Available online at:
https://cc.arcabc.ca/islandora/object/cc%3Apsycjournal

J Camosun Psyc Res. (2021). Vol. 3(1), pp. 131-147.
Submitted Fall 2020; accepted July 2021.

What Is the Biological Cause of Dreams?

Authors: Chloe Nursey*, Devon Heathcote, and Kennedy Brewer

Supervising Instructor: Michael Pollock, Psyc 215 ("Biological Psychology")

Department of Psychology, Camosun College, 3100 Foul Bay Road, Victoria, BC, Canada V8P 5J2

*Corresponding author email: chloenursey@outlook.com

ABSTRACT

The purpose of this experiment was to examine varying types of dreams and how they were connected with our everyday lives. Previous research has shown that the biological causes of dreams can be based on what type of sleep they are in, either REM or NREM, the amount of cortical activation caused by what point of the circadian cycle the dreamer is in, and the type of external or internal stimuli that may initiate the memory sources. In our first (correlational) study, we tested the strength of these relationships by examining naturalistic daily changes in their variables longitudinally over a two-week period. REM sleep was measured by using the information provided from the phone app called Pillow, giving us the percentage spent in REM, as well as the total minutes slept per night from each participant. Amount of sleep in the late circadian morning was measured by recording how many hours past midnight each participant slept in for each night of the study. The amount of light was measured with both the use of an app called Light Meter upon waking each morning and the number of words used to describe each recorded dream by their relevance to light stimulation. Dream recall was determined by the average score that participants gave themselves on a scale of 0-10, depending on the clarity of recalled dreams. Data pooled across participants in our correlational study showed no significant correlations of REM sleep or sleep in the late circadian morning with dream recall. Similarly, light stimulation showed no significant correlation with dream tallies. Although our correlations were not significant, the strongest was sleep in the late circadian morning and dream recall. Based on the strength of correlation found between the strength of dream recall and sleep in late circadian morning in our correlational study, we then conducted a second (experimental) study to test for specifically a causal relationship between these two variables. Over a ten-day period, we randomly assigned participants each day to wake up either one hour earlier or at their normal wake time and measured the effect this had upon dream recall each day. The results of our experimental study showed statistical significance in pooled raw data but not in pooled standardized data. The biological causes of dreams thus remain unsolved.

1. Introduction

1.1 Research Problem

There is much curiosity as to how our minds are able to stimulate such varying dreams and how they behave the way they do. Our research goal is to gain insight as to why some dreams can be remembered in great detail, while other dreams may be hard to remember once we wake up from our rest. Having an understanding of what causes dreams to occur may help those who wish to alter their dreams, make sense of how their dreams relate to their everyday lives, and additionally, have comprehension of how the connections between dreams and the mind are formed. We wish to know what biological mechanisms cause dreams so we can have a better understanding for our own sake, and learn how to make sense of why we have specific dreams during sleep.

1.2 Literature Review

A factor as to why some dreams can be remembered while others cannot, is based on whether the person sleeping is engaged in rapid eye movement (REM) or non-rapid eye movement (NREM) sleep. A study was conducted by Dement & Kleitman (1957) to see what state of sleep would have a better recall of the participants' dreams. The participants consisted of nine adults, five male, two females and they were told to report to the laboratory a little before they went to bed, they were also told to withhold from consuming alcohol and caffeine beverages on the day of the experiment. The participants were recorded by an EEG machine via scalp while they slept and were woken multiple times during their sleep with an alarm to see if they could recall their dreams or not. In total, the participants slept 61 nights therefore there were a total of 152 dream recalls and 39 no recalls during REM sleep, as well as 11 dream recalls and 149 no recalls during NREM. This data shows that 80% of dreams were recalled during REM sleep, while only 7% of dreams were recalled during NREM sleep. This evidence shows the logic behind why dreams are sometimes remembered, but sometimes not is based on whether the person is in REM or NREM sleep before they are awakened.

Additionally, one theory suggests that dreaming is produced by cortical activation created by ultradian and circadian cycles. Wamsley, Hirota, Tucker, Smith, and Antrobus (2006) conducted an experiment to try to better understand the way that ultradian and circadian cycles influenced dreaming. 20 undergraduate students in New York were the participants for this study. Each participant was recommended to keep a sleep log 1 week before the experiment officially began, in which during this week, the participants were required to have an average bedtime before midnight, which could not be more than 1 hour away from the set average, and keep a record of the number of dreams that they were able to recall each night, including notes on remembered content in those dreams. During the main experimental night, participants went to bed 3 hours later than the set time that they'd previously adhered to during the week prior, and were also encouraged to sleep in as long as possible on the experimental night. Data was recorded using electroencephalographic (EEG), electrooculographic (EOG), and electromyographic (EMG) montage (Wamsley et al., 2006, p. 349). Each participant was woken twice, once from a REM and NREM period of their sleep near the lowest point of their circadian body temperature cycle, usually about 2.7 hours before their average waking time the week prior, and once from a REM and NREM period at least 1 hour after what their wake up time had initially, approximately when their circadian-driven cortical activation would be the highest. Awakenings during REM sleep were done 10 minutes into a period of REM, and NREM awakenings were done during stage 2 of the participant's sleep, at least 20 minutes from the last time that they were awake, or from the last period of REM. Each participant was awoken when their name was called on an intercom speaker. Upon waking, the following prerecorded questions were asked over the intercom: 1. Tell me everything that was going through your mind just before I called, 2. Tell me one more time everything that was going through your mind just before I called, 3. Were you trying to do anything? (y/n), 4. Were you trying to find anything? (y/n), 5. Were you trying to solve a problem? (y/n), 6. Was anyone talking? Could you hear any speech? (y/n). (Wamsley et al., 2006, p. 349). After responding to these questions, the participants completed an assessment of the emotional and visual qualities of what had gone on in their minds before waking up, including questions regarding visual clarity and brightness of objects as well as emotional intensity. These assessments were then scored on a few different scales that depicted their word information count, dreamlike quality, and level of bizarreness. Post conduction of the experiment, the results showed that 80% of the participants reported some form of mentation from the lowest point in their circadian body temperature cycle during REM period awakening, 100% reported mentation during the late REM period awakening, and 70% reported mentation from both the lowest body temperature point and late NREM period awakenings. The researchers concluded from this experiment that core cognitive characteristics of the mentation were most prominent during the late morning in both REM and NREM, and that although the cognitive features were expressed more in REM reports than in NREM reports, circadian-driven activation amplified the expression similarly in reports from both sleep stages (Wamsley et al., 2006, p. 349). From the findings of this study, it can be reasoned that a person's daily and circadian rhythm cycles have an impact on when dreams are more likely to occur, and that this influence can be applied to dreaming in both REM and NREM periods of sleep. Cortical activation is assumed to be higher the further into the late circadian morning that one sleeps in. This suggests that someone would be more likely to remember a dream if they had slept in later than someone who had woken up early.

Another possible element to the cause of dreams is the integration of sensory stimulation. In a study conducted by Dement & Wolpert (1958), twelve participants were tasked with reporting to a laboratory shortly before their usual sleep retirement, where they would be connected to various electrodes monitoring brainwave activity and eye movements, and then left to fall asleep in a darkened space. The researchers utilized three different stimuli (a five-second tone of 1000-hz, flashes of light and a light spray of water from a syringe onto the participants' face) when Rapid Eye Movement (REM) was present, and a bell would be sounded to fully wake up the participants and conclude the main testing process. The results of this experiment varied. Dreams transcripts, taken from tests where participants did not awaken, included hearing a close-by roaring sound akin to a plane crash or earthquake, seeing shooting stars or a flash of lightning, and building leaks or rainfall. The water spray appeared to have the most impact, with the 1000-hz tone the least. In addition, the alarm bell, despite not being one of the main stimuli, was incorporated into dreams as they ended, and were frequently described as a ringing doorbell or telephone. The water spray, while significantly lower in occurrence rate comparatively, also bore a chance for similar effect. A secondary study was conducted subsequently, with Dement and Wolpert instead putting focus toward the effect on dreams made by stimuli from internal processes. Three participants were tasked with five instances of complete curtailment of fluid consumption for a period of twenty-four hours minimum, and then to sleep in the laboratory after each separate instance. All participants, before falling asleep, reported experiencing a great thirst, and symptoms included a prominently dried mouth. The results of this second experiment detailed that while dream substance did not exhibit particular awareness of thirst or the need thereof, one-third of the dreams appeared to indicate elements relevant to the imposed restriction, including a toast being raised but the participant having no cup of their own, and the participant heating up roughly a litre of milk for consumption. Based on these results, it is possible that factors from external and internal sources may play a role in dream formation.

1.3 Hypotheses

Based on the above literature review, we predicted the following hypotheses:

- Hypothesis #1: If REM increases during sleep, then dream recall will increase.
- Hypothesis #2: If sleep occurs later in the circadian morning, then dream recall will increase.
- Hypothesis #3: If sensory stimulation during sleep increases, then the quantity of dream content relevant to that stimulation will increase.

2. Methods

2.1 Participants

The three authors of this paper served as the participants in its studies. The participants ranged in age from 19-22 years old, with an average age of 21 years, and included three females. The participants were all undergraduate students at Camosun College who completed the current studies as an assignment for Psyc 215 ("Biological Psychology") and were grouped together due to their mutual interest in the biological causes of dreams. All of the participants reported having frequent dream sequences, which fell within regular sleeping patterns.

2.2 Materials and Procedure

2.2.1 Correlational Study Methods

We first performed a correlational study to test concurrently all of our hypotheses by examining naturalistic daily changes in their variables longitudinally. Each participant kept a study journal with them at all times over this study's two-week period in order to record self-observations of the following four variables: (1) REM sleep, (2) Sleep in late circadian morning, (3) sensory stimulation during sleep, (4) dream content relevant to sensory stimulation, and (5) dream recall.

To measure the amount of time spent in REM sleep, each participant recorded in their study journals the percentage of REM sleep they had throughout the night. This information was provided by the Pillow app and was calculated daily.

To measure the amount of sleep in the late circadian morning, each participant recorded how many hours that they slept past midnight in a journal over the course of the study. Using a chart of an assumed timeline of circadian-driven cortical activation during the night from the Wamsley et al. (2006) article, participants estimated that the level of cortical activation would increase the later into the circadian morning that they woke up (see appendix A for the chart).

To measure sensory stimulation during sleep, each participant recorded in their study journals the level of light present in their immediate surroundings, noted in Lux through the app Light Meter, upon waking.

To measure dream content relevant to sensory stimulation, dreams and their content remembered were also written down, and then passed towards a non-participant for review, where words synonymous to the chosen element, such as light and intensity, within each dream were respectively tallied. The possible values on this tally scale ranged from none (a score of 0), to moderate (a score of 5), to very high (a score of 10). From these records, the average tally scores for the dreams recorded by each participated for each day was calculated.

To measure dream recall, participants recorded in their study journals their ability to remember their dreams on a 0 to 10 scale. Clarity of dreams recollected was ranked from 0 = no detail recalled, 5 = some detail with partial obscurity, and 10 = full recollection. From these records, the average level of detail recalled in dreams of each participant for each following day was calculated.

To assess the strength and statistical significance of associations between variables predicted by our three hypotheses, we performed Pearson product moment correlations of their predictor variables (REM sleep, level of a stimuli, and cortical activation) with their outcome variable (dream recall). For testing Hypothesis #1, we correlated the total amount of time spent in REM sleep each night with whether the participant could recall their dream(s) in detail when they woke up. For testing Hypothesis #2, we correlated the level of circadian-driven cortical activation with the amount of detail in which participants could remember the content of their dream(s). For testing Hypothesis #3, we correlated the nightly measure of stimulus-derived dream content obtained by each participant for each day. We performed all of the above correlations separately for each participant as well as using data pooled across all of the participants. For the correlations using pooled data, in addition to the raw data, we also performed correlations after we had first transformed the data from each participant into *z*-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. A correlation coefficient was considered statistically significant if the probability of its random occurrence (p) was $< .05$ (i.e., less than 5% of the time expected by chance alone).

2.2.2 Experimental Study Methods

Based on the strength of the strength of the correlation between dream recall and sleep in late circadian morning found in our correlational study, we then chose to conduct an experimental study to test for a casual relationship between these two variables for Hypothesis #2.

We manipulated the independent variable, sleep in late circadian morning, over a 10-day period by randomly assigning participants each day to either an experimental group, or control group. For experimental days, participants woke up one hour early from their normal wake time. For control days, participants woke up at their normal wake time. These wake times were based on the average wake time participants had over the 10-day period of the correlational study. The wake times were correspondent to each participant so no external factors affected the study.

We were unable to make this a blind procedure as participants needed to be aware of what time they were waking each morning to get to class and work on time. To determine the conditions, the participants were randomly assigned by flipping a coin to either a control or experimental day (control = heads, experimental = tails). On experimental days, participants woke up one hour earlier from their normal wake time. On control days, participants would wake up at their normal wake time. To control for any bias resulting from rating their own dream recall on an objective scale, participants wrote their dream description in a journal when they had waken, then had an unbiased individual read their dream description and rate it on the dream recall scale (0 = could not remember any dreams, 10 = dreams could be remembered in complete detail) depending on the level of detail they thought was present.

To assess the statistical significance of differences seen in dream recall on hour-variation wakeup experimental days vs. regular wakeup control days, Student's *t*-tests were performed. We performed t-tests separately for each participant as well as using data pooled across all of the participants. For the *t*-tests using pooled data, in addition to using the raw data, we also performed *t*-tests after we had first transformed the data from each participant into *z*-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. An average difference between conditions was considered statistically significant if, using a two-tailed distribution (i.e., allowing this difference to be positive or negative), the probability of its random occurrence (p) was <.05 (i.e., less than 5% of the time expected by chance alone).

3. Results

3.1 Correlational Study Results

As shown in Table 1, both REM sleep and sleep in late circadian morning were not significantly correlated with dream recall. Although not statistically significant for any single participant, sleep in late circadian morning was statistically stronger with dream recall using both pooled raw data (r = -.06, p = .728; see Figure 2.a) and pooled standardized data (r = .20, p = .213). Similarly, REM sleep and dream recall were not significantly correlated for any single participant, but showed similar strength to sleep in late circadian morning using pooled raw data (r = -.04, p = 0.147; see Figure 1.a) and pooled standardized data (r = .13, p = .413). In parallel, no statistically significant correlations were found between light stimulation and dream tallies using any single participant's data, pooled raw data (r = .18, p = .256; see Figure 3.a), or pooled standardized data (r = .15, p = .354), however, one participant's data briefly held statistical significance. Based on a comparison of the correlation coefficients using either the pooled raw data or the pooled standardized data, sleep in late circadian morning showed the strongest correlation with dream recall.

3.2 Experimental Study Results

As shown in Table 2, some significant difference was found in dream recall between early wake time and normal wake time in the pooled raw data. Statistically significant differences between these conditions were not seen using pooled standardized data (p = .123), however, any single participant's data ($p \geq .002$) and pooled raw data (p = .048 ; see Figure 4.a) showed some evidence of significance, with one participant's data showing statistical significance.

4. Discussion

4.1 Summary of Results

Based on previous research, we hypothesized that increases in three variables would be followed by greater dream recall after each night of sleep: the amount of REM sleep (Hypothesis #1), sleep in late circadian morning, (Hypothesis #2), and the amount of light stimulation (Hypothesis #3). Data pooled across participants in our correlational study showed no significance between the relationship of dream recall with REM sleep and sleep in the late circadian morning (Hypotheses #1&2). Additionally, no significance was found between sensory stimulation during sleep, and dream content relevant to sensory stimulation (Hypotheses #3). The strongest correlation was the relationship between dream recall and sleep in the late circadian morning. However, the results of our experimental study did not appear to establish a solid causal role of sleep in the late circadian morning on dream recall.

4.2 Relation of Results to Past Research

Our correlational study did not show a significant relationship between REM sleep and dream recall reported by previous research. Dement & Kleitman (1957) found that dream recall was based on whether the participant was in REM sleep or NREM sleep before they awakened. Dement & Kleitman (1957) had nine adults participate in their study, five males, and two females, and were recorded by an EEG machine via scalp while they slept and were asked to recall their dreams when they woke up. In contrast, our study had three female participants, all in their twenties, and recorded REM sleep through the Pillow app and reported in study journals their ability to recall dream(s), if any, on a 10-point scale. 0 meaning no recall of dream(s), and 10 meaning full recollection of dream(s). The Pillow app was used to calculate the amount of REM sleep the participants had each night, calculated in percentage. Although some data throughout the study suggests that dream recall could be related to the amount of REM sleep participants had, it was not enough to show a significant relationship.

There was no significant relationship found between sleep in the late circadian morning and dream recall. This means that our findings were not consistent with those of the study conducted by Wamsely et al. (2006). In the Wamsley et al. (2006) study they found that waking up when levels of cortical activation were assumed to be higher, like later into the morning for example, was correlated with higher dream recall. While the Wamsely et al. (2006) study used different technologies to measure levels of cortical activation such as EEG, EOG, and EMG, we used the chart included in their article to estimate the level of our own cortical activation at different hours of the morning. We were able to use this chart to assume that our cortical activation would be higher in the later hours of the morning. Similarly, while the Wamsley et al. (2006) study included an assessment where the participants ranked many factors such as dreamlike quality, word information count, and level of bizarreness, we chose to rank our dream recall on a scale from 0-10. A 0 on this scale meant that no dream could be remembered, and a 10 meant that a dream could be remembered in complete detail. Our study could not confirm that a relationship between sleep in the late circadian morning and dream recall does exist. In our experimental study, we restricted how late we would sleep into the circadian morning by waking up an hour earlier than we normally would. A limitation we faced was our inability to conduct a double-blind experiment, due to the fact that alongside knowing the hour that we were waking up at, our study design restricted late circadian morning sleep by one hour in order to go about our daily lives as usual. There was no statistical significance found in our experiment with the one hour difference between conditions. It is recommended that future studies use a larger gap between conditions as well as a larger sample size to find a significance between control and experimental waking times.

Our correlational study failed to confirm the relationship between sensory stimulation and dream content relevance reported by previous research, however, there was a correspondence present. Dement & Wolpert (1958) found that several aspects of stimulation in sleep, measured through equipment monitoring sleep activity and transcripts of recounted dreams, appeared in dreams within various formats, but dreams themselves were not always present within each testing period. Similarly, our participants had dreams of varying strengths and activity, while, however, experiencing sleep periods where dreams involving the chosen stimulation were either entirely vague, and or incredibly undefined, or nonexistent. The methodology of our correlational study differed from that of Dement & Wolpert (1958) in three major ways that might account for the analogous results. Foremost, differences between the studies in how they measured dream content relevance could have affected their findings. Our correlational study relied only upon self-reports of synonymous words used in dream transcripts. Future studies should test whether the objectively verified aspects of stimulation during sleep outlined by Dement & Wolpert (1958), but not subjective self-assessments, predict dream content severity. Second, differences between the studies in how they measured content relevance in dreams could have affected their findings. Lending credence to this possibility is the fact that Dement & Wolpert (1958) could not entirely predict the strength and effects of a sensory stimulus on dreams, such as how strongly an element based around the utilized stimulation was present, and the perceived time duration within each dream. While we measured content relevance based on a tally scale, Dement & Wolpert (1958) based their results on described events in dream transcripts. Future studies should examine whether sensory stimulation is able to predict the severity of only certain self-reported content-relevant dream transcripts. Lastly, differences between the studies in how sensory stimulation was received could have affected their findings. Although testing conditions could be manipulated to the experimenter's desirability, there would be little to no accounting for stimulus reception prior to and post the experimentation period. Future studies should examine the exposure levels of stimulation received, separate and prior to those of manipulated circumstances.

4.3 Implications of Results

Possible practical applications of our current findings are the increased memory of dream content. For example, this could prove to be beneficial toward the creation of innovative ideas appearing to someone in a dream, and they wish to remember them for later application to their lives, but not when or how the innovations would potentially be administered. Additionally, as dreams are often noted as a subconscious means of processing data from both recent and past experiences, an improved recollection of dreams could provide a window for curious minds, whether by the review of prior events or pure introspection, and potentially include this possibility for future research.

We originally conducted the current studies to find a way to better recall content details within dreams that would otherwise be lost normally. Unfortunately, based on our experimental results, we cannot accurately define a method where sleeping later into the circadian morning would ensure higher dream recall. It remains up to future studies to find a working solution to this problem however possible.

References

Dement, W., & Kleitman, N. (1957). The relation of eye movements during sleep to dream activity: An objective method for the study of dreaming. *Journal of Experimental Psychology*, *53*(5), 339-346.

Dement, W., & Wolpert, E. A. (1958). The relation of eye movements, body motility, and external stimuli to dream content. *Journal of Experimental Psychology*, *55*(6), 543–553. https://doi-org.libsecure.camosun.bc.ca:2443/10.1037/h0040031

Wamsley, E. J., Hirota, Y., Tucker, M. A., Smith, M. R., Antrobus, J. S. (2006). Circadian and ultradian influences on dreaming: A dual rhythm model. *Brain Research Bulletin*, *71*(4), 347-354.

Table 1

Correlation coefficient (r) values, with the number of daily trials (n) per correlation in brackets.

Variables correlated	Participant #1	Participant #2	Participant #3	Pooled raw data	Pooled standardized data
REM sleep & dream recall	0.41(14)	-0.15(14)	0.13(14)*	-0.04(42)	0.13(42)
Sleep in late circadian morning & dream recall	0.49(14)	-0.21(14)	0.31(14)	-0.06(42)	0.20(42)
Light stimulation & dream tallies	0.27(14)	-0.33(14)	0.51(14)	0.18(42)	0.15(42)

* $p < .05$.

Table 2

Descriptive statistics on dream recall for early wake time condition and normal wake time condition.

Condition	Statistic	Participant #1	Participant #2	Participant #3	Pooled raw data	Pooled standardized data
Early Wake Time (Experimental)	Mean	3.33	5.50	2.71	3.79*	-0.22
	S.D.	3.44	2.17	3.73	3.28	0.86
	n	6	6	7	19	19
Normal Wake Time (Control)	Mean	9.50	4.00	6.33	6.64	0.38
	S.D.	0.58	3.74	4.73	3.85	1.06
	n	4	4	3	11	11

Dream recall was measured on a 0-10 scale of clarity, where 0 = no details remembered and 10 = full detail remembered

*$p < .05$ for comparison of early wake time condition with its respective normal wake time condition.

Figure 1.a

Scatterplot of REM sleep and dream recall using pooled raw data across participants.

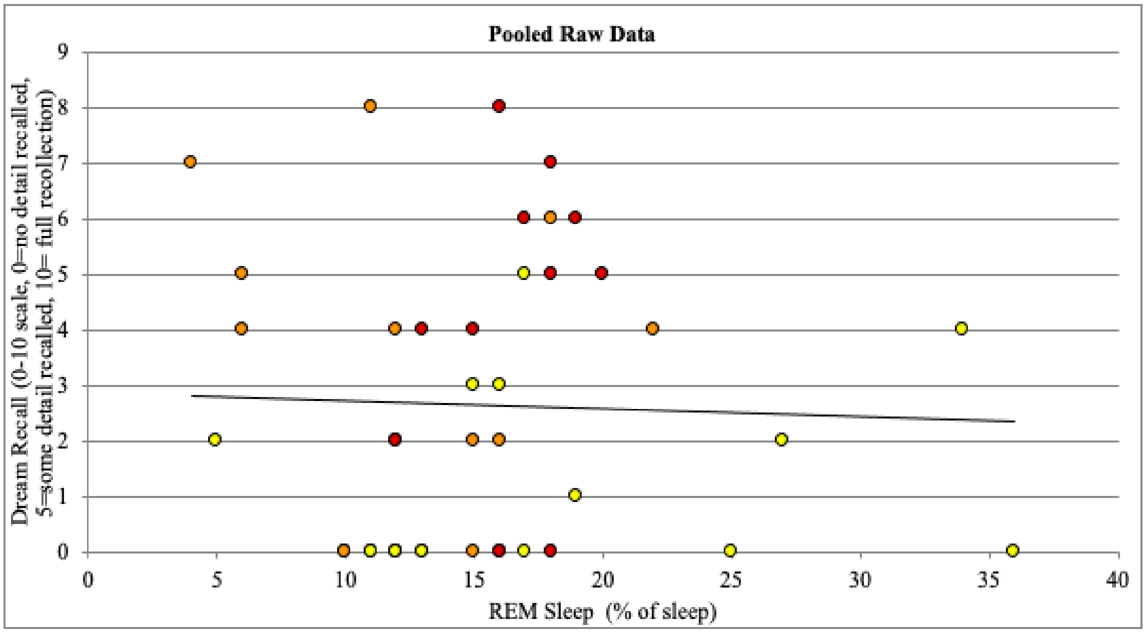
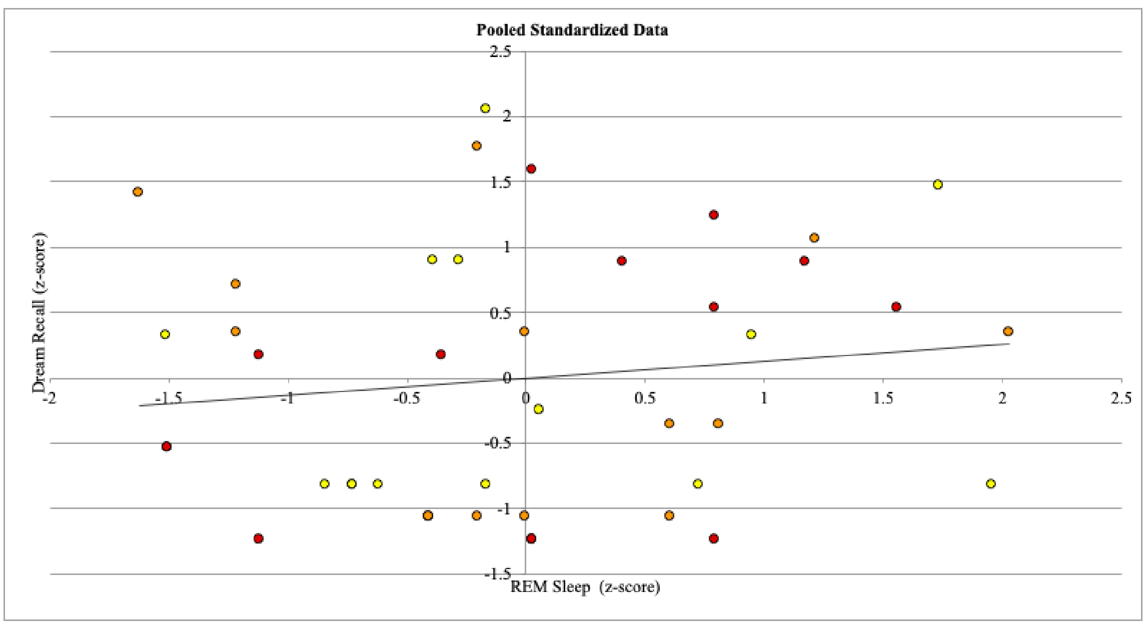


Figure 1.b

Scatterplot of REM sleep and dream recall using pooled standardized data across participants.



Marker color indicates which participant data is from: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 2.a

Scatterplot of sleep in late circadian morning and dream recall using pooled raw data across participants.

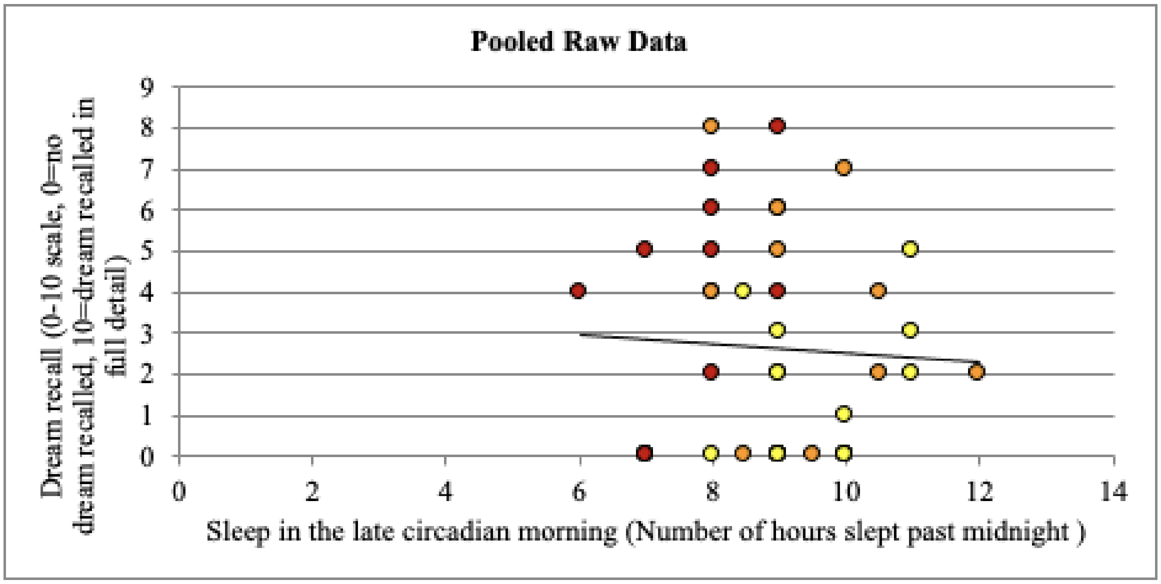
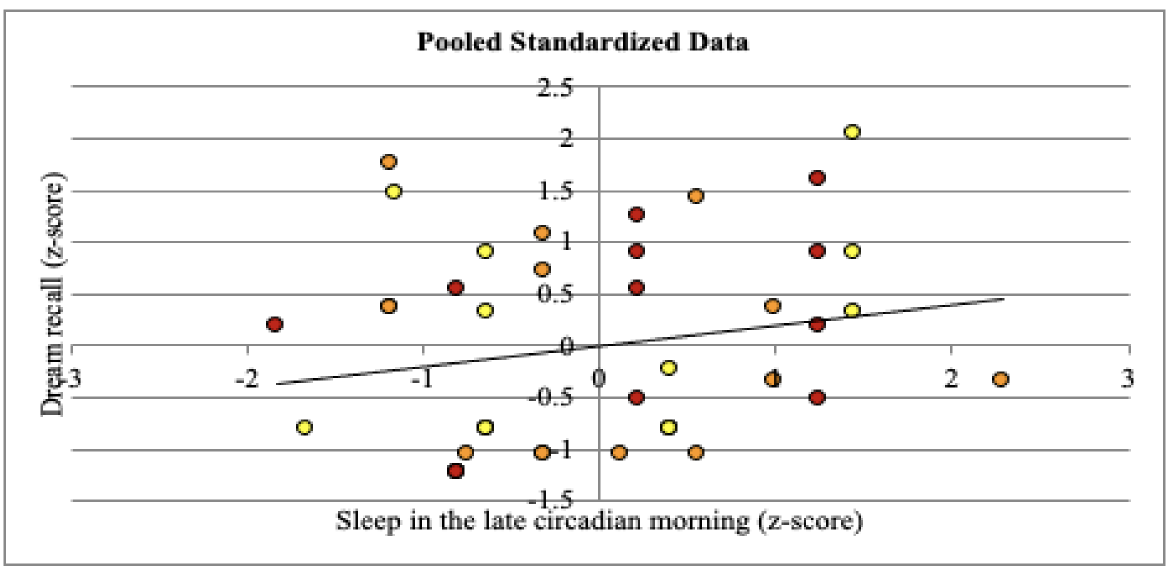


Figure 2.b

Scatterplot of sleep in late circadian morning and dream recall using pooled standardized data across participants.



Marker color indicates which participant data is from: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 3.a

Scatterplot of light stimulation and dream tallies using pooled raw data across participants.

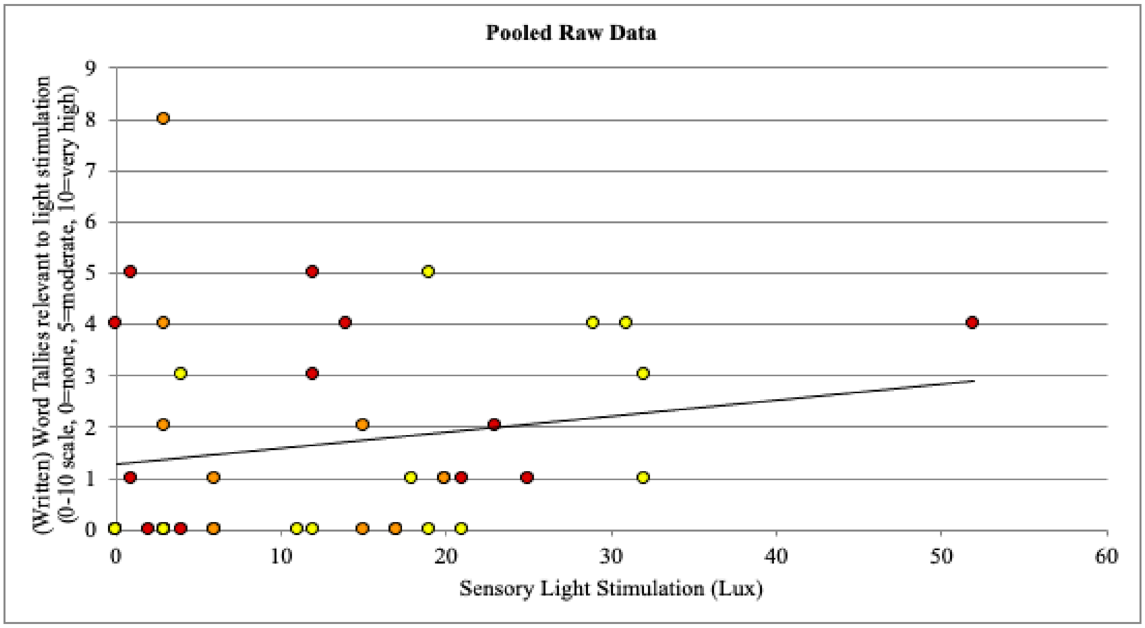
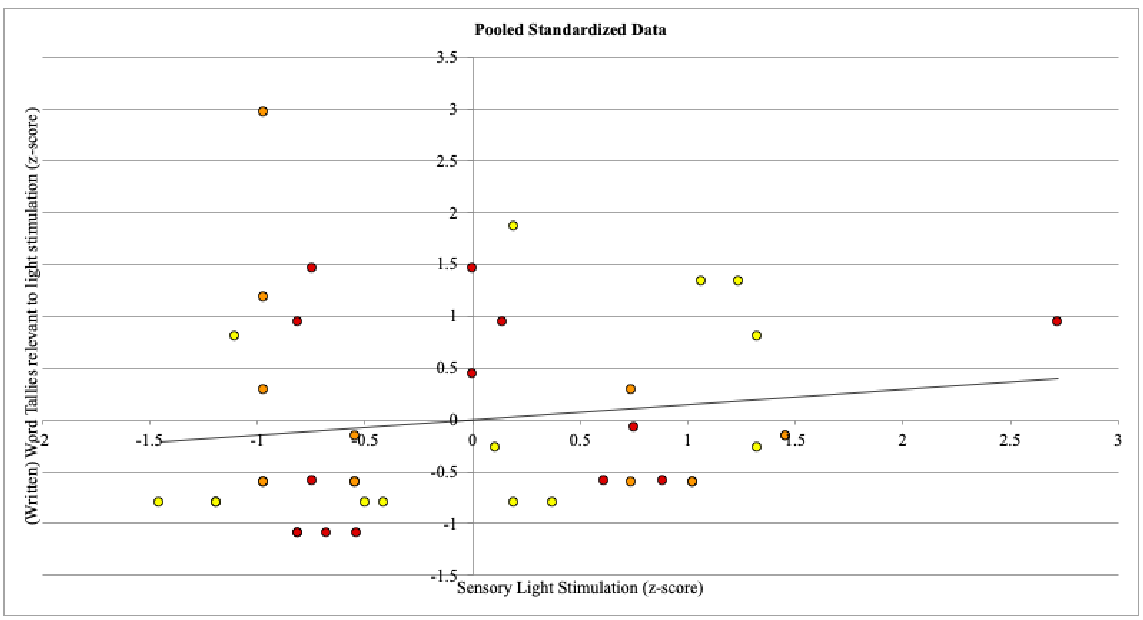


Figure3.b

Scatterplot of light stimulation and dream tallies using pooled standardized data across participants.



Marker color indicates which participant data is from: red = participant #1, orange = participant #2, and yellow = participant #3. Some data might not be visible in the figure due to overlapping markers.

Figure 4.a

Bar graph of dream recall across early wake time and normal wake time conditions using pooled raw data from participants, with error bars showing ± 95% confidence levels, and with an overlapping scatterplot of data from each participant.

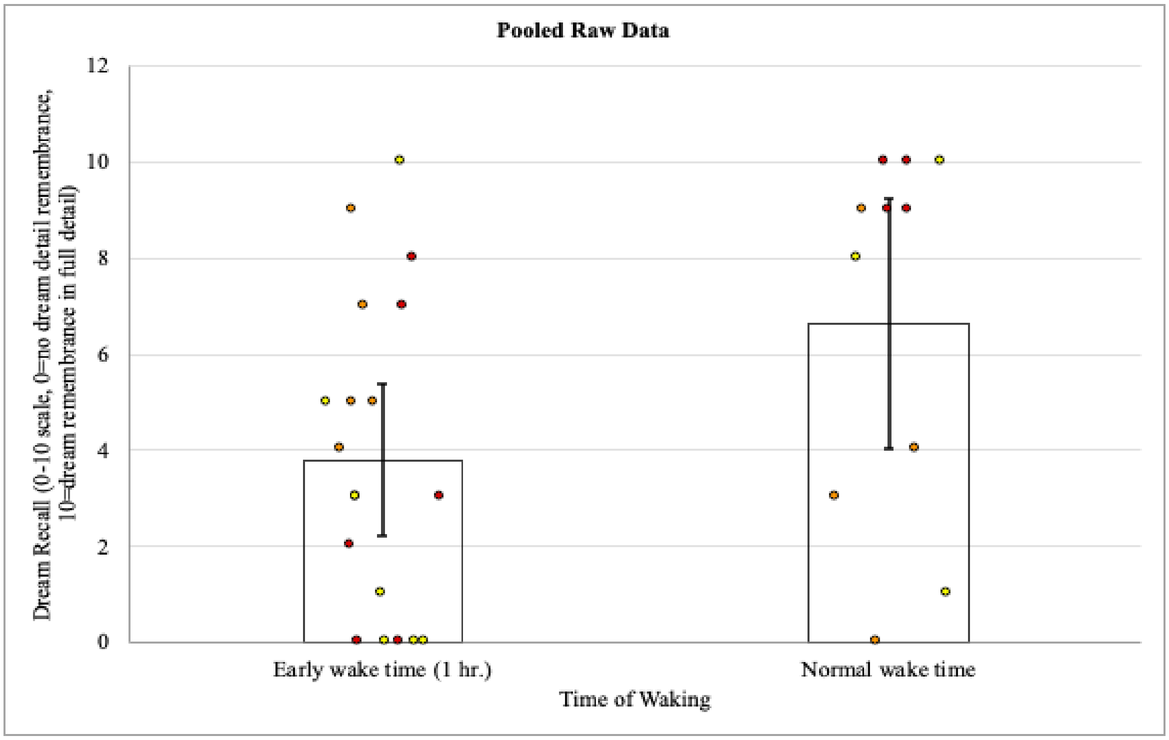
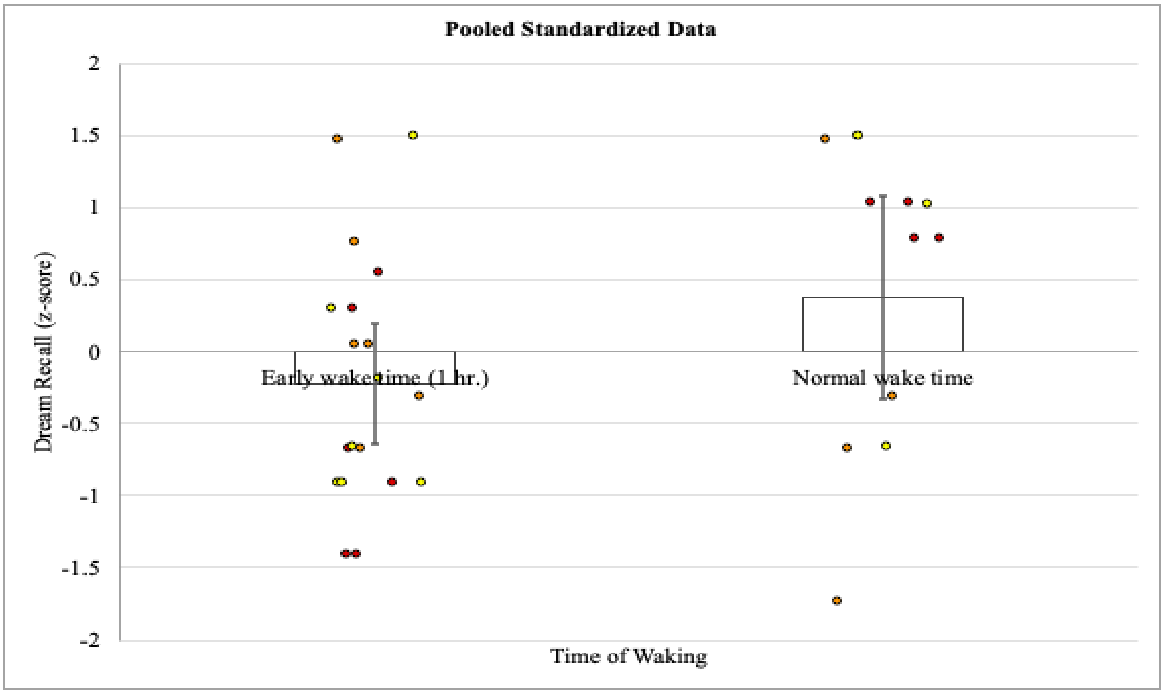


Figure 4.b

Bar graph of dream recall across early wake time and normal wake time conditions using pooled standardized data from participants, with error bars showing ± 95% confidence levels, and with an overlapping scatterplot of data from each participant.



Marker indicates which participant data is from: red - participant #1, orange = participant #2, and yellow = participant #3.

Appendix A

Chart depicting assumed timeline of level circadian-driven cortical activation throughout the night.

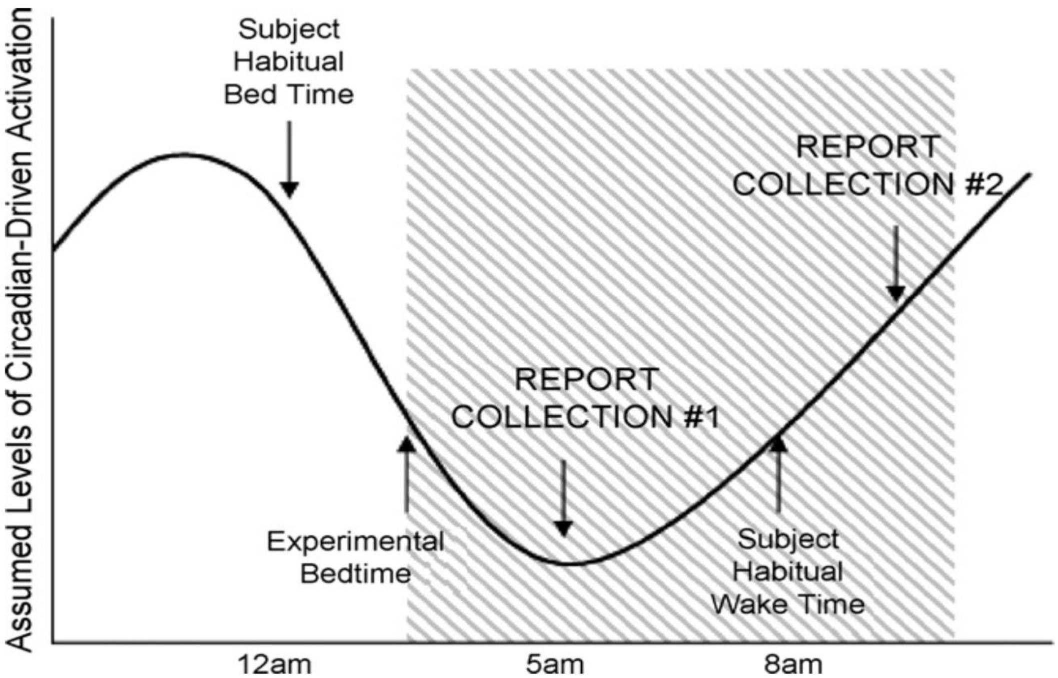


Fig. 1. Experimental timeline for a hypothetical subject with a mean bedtime of 12 a.m. and a mean wake time of 8 a.m. for the week previous to the study.