualtrics. The study consisted of three questionnaires (Dream Lucidity Questionnaire, Video Game Play Frequency and Lucid Dreaming Frequency/Dream Recall Frequency Questionnaire), two scales (Internal Locus of Control Scale and Openness to Experience Scale) and an extended version of the Cognitive Reflection Test taken from Toplak, West and Stanovich (2014); completed by every participant in this order. Every questionnaire was on a different page. After the completion of the questionnaires, participants were directed to a page where they were thanked for their time, debriefed, and given an email address in case they wanted to leave any comments regarding the study.

3. Study 1 Results and Discussion

Correlations were conducted between retrospective Lucid Dream Frequency and dream recall frequency, openness to experience, locus of control, video game play, and CRT scores. Table 1 displays the descriptive statistics for these variables.

Of the 103 participants, 12 reported no lucid dreams (marked 0=never on Schredl and Erlacher's (2004) Lucid Dreaming Frequency and Dream Recall Frequency scale), 71 reported occasional lucid dreams (marked 1=less than once a year, 2=about once a year, 3=about two or four times

Table 1. Descriptive statistics for Study 1 variables

Variable	Mean (SD)
Lucid Dream Frequency	3.89 (1.83)
Openness to Experience	3.67 (0.47)
Locus of Control	4.43 (0.60)
Video Game Play	4.04 (2.18)
CRT scores	3.58 (1.83)
Dream Recall Frequency	5.65 (1.63)

Table 2. Percentages of lucid dreamers

Variable	Number of participants	Percentage
Non-lucid dreamers	12	11.65%
Occasional lucid dreamers	71	68.93%
Frequent lucid dreamers	20	19.42%

a year) and 20 reported having frequent lucid dreams, frequency equal to or higher than once per month (marked 4=about once a month, 5=about two to four times a month, 6=about once a week, 7=several times a week). Percentages are displayed in Table 2.

Alpha level was reduced to .01 to account for the inflated Type 1 error when conducting multiple correlations. There was a significant positive correlation found between Internal Locus of Control and LDF $r = .23$, $p = .01$, 1-tailed, and between Dream Recall and Lucid Dream Frequency $r = .33$, $p < .001$, 1-tailed. The correlation between Openness to Experience scores and LDF; approached significance $r = .18$, $p = .03$, 1-tailed. No significant correlations were found between Video Game Play and LDF or CRT scores and LDF (see Table 3).

Thus the first study supported previous research in finding a relationship between lucid dream frequency and dream recall frequency, and lucid dream frequency and internal locus of control. However, it did not support previous findings pertaining to openness to experience, nor video game play. Further, it did not find evidence for a relationship between lucid dream frequency and scores on the Cognitive Reflections Test, thereby not supporting a dual process hypothesis of lucid dreaming.

A methodological issue with utilising retrospective estimates of lucid dream frequency is that memory biases and expectations may influence these estimates, and result in inaccuracies. Because of this possibility, Study 2 was conducted, using both retrospective estimates and prospective recordings, as follows.

4. Study 2 Method

4.1. Participants

Thirty participants (15 male and 15 female), with ages ranging from 20 to 51 ($M = 25.47$, $SD = 6.59$), were recruited using convenience sampling via posters and fliers from the University of Bedfordshire (N=9), as well as from dreaming related Facebook forums and communities (N=21). Individuals who participated in the first study and were familiar with the Cognitive Reflective Test were not eligible to take part in the study.

4.2. Materials

The questionnaire included Levenson's (1973) Internal Locus of Control scale, two open-ended questions regarding dream recall and frequency of lucid dreams e.g. "How many dreams do you remember on average per week?" and "In a typical month, how many lucid dreams do you have?", John and Srivastava's (1999) Openness to Experience measure from the Big Five Factors of Personality (Goldberg, 1993), and the expanded version of the Cognitive Reflection Test developed by Toplak, West and Stanovich (2014), as detailed the method for Study 1. In addition, a syllogisms test was included, containing 4 categorical syllogisms e.g. "No books are novels. Some magazines are novels. Therefore, some books are not magazines" and 4 conditional syllogisms e.g. "If a person is a guitarist, then he is a professor. If a person is a professor, then he is a musician".

The dream diary consisted of 30 tables (one per day for the duration of the study), each table containing five boxes that participants could tick if they had had one of the following dreams: a lucid dream, a dream with a logical pattern, a dream with negative content, a dream with positive content,

Table 3. Correlation Coefficient

	Dream Recall	CRT scores	Openness to Experience	Locus of Control	Game Play frequency
LDF	.34*	-.02	.18	.23*	.14
Dream Recall	---	.05	.12	.001	-.13
CRT scores		---	.11	.21*	.29*
Openness to Experience			---	.29*	.20*
Locus of Control				---	.12
Game Play Frequency					---

* Correlation is significant at the $p < .01$ level.

Table 4. Frequency of lucid dreams in prospective and retrospective measures

Prospective measure								
No. of participants	7 (23.3%)	3 (10%)	6 (20%)	6 (20%)	3 (10%)	3 (10%)	1 (3.3%)	1 (3.3%)
No. of lucid dreams reported	0	1	2	3	4	5	6	23
Retrospective measure								
No. of participants	6 (20%)	6 (20%)	8 (26.7%)	5 (16.7%)	1 (3.3%)	3 (10%)	1 (3.3%)	
No. of lucid dreams reported	0	1	2	3	4	5	20	

and/or a recurrent dream). Explanations of lucid dream, logical pattern and recurring dream were provided on the first page of the dream diary. Analyses were not conducted on the frequency of logical, negative, positive, or recurrent dreams; these questions were asked rather to disguise the purpose of the study.

4.3. Procedure

The study received ethical approval from the University of Bedfordshire prior to the collection of data. Participants were recruited from the University of Bedfordshire as well as from the internet. The study consisted of two open ended questions (dream recall/lucid dream frequency), two scales (Internal Locus of Control Scale and Openness to Experience Scale), an extended version of the Cognitive Reflection Test taken from Toplak, West and Stanovich (2014), and a Syllogisms Test; completed by every participant in this order. Every questionnaire was on a different page. After the completion of the questionnaires, participants were directed to a page where they were shown the correct answers to the test questions, thanked for their time, debriefed, and given an email address in case they wanted to leave any comments regarding the study or withdrawn from the study. The dream diary was given after the completion of the online questionnaire. Participants were instructed to fill in one table every morning for a month; this consisted of circling the number of dreams that they remembered and ticking the appropriate boxes for each of the dreams. The last page of the diary consisted of participants being thanked for their time and reminded to return the diary after one month.

Table 5. Descriptive statistics for Study 2 variables

Variable	Mean (SD)
Prospective LDF	2.96 (4.17)
Retrospective LDF	2.53 (3.62)
Locus of Control	4.31 (1.09)
Openness to Experience	3.30 (0.71)
CRT scores	4.10 (2.02)
Syllogisms Test scores	5.56 (1.13)

5. Study 2 Results

The prospective measure of lucid dreams revealed that 7 individuals (23.3%) reported no lucid dreams with the rest of the 23 participants reporting at least one lucid dream during the month of the study. From the retrospective measure of lucid dreams, 6 (20%) reported no lucid dreams and 24 reported at least one lucid dream (see Table 4). Descriptive statistics for the variables are displayed in Table 5.

Spearman's correlations were conducted to assess the relationship between Openness to Experience, Locus of Control, Dream Recall, CRT scores, Syllogisms test scores, and prospective and retrospective measures of LDF. Alpha level was reduced to .01 to account for the inflated Type 1 error when conducting multiple correlations. There was a very high significant positive correlation found between Internal Locus of Control and prospective/retrospective measures of LDF, $r = .80$, $p < .001$ $r = .80$, $p < .001$ between high Openness to Experience and prospective/retrospective LDF, $r = .85$, $p < .001$ / $r = .80$, $p < .001$. The correlation between high Dream Recall and prospective/retrospective measures of LDF approached significance, $r = .23$, $p = .02$. No significant correlations were found between either CRT scores or syllogisms test scores and prospective/retrospective measures of LDF. A very high significant correlation was found between prospective and retrospective measures of lucid dream frequency, $r = .91$, $p < .001$.

Using prospective measures, then, relationships were found between LDF and openness, and LDF and locus of control. However, no relationship was found between LDF and CRT scores using either the retrospective or the prospective measure of LDF; likewise, no relationship was found between LDF and syllogisms scores using either retrospective or prospective method. Thus, the second study confirmed the findings of Study 1 in failing to support a dual processing hypothesis of lucid dreaming.

6. General Discussion

Overall, the findings of the present paper indicate that there are relationships between prospective and retrospective measures of lucid dream frequency (LDF) and openness to experience, locus of control, and dream recall frequency. However, the dual processing hypothesis of lucid dreaming was not supported: no relationship between LDF and Cognitive Reflective Test scores, nor with scores on a syllogisms test, was found, neither with retrospective nor prospective estimates of LDF. In addition there was no relationship found between LDF and video game play.

Table 6. Correlation Coefficients for all variables

	rLDF	Locus of Control	Openness to Experience	CRT scores	Syllogisms scores	Dream Recall
pLDF	.91**	.80**	.85**	.18	.23	.16
rLDF	---	.91**	.80**	.26	.24	.23
Locus of Control		---	.75**	.37	.17	.25
Openness to Experience			---	.34	.17	.37
CRT scores				---	.12	.47**
Syllogisms scores					---	.06

* Correlation is significant at the $p < .01$ level.

There was a very high correlation between prospective and retrospective measures of LDF; thus participants correctly estimated their frequency of lucid dreams in a month prior to having them recorded in a dream journal. Diary measures have been shown to correlate with scientifically verified lucid dreaming measured in the laboratory (Kueny, 1985). Thus, when it comes to estimating the frequency of lucid dreams in questionnaires, participants can provide reliable data. In the first study, roughly 87% of the sample was classified as lucid dreamers, whereas in the second study, 80% were detected using prospective measures. By measuring their frequency using a retrospective approach, the sample from the second study had 76% lucid dreamers. This finding agrees with previous findings that student samples contained 82% lucid dreamers (Schredl & Erlacher, 2004). However, the current study defined lucid dreaming in terms of awareness of the dream state and also the ability to control it; future research should investigate lucid dream frequency comparing frequency for awareness of the dream state alone, and frequency for awareness of the dream state and control. The data from both studies revealed that there was a relationship between locus of control and LDF, suggesting that lucid dreamers have a more internal locus of control than non-lucid dreamers. This finding is in accordance with previous studies assessing the relationship between locus of control and LDF (Blagrove & Hartnell, 2000; Blagrove & Tucker, 1994). Patrick and Durndell (2004) argue that internal locus of control positively correlates with waking life attempts to control the environment and control is central to maintaining a lucid dream; thus individuals with an internal locus of control would exhibit more control over the dream environment.

LDF also correlated with openness to experience in both studies. This finding is in agreement with previous studies that have found significant correlations between the openness to experience factor and LDF (Schredl & Erlacher, 2004; Watson, 2003). Correlations were unusually high in the second study for LDF and locus of control and openness to experience. This may be due to the sample; the participants are likely to have had a special interest in dreams since they volunteered to do research that was unusually involved but without incentive, and many of whom were recruited from dream-related groups online. Therefore, the findings of the second study would benefit from replication with a more representative sample. In addition, the locus of control and openness scores were self-report measures, whereas the CRT and syllogisms relied on the participant getting the right answer; so the high correlations may perhaps reflect participants' perception of a potential link between lucid dreaming and internal locus of control / openness, as these measures are vulnerable to expectation biases.

The analysis further revealed that there was a relationship between dream recall and LDF; thus, individuals who have a higher rate of dream recall also have a higher rate of LDF. The correlation between the two measures had been previously reported in studies (Blackmore, 1982; Watson, 2001; Schredl & Erlacher, 2004; Schredl & Erlacher, 2011). It makes sense that individuals who recall more dreams in general, also report more lucid dreams.

There was no relationship found between videogame play and lucid dream frequency. This finding did not support previous research. It may be that the scale used was not reliably able to measure game playing; future research should implement other methods of measuring gameplay to further investigate this.

There was no relationship found between both prospective and retrospective LDF and CRT scores, nor between prospective/retrospective LDF and syllogisms test scores. As these were employed as measures of reflective cognitive ability, it would be reasonable to conclude that there is no relationship between the frequency of dream accounts of reflective reasoning manifested in the form of lucid dreams and waking life reflective ability measured with the cognitive reflective test and with performance on syllogisms tests. However, it may be that different measures would provide us with different results; the tests employed in the present study might not measure the same type of reflective ability as that manifested in lucid dreams. Dream reflection does imply an awareness of the conditions within the dream, thus reflective awareness of the environment and oneself could be measured instead of reflective reasoning abilities. However, these prove to be hard to measure and require an in depth understanding of awareness as a feature of consciousness, which is poorly understood. Furthermore, the correlation between CRT scores and Syllogism test scores in the present study was weak, which indicates that the two tests did not measure the same kind of thinking style. Further research could implement other measures of reflective reasoning abilities or focus on measuring reflective awareness of the environment and of oneself.

On the other hand, this was not the first study to fail to find a relationship between lucid dreaming and a task known to require dorsolateral prefrontal cortex activation. In Neider et al.'s (2010) study, participants who were more

lucid in their dreams than others performed better at the Iowa Gambling Task, which is known to activate the ventromedial prefrontal cortex, but not at the Wisconsin Card Sort task, which is known to activate the dorsolateral prefrontal cortex. In addition to this, the effect of transcranial direct current stimulation (tDCS) on the dorsolateral prefrontal cortex only enhanced lucidity in dreams in participants who already were experiencing lucid dreams frequently, but not in those who experienced lucid dreams infrequently or never (Stumbrys, Erlacher, & Schredl, 2013). These findings coupled with those of the present study query the degree of involvement of the dorsolateral prefrontal cortex in lucid dreaming. It is likely that lucid dream onset is more complicated than a simple reactivation of the dorsolateral prefrontal cortex; as suggested by Mota-Rolim et al. (2010), it may be that different neural substrates are implicated in different kinds of lucid dreaming, since lucid dreaming is not a unitary phenomenon.

Although humans spend one third of their life sleeping, most models of human cognition are structured based upon evidence derived from waking-life cognition. The development of a 24 hour model of cognition is necessary for the further understanding of consciousness. The existence of lucid dreaming reveals higher-order cognitive skills present during sleep; skills that previously have been assumed to be characteristic only of waking life. The question remains whether there is any relationship between the manifestation of higher-order cognitive skills in dreams and their manifestation in waking life. The uniquely human ability to reflect upon ourselves, think about past and plan the future could help illuminate the human condition.

6.1. Conclusion

There was no relationship found between rational reflective abilities measured with the Cognitive Reflective Test nor the syllogisms test and lucid dream frequency, whether measured retrospectively or prospectively, therefore providing no evidence for a dual-processing account of lucid dreaming. However, internal locus of control, dream recall frequency, and openness to experience were correlated with lucid dream frequency, supporting previous research. Further studies could implement other measures of reflective reasoning abilities or reflective awareness in order to assess if REM sleep accounts of reflection (i.e. lucid dreaming) correlate with different waking life reflective abilities.

References

Baumeister, R. F., & Bushman, B. J. (2008). Social psychology and human nature. Belmont, CA: Thomson Higher Education.

Beaulieu-Prevost, D., & Zadra, A. (2005). Dream recall frequency and attitude towards dreams: A reinterpretation of the relation. Personality and Individual Differences, 38(4), 919–927.

Blackmore, S. J. (1982). Have you ever had an OBE? The wording of the question. Journal of the Society for Psychical Research, 51, 292-302.

Blagrove, M., & Hartnell, S. (2000). Lucid dreaming: Associations with internal locus of control, need for cognition and creativity. Personality and Individual Differences, 28, 41–47.

Blagrove, M., & Tucker, M. (1994). Individual differences in locus of control and the reporting of lucid dreaming. Personality and Individual Differences, 16(6), 981–984.

Brunetti, M., Perrucci, M. G., Di Naccio, M. R., Ferretti, A., Del Gratta, C., Casadio, C., Romani, G. L. (2014). Framing deductive reasoning with emotional content: an fMRI study. Brain and Cognition, 153(60).

Cohen, D. B. (1969). Frequency of dream recall estimated by three methods and related to defense preference and anxiety. Journal of Consulting and Clinical Psychology, 33(6), 661–667.

Costa, P. T., & McCrae, R. R. (1992). NEO personality Inventory professional manual. Journal of personality, 55 (2), 299-316.

De Neys, W., Vartanian, O., & Goel, V. (2008). Smarter Than We Think: When Our Brains Detect That We Are Biased. Psychological Science, 19(5), 483–489.

Dresler, M., Wehrle, R., Spoormaker, V. I., Koch, S. P., Holsboer, F., Steiger, A., Czisch, M. (2012). Neural Correlates of Dream Lucidity Obtained from Contrasting Lucid versus Non-Lucid REM Sleep: A Combined EEG/fMRI Case Study. Sleep, 35(7), 1017-1020.

Erlacher, D., Schredl, M., Watanabe, T., Yamana, J., Gantzert, F. (2008). The incidence of lucid dreaming within a Japanese university student sample. International Journal of Dream Research, 1 (2), 39-43.

Evans, J. T. (2003). In two minds: dual-process accounts of reasoning. Trends in Cognitive Sciences, 7 (10), 454–459.

Evans, J. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. Annual Review of Psychology.

Evans, J. T. (2010). Thinking twice: Two minds in one brain. Oxford: Oxford University Press.

Evans, J. T., & Over, D. E. (2004). If. Oxford: Oxford University Press.

Evans, J. T., & Stanovich, K., (2013). Dual-Process Theories of Higher Cognition: Advancing the Debate. Perspectives on Psychological Science, 8(3), 223-241.

Evans, J. T., Barston, J. L., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. Memory & Cognition, 11(3), 295–306.

Frederick, S. (2005). Cognitive Reflection and Decision Making. The Journal of Economic Perspectives, 4, 25.

Fuster, J. (1997). The prefrontal cortex: anatomy, physiology, and neuropsychology of the frontal lobes. New York: Raven.

Gackenbach, J. (2006). Video game play and lucid dreams: Implications for the development of consciousness. Dreaming, 16(2), 96–110.

Gackenbach, J. (2009). Electronic media and lucid-control dreams: Morning after reports. Dreaming, 19(1), 1–6.

Gackenbach, J., & Dopko, R. (2012). The relationship between video game play, dream bizarreness, and creativity. International Journal of Dream Research, 5(1), 23-36.

Gackenbach, J., & Kuruvilla, B. (2008). The relationship between video game play and threat simulation dreams. Dreaming, 18(4), 236–256.

Gackenbach, J., & Kuruvilla, B. (2013). Cognitive structure associated with the lucid features of gamers dreams. Dreaming, 23(4), 256-265.

Goel, V., & Dolan, R. J. (2003). Explaining modulation of reasoning by belief. Cognition, 87(1).

Goel, V., Bruchel, C., Frith, C., & Dolan, R. (2000). Dissociation of mechanisms underlying syllogistic reasoning. Neuroimage, 12(5).

Goldberg, L. R. (1993). The structure of phenotypic personality traits. American Psychologist, 48(1), 26–34.

Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games. American Psychologist, 69(1), 66–78.

Greene, J., Nystrom, L. E., Engell, A. D., Darley, J. M., & Cohen, J. D. (2004). The neural basis of cognitive conflict and control in moral judgment. Neuron, 44, 389–400.

Hess, G., Schredl, M., & Goritz, A. S. (2016). Lucid Dreaming Frequency and the Big Five Personality Factors. Imagination, Cognition and Personality.

Hurd, R., & Berkeley, K. (2014). Lucid Dreaming: New Perspectives on Consciousness in Sleep. Santa Barbara, California: Practical and Applied Psychology Series.

John, O. P., & Srivastava, S. (1999). The Big-Five trait taxonomy: History, measurement, and theoretical perspectives. In L. A. Pervin & O. P. John (Eds.), Handbook of personality: Theory and research, 2, 102–138.

Johnson, S. C. (2002). Neural correlates of self-reflection. Brain, 125(8), 1808–1814.

LaBerge, S. (1990). Lucid dreaming: Psychophysiological studies of consciousness during REM sleep. Sleep and Cognition, 109–126.

LaBerge, S. P. (1980). Lucid Dreaming as a Learnable Skill: A Case Study. Perceptual and Motor Skills, 51(3), 1039–1042.

LaBerge, S., & Rheingold, H. (1990). Exploring the World of Lucid Dreaming. New logical deductions. Canadian Journal of Experimental Psychology, 50(3), 315-319.

Levenson, H. (1973). Multidimensional locus of control in psychiatric patients. Journal of Consulting and Clinical Psychology, 41(3), 397-404.

McCrae, R. R., & John, O. P. (1992). An introduction to the Five-Factor Model and its applications. Journal of Personality, 60 (2), 175–215.

Miller, B. L., & Cummings, J. L. (1999). The human frontal lobes: Functions and disorders. New York: Guilford Press.

Mota-Rolim, S. A., Erlacher, D., Tort, A. B. L., Araujo, J. F., & Ribeiro, S. (2010). Different Kinds of Subjective Experience During Lucid Dreaming May Have Different Neural Substrates: Commentary on “The Neurobiology of Consciousness: Lucid Dreaming Wakes Up” by J. Allan Hobson. International Journal of Dream Research, 3(1), 33–35. http://doi.org/10.11588/ijodr.2010.1.596

Neider, M., Pace-Schott, E. F., Forselius, E., Pittman, B., & Morgan, P. T. (2011). Lucid dreaming and ventromedial versus dorsolateral prefrontal task performance. Consciousness and Cognition, 20(2), 234–244. http://doi.org/10.1016/j.concog.2010.08.001

Patrick, A., & Durndell, A. (2004). Lucid dreaming and personality: a replication. Dreaming, 14 (4), 234 – 239.

Robert, G., & Zadra, A. (2008). Measuring nightmare and bad dream frequency: impact of retrospective and prospective instruments. Journal of Sleep Research, 17(2), 132–139.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs: General and Applied, 80(1), 1–28.

Saunders, D. T., Roe, C. A., Smith, G., & Clegg, H. (2016). Lucid dreaming incidence: A quality effects meta-analysis of 50 years of research. Consciousness and Cognition, 43, 197–215

Schredl, M., & Erlacher, D. (2004). Lucid dreaming frequency and personality. Personality and Individual Differences, 37(7), 1463–1473.

Schredl, M., & Erlacher, D. (2011). Frequency of lucid dreaming in a representative German sample. Perceptual & Motor Skills, 112(1), 104-108.

Schredl, M., Henley-Einion, J., & Blagrove, M. (2016). Lucid dreaming and personality in children/adolescents and adults: The UK library study. International Journal of Dream Research, 9(1), 75–78

Stanovich, K. E. (1999). Who is rational? Studies of individual differences in reasoning. Applied Cognitive Psychology, 14(6), 595–597.

Stumbrys, T., Erlacher, D., & Schredl, M. (2013). Testing the involvement of the prefrontal cortex in lucid dreaming: A tDCS study. Consciousness and Cognition, 22(4), 1214–1222. http://doi.org/10.1016/j.concog.2013.08.005

Tholey, P. (1989). Overview of the Development of Lucid Dream Research in Germany. Lucidity Letter, 8(2), 1-30.

Thompson, V. A. (1996). Reasoning from false premises: The role of soundness in making. Canadian Journal of Experimental Psychology, 50(3).

Toplak, M., West, R., & Stanovich, K., (2014). Assessing miserly information processing: An expansion of the Cognitive Reflection Test. Thinking and Reasoning, 20(2), 147-168.

Tsujii, T., Watanabe, S. (2009). Neural correlates of dual-task effect on belief-bias syllogistic reasoning: a near-infrared spectroscopy study. Advances in Brain Imaging, 1287, 118-125.

Voss, U., Holzmann, R., Tuin, I., & Hobson, A. (2009). Lucid dreaming: a state of consciousness with features of both waking and non-lucid dreaming. Sleep, 32(9), 1191-1200.

Watson, D. (2003). To dream, perchance to remember: Individual differences in dream recall. Personality & Individual Differences, 34(7), 1271–1286.