Fluctuations in perception vividness in lucid dreams

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Summary. Lucid dreams (LDs) are dreams in which people recognize that they are experiencing the dream plot. Sometimes, perception vividness can be low during an LD, which can affect the practitioner's satisfaction with, application of, and research on the phenomenon. In this study, we explore how perception level changes during an LD and what level satisfies practitioners. In this online experiment, we instructed 86 volunteers to enter an LD and perform typical tasks while paying attention to perception vividness level at the beginning and during the experience. Upon awakening, the volunteers assessed their satisfaction with the perception vividness experienced. Perception vividness remained at the same level for only 32% of participants. For other participants, perception vividness either spontaneously decreased (15%), increased (18%), or floated (35%). No participants were satisfied with a perception vividness of less than 70%. Meanwhile, half of the participants were satisfied with perception vividness ranging from 70-79%, 76% of participants were satisfied with perception vividness ranging from 80-99%, and 92% were satisfied when perception vividness exceeded 100%. There is a need to create methods that increase practitioners' perception vividness during an LD. Also, research should explore new directions for researching LDs and their efficiency.

Keywords: Lucid dreams, consciousness, perception vividness, REM sleep, phase state

1. Introduction

Lucid dreams (LDs) are dreams in which a person is aware that they are dreaming (LaBerge, 1985). LDs usually occur during REM sleep when the activity in the frontal cortex occurs at a frequency of 40 Hz (Voss, Holzmann, Tuin, & Hobson, 2009). However, LDs can also occur during non-REM sleep (Dane & Castle, 1984; Mota Rolim et al., 2015; Tadas Stumbrys & Erlacher, 2012).

Practitioners perceive different types of LDs in different ways. For example, some practitioners who enter an LD immediately after waking up or upon falling asleep perceive the experience as an out-of-body experience instead of awareness in the dream plot (Levitan, LaBerge, DeGracia, & Zimbardo, 1999; Mahowald & Schenck, 2005; Raduga, 2014). LDs, out-of-body experiences, sleep paralysis (Dresler et al., 2012; Terzaghi, Ratti, Manni, & Manni, 2012; Voss et al., 2009), and false awakenings (Barrett, 1991) have some common features, such as being self-conscious during REM sleep (LaBerge, Levitan, Brylowski A., & Dement W., 1988; Nelson, Mattingly, & Schmitt, 2007). In a previous study, 88% of survey respondents (Raduga, Kuyava, & Sevcenko, 2020) reported having experienced one of these listed phenomena at least once in their life. Although LDs occurs periodically for most people, the underlying neurobiological processes have not yet been sufficiently studied (Baird, Mota-Rolim, & Dresler, 2019).

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Some studies have shown possible practical applications of the LD. For example, while in the LD, people can interact with a personal computer and control its functions (Mallett, 2020). Nightmare prevention (Zadra & Pihl, 1997) and motor skills exercises (de Macêdo, Ferreira, de Almondes, Kirov, & Mota-Rolim, 2019) are among other documented PS applications. One study even presented a case where LDs helped significantly reduce 22-year chronic postoperative pain (Zappaterra, Jim, & Pangarkar, 2014).

Along with LD induction (Saunders, Roe, Smith, & Clegg, 2016), low perception vividness in LD (VLD) can be a problem for practitioners (Raduga, 2014). For example, in a previous study, participants could not achieve the goal set for the experiment due to low VLD (Erlacher, Schädlich, Stumbrys, & Schredl, 2014). Furthermore, among the participants surveyed by Schredl, Rieger, and Göritz (2018), 32% reported never being unable to control their body while in the LD, and only 13% reported that they can always control the body. These findings could also be associated with low VLD.

At the moment, there is no research on initial VLD levels and how they change during a PS experience. Based on the hypothesis that VLD is an important factor in LD experiences, we have studied methods for increasing VLD in previous works (Raduga, Shashkov, & Zhunusova, 2020b; Raduga, Zhunusova, & Shashkov, 2020). In the present study, we decided to test how relevant the need to increase VLD is for practitioners. We also examine how VLD changes when no deliberate attempt is made to influence it.

While assessing how high of a VLD level is considered sufficient by practitioners, we considered practitioners' satisfaction with the VLD a subjective factor to clarify our findings. Specifically, we tested whether a high VLD would be more satisfactory than a low VLD. According to a survey, 40% of practitioners independently use LD practices to improve their physical or mental health (Erlacher, Schredl, & Stumbrys, 2020). In another study, Konkoly and Burke (2019) found that, compared to the day before an LD ex-

perience, LD practitioners had higher self-esteem and life satisfaction the day after successful practice.

One possibility is that practitioners use LDs to fulfill desires that are impossible to fulfill in real life, such as flying, traveling, meeting certain people, and having sexual experiences (Raduga, 2014). We hypothesize that this type of application could explain the improvement in practitioners' psycho-emotional states after an LD. It is conceivable that a higher VLD level correlates to a more complete sense of satisfaction of desires and, in turn, a greater psycho-emotional effect. Therefore, VLD should be considered an important study topic.

Hypothesis

The main hypothesis is that VLD level changes during an LD experience. We expect a significant number of the participants to report that VLD increased, decreased, or floated, even though they were instructed not to attempt to influence it.

An additional hypothesis was that VLD satisfaction is positively correlated with the maximum VLD level. We expect that more participants will report VLD satisfaction at higher VLD levels. We also hope to determine below what VLD level participants stop reporting VLD satisfaction.

Furthermore, we propose that VLD fluctuations and VLD satisfaction depend on each other. We also expect the LD induction method, the practitioner's gender and previous experience, and the LD time and duration to affect VLD fluctuations and satisfaction.

Confirmation of our hypotheses can improve the understanding of perception in LDs and would indicate a need to create special techniques to increase VLD, which may increase the frequency with which LD goals are achieved among ordinary people.

2. Method

2.1. Research resource and participants

Field experiments were conducted from September 2 to December 9, 2020. A total of 130 people (75 males and 55 females) participated in the experiment. Reports from 86 participants (50 males and 36 females) were accepted for analysis, and 44 were rejected due to non-compliance with instructions or because inapplicable descriptions were provided, which were not subsequently corrected. In most of the rejected reports, the participants used VLD-increasing techniques despite being instructed not to. Participants received instructions for self-administering the experimental protocol from the website of a specially created online resource (https://pro.aing.ru). All participants confirmed that they were at least 18 years of age and that they did not have any physiological or psychological problems that could be complicated by LD practice. There was no maximum age limit for participants. Since the study was conducted by an independent research group with no institutional review board, and since all participants confirmed voluntary participation, the study does not have ethical approval.

The participants accessed the tasks to be performed while in the LD by registering on the website and providing their personal information. Each report was accepted or rejected depending on the LD assignment and the correctness of the experience's description. The task was considered correctly completed if the participant deliberately did not perform VLD-increasing or LD-maintaining actions and if they paid attention to VLD fluctuations immediately after waking up. Participants were not allowed to discuss their results or publish them because doing so could affect the results of other participants. There was no monetary reward for submitting the reports—participants were motivated only by their interest in the objectives of the study and the possibility of improving their own practice.

2.2. Experimental task

In accordance with the assignment, participants were to induce an LD by any method (1) and go about their usual activities or follow a personal plan of action without using any method for increasing VLD (2). Upon awakening, participants were asked to subjectively rate VLD on a scale from 0 to 100, with 100 representing a level of perception vividness equal to that experienced during wakefulness and 0 representing complete darkness and emptiness. The VLD at the beginning of the LD, the maximum VLD level achieved, and any fluctuations in VLD throughout the experience should have been assessed (3). Participants were instructed to complete the form on the website according to the results of the experiment as soon as possible (4).

Participants were asked to complete the task only once and then immediately leave a report, regardless of the result. In addition to the listed VLD-related parameters, the reports included information about the LD induction method used, all LD events that occurred, and the type of LD ending. The reporting form is presented in Appendix 2. The participants had up to four months to complete the assignment and prepare the report, depending on their registration date.

2.3. Statistical analysis

We used contingency tables and chi-square tests in JASP (Version 0.11.1) to analyze the reports. The analysis included all available criteria (initial VLD level, maximum VLD level, VLD fluctuations, VLD satisfaction, gender, LD induction method, experience level, LD ending type, LD duration, and LD time) and their correlations. The significance level was set at alpha = .05, and Bonferroni corrections were applied as a post-hoc test. Non-applicable data (N/A) were not considered in the analysis and were deleted from tables, along with the entire corresponding row.

Participants were grouped based on their subjective initial VLD scores as follows: 0-9%, 10-19%, 20-29%, 30-39%, 40-49%, 50-59%, 60-69%, 70-79%, 80-89%, 90-99%, ≥100%, n/a (other or unclear options). The same ratings were used when distributing participants according to maximum VLD levels. The VLD satisfaction indicator was based on participants' responses (yes, no, or n/a (other or unclear options)). The following criteria were used to indicate VLD fluctuations: down, float, same, rise, n/a (other or unclear options).

Participants were divided into groups according to the number of LDs experienced in their lifetime: <4, 4-10, 11-30, 31-100, 101-500, >500, n/a (other or unclear options). The following criteria were used to indicate the LD time: 0:00-2:59, 3:00-5:59, 6:00-8:59, 9:00-11:59, 12:00-14:59, 15:00-17:59, 18:00-20:59, 21:00-23:59, n/a (other or unclear options). The following simplified classification was used to group participants according to the LD induction method used (Raduga, 2020): indirect (upon awakening), direct (without sleep, upon falling asleep, or immediately af-

Table 1. VLD Fluctuation Distribution of VLD Satisfaction

	VLD fluctuations				
VLD satisfaction y/n	Down	Float	Rise	Same	Total (N = 85)
Yes	7 (54%)	25 (83%)	10 (67%)	21 (78%)	63 (74%)
No	6 (46%)	5 (17%)	5 (33%)	6 (22%)	22 (26%)

ter falling asleep), ld (becoming conscious during a dream), n/a (other or unclear options). LD endings were grouped according to the following categories: fake (false awakening), outer (waking because of external sounds or irritations), force (waking against one's will), self (deliberate awakening), dream (falling asleep), n/a (other or unclear options).

3. Results

Of the valid responses, 74% (N = 64) reported positive VLD satisfaction, and 26% (N = 23) reported negative VLD satisfaction.

3.1. VLD fluctuations

Of the participants, 32% reported that VLD remained at the same level during the LD, 15% reported that VLD level decreased, 18% reported that it increased, and 35% of the participants experienced floating VLD levels.

3.2. VLD fluctuations – initial VLD level

VLD remained at the same level much more often when it was initially equal to or higher than 100% (62% of cases) compared with other groups of initial VLD level.

VLD level floated more often when it initially ranged from 60-69% or 70-79% (60% and 58%, respectively), compared with the other groups of initial VLD level.

The χ^2-test confirmed a statistically significant difference between VLD fluctuations (down, float, rise, same) and initial VLD groups (χ^2 (30, N = 85) = 44.767, P = .041). The post-hoc tests did not show a significant difference between VLD fluctuation variants (down, float, rise, and same) and initial VLD groups.

3.3. VLD satisfaction – initial VLD level

We did not see a directly proportional increase in VLD satisfaction as the initial level of VPS increased among groups. Nonetheless, the χ^2-test confirmed a statistically significant relationship between VLD satisfaction (positive or negative) and initial VLD groups (χ^2 (10, N = 86) = 29.389, P = .001). The post-hoc test showed a significant difference between positive VLD satisfaction and initial VLD (χ^2 (8, N = 63) = 50.286, $P_{bonferroni}$ < .002).

3.4. VLD satisfaction – maximum VLD level

Among all participants, maximum VLD was reported within the ranges of 10-19%, 30-39%, 40-49%, 50-59%, 60-69%, 70-79%, 80-89%, 90-99%, and ≥100%. No participants with maximum VLD values ranging from 10-19%, 30-39%, 40-49%, 50-59%, and 60-69% reported positive VLD satisfaction (0 cases). Meanwhile, participants for whom maximum VLD values ranged from 70-79%, 80-89%, 90-99%, and ≥100% reported positive VLD satisfaction in 50%, 76%, 75%, and 92% of cases, respectively. The χ^2-test confirmed a statistically significant difference between VLD satisfaction (positive or negative) and maximum VLD (χ^2 (8, N = 86) = 35.836, P < .001). The post-hoc test showed a significant difference between positive VLD satisfaction and maximum VLD (χ^2 (3, N = 63) = 39.413, $P_{bonferroni}$ < .002). Table 2.

3.5. Other findings

The χ^2-test analysis did not show any statistically significant differences between VLD fluctuations and maximum VLD level, LD induction method, LD ending type, experience, gender, LD duration, and LD time. The χ^2-test analysis also did not show any statistically significant difference between VLD satisfaction and VLD fluctuations, LD induction method, LD ending type, experience, gender, LD duration, and LD time.

4. Discussion

We studied important determinants of creating and using techniques that increase VLD. We did this by investigating how the VLD levels change during LDs and whether a higher level of VLD leads to more satisfaction among practitioners. According to our hypothesis, VLD should not have remained at the same level for a significant number of participants—we expected most participants to report spontaneous decreases, increases, or floating. We also expected higher VLD levels to be associated with greater positive VLD satisfaction.

We asked participants to induce an LD by any method and then go about their usual activities or follow a personal

Table 2. Maximum VLD Level Distribution of VLD Satisfaction

	VLD satisfaction y/n	
Maximum VLD ranges	Yes	No
10-19%	*0 (0%)*	1 (100%)
30-39%	*0 (0%)*	1 (100%)
40-49%	*0 (0%)*	3 (100%)
50-59%	0 (0%)	4 (100%)
60-69%	*0 (0%)*	5 (100%)
70-79%	2 (50%)	2 (50%)
80-89%	*13 (76%)*	4 (24%)
90-99%	*12 (75%)*	4 (25%)
≥100%	36 (92%)	3 (8%)
Total (N=86)	*63 (73%)*	23 (27%)

Table 3. Correlations between VLD satisfaction, VLD fluctuations, VLD level, LD induction method, LD ending type, experience, gender, LD duration, and LD time

			df	N	χ^2 value	p
VLD satisfaction	-	VLD fluctuations	3	85	4.736	0.192
VLD satisfaction	-	Initial VLD level	10	86	29.389	0.001
VLD satisfaction	-	Maximum VLD level	8	86	35.836	< .001
VLD satisfaction	-	LD induction method	2	82	4.852	0.088
VLD satisfaction	-	LD ending type	4	81	1.616	0.806
VLD satisfaction	-	Experience	5	85	0.217	0.999
VLD satisfaction	-	Gender	1	86	0.295	0.587
VLD satisfaction	-	LD duration	6	86	8.213	0.223
VLD satisfaction	-	LD time	6	85	9.132	0.166
VLD fluctuations	-	Initial VLD level	30	85	44.767	0.041
VLD fluctuations	-	Maximum VLD level	24	85	34.253	0.080
VLD fluctuations	-	LD induction method	6	81	7.221	0.301
VLD fluctuations	-	LD ending type	12	81	12.732	0.389
VLD fluctuations	-	Experience	15	84	10.340	0.798
VLD fluctuations	-	Gender	3	85	2.654	0.448
VLD fluctuations	-	LD duration	15	85	13.302	0.579
VLD fluctuations	-	LD time	18	84	16.161	0.581

plan of action. Participants were also instructed to evaluate the VLD level at the beginning of the experience, the maximum VLD value, and any changes in VLD throughout the LD experience. Participants were not allowed to use VLD -increasing techniques since we wanted to observe naturally occurring changes in the VLD level. This ensured that the participants' emotions and certainty about the effectiveness of their actions to increase VLD did not distort the results.

Hypotheses confirmation

The results support the hypothesis that VLD did not remain at the same level during PS in most cases. The VLD level remained the same in only one-third of cases and either increased, decreased, or floated in the remaining two-thirds of cases.

We detected a statistically significant relationship between VLD fluctuations and initial VLD levels. VLD levels increased significantly more often when the initial VLD value was low than when it was high. VLD levels increased in half of the cases with initial VLD values below 60% but in less than one-tenth of cases with initial VLD levels greater than 60%. It is conceivable that the tendency of initially low VLD values to increase is related to the similar nature of LD experiences and ordinary dreams, specifically considering that no effort is required to experience acceptable perception vividness in an ordinary dream. For example, it could be obvious if the practitioner enters the LD from wakefulness and sees only darkness for a while, after which the details of the environment automatically appear.

The level of VLD floated much more often in participants with an initial VLD of 60-79% (in more than half of the cases) than in any other initial VLD group. This is assumed to be because the VLD level was initially in a conditionally average value and, thus, had plenty of room to either increase or decrease. We also saw that VLD levels remained the same much more often when the initial value was greater than or equal to 100% than when it was any other value. It is conceivable that this result was found because such a high level of VLD can captivate the practitioner, thus aiding its maintenance.

The results confirm the hypothesis that higher VLD values are likely to lead to VLD satisfaction. We found that increased VLD satisfaction was correlated with higher maximum VLD values but not with initial VLD values. This was found even though the χ^2-test indicated the presence of a statistically significant relationship between VLD satisfaction and both initial and maximum VLD values. This is most likely due to the tendency of initially low VLD to increase. Thus, all participants with a positive VLD satisfaction and an initial VLD of less than 70% reported maximum VLD values of more than 80%.

We found that the rate of VLD satisfaction increased as maximum VLD increased. Also, VLD satisfaction increased drastically among participants with maximum VLD values ranging from 60-69%, 70-79%, and 80-89% (no VLD satisfaction cases, half VLD satisfaction cases, and three-quarters of VLD satisfaction cases, respectively). This suggests that there is a conditionally average value of VLD that is satisfactory for most practitioners and can be guided by when evaluating the effectiveness of VLD -increasing techniques.

However, three participants reported negative VLD satisfaction even though they reported VLD values greater than 100%. For two of them, we hypothesize this happened due to severe fluctuations in VLD, which could have dropped below the original values (60% and 90%) at some point during the LD experience. The negative VLD satisfaction for the other participant might have been caused by an incorrect subjective assessment of VLD level, given that the initial VLD was 80% and increased during PS.

Considering the above evidence, we conclude that practitioners prefer to experience high VLD values throughout the entire LD experience as opposed to at certain points in time. Although no statistically significant relationship was found, if the maximum VLD level was above 60%, participants tended to report more positive VLD satisfaction when the VLD level remained the same during the LD compared to when VLD levels floated, increased, or decreased.

The results do not confirm the hypotheses that VLD fluctuations and VLD satisfaction depend on each other or that they depend on the LD induction method, the practitioner's gender and experience, and LD time and duration. However, relationships between these parameters might be revealed in studies with larger samples.

5. Limitations

The main limitation of this study is that VLD levels, VLD fluctuations, and VLD satisfaction were assessed subjectively. Nevertheless, the task of this research is to study whether different levels of VLD satisfaction can occur at the same VLD level. We assumed that all participants' assessments of VLD fluctuations were equally accurate since the assessment involves criteria that are familiar to ordinary people.

Another limitation of this study is related to the researchers' inability to determine what proportion of participants were satisfied with the level of VLD in ordinary LD experiences (i.e., those not associated with experiments). The participants might have unintentionally influenced the VLD level simply because they were considering it per the instructions they were given. This could happen because of a similar auto-suggestion mechanism that could have caused participants to increase VLD by imagining that they were in reality (Raduga, Zhunusova, Shashkov, 2020).

Also, the assessment of the VLD level implies an active interaction with the LD space—at least with the help of vision, which, presumably, should also increase VLD (the method of increasing VLD by peering into objects of the LD environment is being investigated in a parallel study). All of these possibilities require additional research investigating the proportion of practitioners who are satisfied with VLD levels in their daily LD experiences as measured through separate surveys.

6. Conclusions and Future Studies

The present study shows that perception vividness flows during an LD and that it satisfies practitioners only after a certain VLD level is reached. Although we found some tendency for initially low VLD values to increase, we believe that the causes of spontaneous VLD fluctuations require more fundamental scientific research. This knowledge would provide a better understanding of the nature of subjective perceptions in an LD.

Of course, there are other objective reasons for the creation of VLD-increasing methods, such as the inability to achieve goals in LDs. Nevertheless, we believe that the separate VLD satisfaction is of great importance, especially in cases of LD practice for experiencing desired situations and sensations that are impossible in reality. This, in turn, can influence the intensity of the emotional and psychological effects experienced by the practitioner after they awaken, as well as their motivation to practice again in the future.

In previous works, we have investigated the effectiveness of some VLD-increasing techniques, such as spinning (Raduga, Shashkov, et al., 2020b), imagining reality (Raduga et al., 2020), falling upside down (Raduga, Shashkov, & Zhunusova, 2020a), and performing physical exercises. We intend to continue undertaking such research to find the best way to increase the quality of LD experiences. By doing this, we hope to open up new facets in LD research that can be used in personal practice to improve people's lives.

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Appendix

Reporting form on the website (translated from Russian)

RESULT AT THE BEGINNING OF THE PHASE (please describe the perception vividness; for example, 60% of reality) - * required field

MAXIMUM RESULT (please indicate the maximum perception vividness in the phase; for example, 120% or 80% of reality) - * required field

RESULT IN DYNAMICS (please describe how perception vividness changed in the phase: rise, float, decrease, same) - * required field

SATISFACTION WITH PERCEPTION VIVIDNESS (Were you satisfied with perception vividness in the phase?) - * required field

YOUR AGE - * required field

DATE AND TIME OF THE PHASE (for example, June 31, 2020, 05.30 am) - * required field

NUMBER OF PHASE STATES IN LIFETIME (at least approximately) - * required field

DESCRIBE THE ENTRY INTO THE PHASE (the whole process, including techniques) - * required field

DESCRIPTION OF THE EXPERIENCE (including the experiment and all events in the phase) - * required field

HOW THE PHASE ENDED - * required field

PHASE DURATION (at least approximately) - * required field

COMMENTS