Lucid Dreaming and the Prefrontal Cortex Performance III

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Abstract

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Objectives

The purpose of this study is to prove that ventromedial but not the dorsolateral prefrontal cortical functions will prove one's ability to lucid dream. The precuneus is also tested to distinguish lucid from non-lucid dreamers. Each part of the brain listed above is correlated to cognitive behaviors (i.e.; decision making, risk taking, reaction time, and memory). These functions are observed throughout the study to test their degree of enhancement.

Methods

Each participant endured a week of intense lucid dreaming induction treatment. They were administered questionnaires, assessments, cognitive computer tasks, and a dream journal. While the questionnaires were only completed once, computer tasks were done at the beginning and end of the study to compare the development of the behaviors tested. By recording their dreams each night, and filling out an additional survey every time they go to sleep and wake up, the level of lucidity per participant was determined.

Results

The ventromedial prefrontal cortex was more active in lucid dreaming than the dorsolateral prefrontal cortex. This was shown by comparing aspects from each computer task to other questionnaires. The VMPFC had more significant r values, while the DLPFC didn't have any significant values. As for the precuneus, the results were significant when plotted with lucid dreaming aspects.

Conclusions

The VMPFC but not the DLPFC are associated with lucid dreaming. This confirms the findings of Neider et al., 2011. The novel finding here is that the precuneus was in fact activated during lucid dreaming induction treatment as shown in the reduced reaction time between trials and increased memorization of the code.

Table of Contents

Lists of Figures and Tables

Review of Literature

Dreams arise in one's rapid eye movement (REM) sleep, characterized by powerful visions, the deepest sleep stage, paralyzed muscles, and irregular breathing. This stage comes after non-rapid eye movement sleep (nREM), which includes relaxed muscles, little eye movement, and slow brain waves (Hossen, 2012). The two stages never occur at the same time, just as someone can never be in a wakeful state while in a sleep stage. Oftentimes, a dream occurs during REM sleep. This phenomenon is a sequence of emotions, visions, or thoughts but is only an imagination (Cicogna and Bosinelli, 2001). A dream sequence mainly occurs in the cerebral cortex of the brain. Its functions include thoughts, awareness, and memory (King, 2012). Although most activity during a dream is in the cerebral cortex, a specific pattern of regional brain activity is also found. Some other areas of the brain activate during a dream including the hippocampus, emotions; occipito-temporal visual cortex, visual processing; and the cerebellum, cognitive behaviors (Desseilles et al., 2010).

Lucid dreaming occurs when one is aware they are dreaming (Blagrove, 1998). It is a metacognitive technique that can aid in the controlling of cognitive performance, or "thinking about thinking" (Kahan et al., 2006). This phenomenon is an exception to the three states of being: wakefulness, nREM sleep, and REM sleep. Even though

lucid dreaming occurs in one's REM sleep stage, the brain shows signs of wakefulness. Therefore, the dreamer is in two states at one time (Tang et al., 2006). This occurrence has been shown with electroencephalogram (EEG) scans of brain activation during lucid dreaming. While someone is awake, the posterior cingulate is stimulated; while one is in REM sleep, it's deactivated. During lucid dreaming, the posterior cingulate is triggered along with other parts of the brain that only activate during REM sleep and not in a wakeful state (Hobson, 2009). Lucid dreaming is associated with the reactivation of areas that normally deactivate during REM sleep. For example, during REM sleep, activity in the thalamus and amygdala increase while the dorsolateral prefrontal cortex deactivate.

Thus, there is increased neural activation in the frontal and frontolateral regions of the brain. Specifically, the dorsolateral prefrontal cortex (DLPFC) plays a major role in lucid dreaming, although it deactivates in normal REM sleep (Dresler et al., 2012). In addition to the DLPFC, the ventromedial prefrontal cortex (VMPFC) is activated. This region's functions include decision making, risk taking, and fears (Neider et al., 2011). The prefrontal cortex is an important region of the brain that has been correlated to lucid dreaming because it increases one's complex cognitive behaviors: remembrance, understanding, interpretation, and problem solving (Lawrence et al., 2009). The specific behavior across the brain characterizes lucid dreaming with its abnormal activation and deactivation.

Another region of the brain that characterizes lucid dreaming is the precuneus. It is a part of the brain in the superior parietal lobule in front of the occipital lobe. Its known functions include episodic memory, visual processing, and consciousness aspects (Qin-Lin et al., 2015). Recently, studies have been conducted to test the precuneus' effect on reaction time. Although there is not one specific part of the brain that controls reaction time (RT), the precuneus plays a key element in reducing it (Oishi et al., 2005). This region also has the strongest increase in activation during a lucid dream compared to non-lucid REM sleep. This upsurge occurs because visual perception and conscious awareness are monitored in this region of the brain. Lucid dreaming is associated with visual clarity of one's dream. Therefore, the precuneus works to clarify the dream (Dresler et al., 2012), while other parts of the brain do their job to gain awareness.

This research will focus on how lucid dreaming induction can affect one's reaction time, risk taking, and decision making because of the co-activation of the VMPFC, DLPFC, and precuneus.

Research Question and Hypotheses

What effect does lucid dreaming induction treatment have on one's risk taking, decision making, and reaction time?

H_0: If a participant undergoes intense lucid dreaming induction treatment, ventromedial prefrontal cortical function as measured by standardized tasks will not predict ability to learn to have lucid dreams. And the precuneus will have no distinguishing abilities between lucid and non-lucid dreamers.

H_I: If a participant undergoes intense lucid dreaming induction treatment, then ventromedial but not dorsolateral prefrontal cortical function as measured by standardized tasks will predict ability to learn to have lucid dreams, as indicated by previous research (Neider et al. 2010).

H2: If a participant undergoes intense lucid dreaming induction treatment, the role of the precuneus in distinguishing lucid from non-lucid dreamers will be evident.

Methods

Participants

This study focused on the effect of lucid dreaming induction treatment on high school students. Teenagers had the ability to quickly adapt to new techniques, so these participants were from a public high school in Westchester County, New York. They were recruited by word of mouth, flyers hung around the school, and through social media. All participants were qualified if they slept around 8 hours a night, and did not take any medication that could interfere with the results. In order to participate, students needed to hand in two consent forms: one depending on their age (18 or older vs. 17 or younger), and a parental consent form regardless of age. These forms ensured the participants that all of the information they give is completely confidential. Although their results will be published, the personal information given will not be associated with the participant in any way. Lastly, once each person completed the study, they were given a $20 Amazon gift card.

Study Design

Each participant completed a few baseline assessments, questionnaires, and three cognitive computer tasks. After this, they went go through seven days of lucid dreaming induction treatment. On the last day, participants did a follow up of the same computer tasks and assessments.

Assessments/Questionnaires

Participants gave their ages, sexes, races/ethnicities, grade levels, and handedness in a brief demographic form. Next, they completed a Baseline Lucidity Assessment that tested their current lucid dreaming level. The Pittsburg Sleep Quality Index (PSQI) assesses one's sleep quality and quantity over the past month. It helped to determine which participants are "good" and which are "bad" sleepers. The LuCiD Scale determines the dimensions of control and insight that each participant has on their dream (Voss et al., 2013). The next assessment is the Morningness-Eveningness Questionnaire which determines if they are more of a morning or evening person. Furthermore, the timing of psychological behaviors is different for each person and is affected by their sleep patterns (Carrier et al., 1997). The final assessment before the computer tasks was the Leeds Sleep Evaluation Questionnaire which assesses how easily one falls asleep, their quality of sleep, how easy/hard it is for them to wake up, and their behavior following awakening (Tarrasch et al., 2003).

Cognitive Computer Tasks

Wisconsin Card Sort Task (WCST: Psychological Assessment Resources, Inc.)

The Wisconsin Card Sort Task tests the activation of the dorsolateral prefrontal cortex (DLPFC). This area of the brain is associated with one's executive functions and working memory (Struss et al., 2002). In this task, participants virtually sorted cards into four different piles. After they chose which card will go where, they were told whether they were right or wrong. If they were right, the pattern is correctly followed, but if they were wrong if it was not. This pattern entailed either matching colors, shapes, or number of shapes on the cards. The participants were not prompted to what the pattern was, but eventually picked up on it until it switched to the next pattern.

Iowa Gambling Task (IGT: Psychological Assessment Resources, Inc.)

The Iowa Gambling Task tests the activation of one's ventromedial prefrontal cortex (VMPFC). This part of the brain is associated with risk taking and decision making (Kringelbach et al., 2004). The IGT is a risk and reward task. Participants saw four piles on the screen. Two were bad piles and two were good piles. Each card had a certain amount of virtual money. So, participants could either gain, lose, or gain and lose money from just one card. They were not told which pile was good or bad, and how many cards they had left to choose from. The goal of the task is to be able to note which piles are good and bad, and to have more money than they started the task with (Bechura et al., 1994).

Serial Reaction Time Task (SRTT)

The Serial Reaction Time Task tests one's reaction time which is associated with the precuneus (Oishi, 2004). In this task, participants endured about twenty minutes of reaction time tests. A four letter pattern appeared on the screen and participants pressed either 1, 2, 3 or 4, using their dominant hand on the keyboard depending on where the X was in the sequence. For example, if the sequence was AAXA, the participant would press the number 3 with their ring finger as quickly as possible. The pattern always had three A's and one X. Also, it was crucial that the participant had their four fingers lined up on the keys marked 1, 2, 3, and 4 on the keyboard and that they used all four fingers, not just one or two. There were ten sequences and then a five second break throughout the test. The last part of the task was to try to figure out the recurring pattern in the sequences. At first, it seemed like where the X was located was random, but participants eventually realized that there was one recurring ten sequence pattern. This one was not the only pattern throughout the whole time, but it appeared the most. So, participants had to notice where the X is located (1, 2, 3, or 4) in the repeated pattern. They were not told what the pattern was, but were be notified when they are half way through the task.

Lucid Dreaming Induction Treatment

After completing the computer tasks, assessments, and questionnaires, the participants completed seven days of lucid dreaming induction treatment by themselves. They were given a lucid dreaming information sheet, a dream

journal, a few daily assessments, and two questionnaires to complete at home. As they attempted to lucid dream, they also wrote down their dreams each night and completed the daily assessments. Each participant strived to get at least eight hours of sleep and to go to sleep around the same time each night (within an hour).

Results

The WCST, IGT, and SRTT yielded results reflecting the performance of each participant and how their sleep quality changed within their one week of lucid dreaming induction treatment.

Table 1 shows the data collected from the WCST. When the WCST was compared to each questionnaire, none of the results were significant enough to be considered. It is important however, to note that when the participant's initial results were compared to their second round results, most of them improved on the task. This is seen most prominently in the difference between the trials administered which will be further explained in the discussion section.

Data for IGT test is represented in Table 2. The red numbers indicate negative net total money, meaning that the participant ended up in debt. In this task, participants had to make 100 card selections. These 100 cards were sorted into 5 different decks with two negative and two positive decks (negative being the "bad deck" and positive being the "good deck). The goal was for each participant was to have a positive net total which would indicate that they chose one the better decks. The "Quintile 5-1" column indicates their total score for the decks.

Figure 1

Figure 1

Figure 2

Figure 2

The SRTT data suggests that one's reaction time is enhanced through lucid dreaming, which concludes that the precuneus is correlated with lucid dreaming. As shown in the graph to the right, the participants also had to memorize a specific pattern in the numbers they saw. The blue columns indicate the first trial and the orange columns indicate the second trial. The columns on the left (labeled 1) indicate the number of participants who memorized the ten-digit pattern and the right (the bars labeled 2), are the participants who failed to memorize the sequence. It is evident that during the second trial more participants memorized the code.

Discussion and Conclusion

After comparing many aspects of lucid dreaming; one's sleep quality, how delusional someone is, and more, many conclusions were drawn. First and foremost, these results confirmed Neider's study in 2011 that indicated that the ventromedial prefrontal cortex (VMPFC) is more significantly associated with lucid dreaming than the dorsolateral prefrontal (DLPFC) cortex. This was shown in graphs 1 and 2. There were no significant graphs to connect lucid dreaming to the WCST results which tests one's DLPFC. But, the most people's results did improve from the first trial to the second one, so although their decision making was enhanced, it wasn't significant enough to include it as a correlation to the DLPFC.

As for the VMPFC, that data was significant when the IGT was compared to other lucid dreaming aspects. For example, the LuCid Scale measure one's level of lucidity and when this score was compared to their results in the IGT, there was a significant correlation. This noteworthy connection indicates that the level of lucidity has a

connection to how able one is to make a risky decision and then stick with it. By sticking with this choice, their memory was tested which is also associated the VMPFC, showing that memory, decision making, and risk taking all do have link to lucid dreaming. In addition, the money increase for most participants reveals that they stuck with the pattern and figured out which decks were the "good decks" and were able to end up either not in debt any more, or less in debt.

The data from the SRTT task indicates that student's reaction times were enhanced. This is shown by their times which were reduced from the first time they completed the task to the second time. Thus, the precuneus is activated during lucid dreaming induction treatment. In addition to the reaction time, the participant's memorization skills were clearly enhanced because more participants were able to remember the ten-digit code after the second round as compared to after the first.

In conclusion, the dorsolateral prefrontal cortex is less significantly activated during lucid dreaming than the ventromedial prefrontal cortex because it yielded significant results. These findings confirmed those of Neider's in 2011. Additionally, the precuneus is activated during lucid dreaming induction treatment due to an enhanced reaction time and memorization skills, as displayed by the SRTT task results.

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