The Effects of Self-Reported Sleep Characteristics on Relational Responding

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Abstract

Society heavily promotes the need to "get your eight hours" when referring to getting adequate sleep. Alas, research does recommend and support at least seven hours of sleep for individuals 18 years and older. There is a litany of negative effects when sleep is lacking, especially in cognitive function. One such form, relational memory, has been heavily researched and continuously supported in the benefits of sleep to forming complex relations with new information. There is very little, if any, research investigating whether sleep quantity or sleep quality has a more significant effect on relational responding. This study aimed to answer this question by using a match-to-sample task. Participants took a pre-test, were trained in A-B and B-C relations, and then tested again in a post-test task before answering a ten-question sleep survey about the quantity and quality of their sleep. Results of the task and survey show that although self-reported sleep quality did not have a significant effect on relational responding, perceived sleep quantity did with a negative correlation between scores on the sleep quantity portion of the survey and participant scores on the relational responding task. College students, who often suffer from sleep loss for a multitude of reasons, may benefit greatly from research on the effects that sleep has on relational responding. Likewise, those working with ASD clients in behavioral therapy settings may find this research relevant as well. Studies have shown that ASD populations are often plagued by sleep problems and relational responding tasks such as stimulus equivalence are often used in behavior therapies such as applied behavior analysis.

Keywords: sleep, relational memory, relational responding, stimulus equivalence, naps, college students, match-to-sample

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The Effects of Self-Reported Sleep Characteristics on Relational Responding

It is fairly common knowledge in Western society that getting the proper amount of sleep is vital for daily function. Typically, that is said to be 8 hours of sleep a night. The most recent recommendations for sleep in adults are at least 7 hours per night (CDC, 2022; Sleep Foundation, 2024) with Harvard Summer School (2021) stating the adult range for sleep should be between 7 and 9 hours per night. Research shows, however, that approximately one-third of adults are not getting at least the recommended 7 hours of sleep in a typical 24-hour period, and that 37.9% of adults surveyed even fell asleep during daytime hours sometime in the month preceding the study (National Sleep Foundation, 2011). This act of not getting enough sleep per night is known as partial sleep deprivation. Contrary to total sleep deprivation, where the person goes without sleep for long periods of time (at least 18 consecutive hours but typically at least 24 hours), partial sleep deprivation involves sleeping every night but without getting enough sleep while doing so (Owens, 2014).

When a person suffers from sleep deprivation, they begin to accrue what is known as a “sleep debt” (Mednick & Ehrman, 2006). This sleep debt will compound for as long as that person goes without getting the recommended amount of sleep and will quickly lead to negative effects on performance, sometimes even within one to two days (Coren, 1996).Czeisler (2006) stated that averaging four hours of sleep a night over several days is the same as being awake for 24 hours which, equivalently, has the same cognitive impairment as a blood alcohol level of 0.1%. Furthermore, Mednick & Erhman (2006) surmise that the effects are similar when taking one drink as getting one less hour of sleep than is recommended.

High schoolers and young adults are especially susceptible to suffering from sleep deprivation as their circadian rhythms begin to shift in a manner that has them staying awake later at night and sleeping later in the mornings (Wise, 2018). This is contradictory to the typical start time for school, and the effects of the circadian rhythm shift can be seen well into the college years, where classes often begin early in the morning. With biology in mind, it is not surprising that sleep problems are prevalent among college students. Kloss et al. (2016) reported that almost 70% of college students suffered from sleep problems. Similarly, Lund et al. (2010) found that 70% of college students reported getting less than 7 hours of sleep per day. Wise (2018) cited the findings of the 2015 American College Health Association-National College Health Assessment II, where an astounding 91% of undergraduate students reported daytime tiredness and sleepiness occurring in the previous seven days.

Besides school schedules conflicting with their biological clocks, there are other factors contributing to sleep deprivation in college students. College students (and many other adult individuals) may find themselves in a vicious cycle of caffeine consumption. One study of students in Saudi Arabia saw energy drink consumption rates as high as 46% (Faris, 2014), and a study of 496 college students in the United States saw 51% of participants reporting energy drink consumption at more than one every single month. 67% of those that were consuming the energy drinks reported inadequate sleep as the reason for said consumption (Malinauskas et al., 2007). Faris et al. (2016) demonstrated a statistically significant relationship between the use of stimulants and poor sleep quality. With research showing that consuming caffeinated beverages can contribute to poor sleep quality (McIlvain et al., 2011) and poor sleep quality leading to the consumption of caffeinated beverages, society may very quickly find themselves caught in a philosophical “chicken or the egg” argument and the dilemma of college students struggling to figure out how to break the cycle.

College students are not free of distraction from sleep at bedtime, either. With technology continuously evolving and readily available in multiple forms, it should come as no surprise that technology also plays a part in sleep deprivation in the college-aged population. Several studies have shown that frequent use of devices such as smartphones, tablets, and watching television near bedtime can negatively affect young adults' sleep quality (Karimy et al., 2020; Saquib, 2020; Zachariae et al., 2016). Additionally, bedtime usage can immediately lead to sleep delays and loss, near-future daytime tiredness, and long-term poor sleep quality and irregular sleep patterns (Bartel et al., 2014; Kubiszewski et al., 2013; Exelmans, 2016). Technology is another vicious cycle similar to that of caffeinated beverages in that people may reach for their devices when they are unable to fall asleep which in turn leads to other sleep problems.

There are some cultural implications to what should be considered the recommended amount of sleep. Cheung et al. (2021) conducted a cross-cultural study that examined the differences in sleep duration between Japanese and Canadian college students. The findings indicated that although the Japanese students slept significantly less than European-Canadian and Japanese-Canadian students, they did not appear to suffer from the same implications of sleep deprivation as the European- and Japanese-Canadian students did. In fact, research shows that Asian countries tend to sleep anywhere from 40 minutes to 2 hours less, on average, than North Americans, Europeans, and Australians (Olds et al., 2010). There is also commonly a positive view on biphasic sleep, or splitting sleep into two sessions, rather than the monophasic sleep that is promoted in Western society (Barone, 2000; Samson et al., 2017).

Indeed, there is some supporting research on the benefits of biphasic sleep in the form of naps, although the research has a few cautionary notes. Mednick et al. (2003) found that taking 90-minute naps can provide functional improvement at a level similar to a night of sleep and that a nap preceding a night of sleep has the same benefits as getting two nights of sleep. Buboltz et al. (2006) found, however, that if naps occurred in the late afternoon or early evening, they were more likely to lead to a delay in falling asleep and a reduction in sleep quality. Mednick & Drummond (2009) expanded on that finding, stating that so long as naps do not occur within the 2- to 3-hour timeframe before bedtime, they will not disrupt nighttime sleep, and Ye et al. (2015) solidified Buboltz et al.'s earlier finding that napping later in the day can lead to nighttime sleep disruption.

Just as the amount of sleep needed is well-researched, so are the benefits of sleep and the negative effects sleep deprivation can have on memory. Sleep is necessary for memory consolidation (Diekelmann & Born, 2010; Curcio, 2006), the integration and generalization of memory (Ellenbogen et al., 2007; Lau et al., 2010, 2011), and in bringing new comprehension to difficult problems through the facilitation of qualitative memory changes (Walker & Stickgold, 2010). Rodrigues et al. (2019) cites sleep deprivation as causing impaired memory and decision-making, and Chen et al. (2020) cited studies from Lo et al. (2012) and Goel et al. (2009) with findings showing an impaired ability to sustain attention when sleep deprivation was at play. Insomnia and sleep deprivation can also lead to impairments in working memory and on working memory tasks (Lo et al., 2012, 2016; Rangtell et al., 2018). Pilcher & Huffcutt (1996) equated a sleep-deprived individual's functioning level to that of the ninth percentile for individuals who are not sleep-deprived.

As previously stated, college students have a high prevalence of sleep deprivation. Phan et al. (2019) found that poor sleep quantity and quality had a negative effect on memory capacity in college students. In Pilcher & Walters (1997), researchers experimentally restricted sleep in college students. In doing so, they found that the students not only performed poorly on critical thinking tasks, but they also had a false sense of how mentally impaired they were. Likewise, sleep-deprived young adults who were told to rate their concentration, effort, and cognitive performance did so with higher ratings than those that were not sleep-deprived even though the data showed impairments in psychomotor performance, memory, and computational speed (Curcio et al., 2006). Harrison et al. (2000) equated the cognitive profile of these individuals as being consistent with documented prefrontal cortex impairments in 60-year-old patients. Finally, lack of sleep in college students can lead to memory deficits and the inability to learn new things, absorb new information, and retain recently learned material (CDC, 2018; Schoenborn et al., 2013; National Sleep Foundation, 2011; Kloss et al., 2016; Owens, 2014; Owens et al., 2017).

Episodic memory, or memory involving events, is one such area that can be affected by sleep deprivation. Relational responding is a component of episodic memory (Ngo et al., 2017) and involves recalling information and forming relationships between pieces of information by organizing it and integrating it from multiple sources (Fantino & Stolarz-Fantino, 2013; Vasconcelos, 2008). More simply put, relational memory is "the ability to make associations between items learned separately" (Lau, Tucker, & Fishbein, 2010). Event information is essentially maintained in a relational memory framework, where individual elements are bound together to form a representation of the event as a whole (Eichenbaum, 2004; Rubin & Umanath, 2015). It is a fundamental property of human cognition and is the flexible ability to generalize across existing stores of information (Ellenbogen et al., 2007). Relational memory appears to develop until around age 6; after that, there is no significant difference in performance accuracy between 6-year-olds and adults (Ngo et al., 2017).

When researching relational memory, a task called stimulus equivalence is often used. Ngo et al. (2017) describe this process as utilizing paired-associates tasks by memory retrieval of co-occurring items that are not technically related to one another outside of being paired for the sake of the task at hand. The American Psychological Association defines stimulus equivalence in the APA Dictionary of Psychology (2018) as “the condition in which two or more related stimuli elicit the same response.” Stimulus equivalence has three parts to be achieved: reflexivity, symmetry, and transitivity. In reflexivity, like stimuli are matched with like stimuli (i.e., A=A). Symmetry involves being able to inversely match two paired stimuli when one display order is taught (i.e., A=B is taught and equivalently, A is chosen when B is displayed as the sample stimulus). Transitivity involves making inferences from taught pairs, where A=B and B=C is taught and C is correctly chosen when A is displayed as the sample stimulus. Dymond & Llewellyn (2019) use the example of learning the spoken word “car” being matched to a picture of a car (A=B). If the picture of the car (B) elicits the response of the spoken word “car” (A), then symmetry was achieved (B=A). If the picture of the car (B) was then also taught to match the written word “car” (C) and the individual was able to match the spoken word “car” (A) with the written word “car” (C) without being taught, transitivity was achieved (A=C) as an untrained, emergent relation.

Lau et al. (2010) found that participants who had the advantage of a nap in their study displayed better relational memory than their counterparts who were not afforded a nap. They concluded that daytime napping seemed to facilitate the formation of relational memories, although they surmised that these findings may be task-specific. Lau et al. (2011) again found that even taking a brief nap may help with the reorganization of “discrete memory traces into flexible relational memory networks” (p. 1). This napping period assisted in task performance irrespective of whether the nap was directly after learning or after a delay. Ellenbogen et al. (2007) found that offline periods, such as the 12-hour post-training sleep used in their study, allowed for relational knowledge to evolve and complex transitively inferred relations to occur across a higher degree of removal in a series of stimuli premise pairs. Several studies also found that sleep periods did not need to be very long to improve working memory. Ruch et al. (2012) reviewed several studies that showed memory retention could be achieved with naps as small as six minutes and de Lange (2016) suggested that a 20-minute nap was beneficial for memory enhancement. Sleep has shown to also influence long-term recollection of information as well. Wagner et al. (2006) found in their study that participants who slept for three hours after reading emotionally themed texts could recall the same information as much as four years later, whereas participants who stayed awake were not able to recall the information three hours after learning it. Not all studies have found sleep to benefit performance in relational memory tasks, however. Dymond & Llewellyn (2019) stated that there was no clear benefit for sleep when faced with a stimulus equivalence task that required a subject to integrate multiple sources of information. Their caveat to this finding was that stimulus equivalence has been under-investigated when regarding relational memory and sleep. Five years later, this still appears to hold true.

The current study wished to add to the sparce research currently in circulation for relational memory and sleep while adding the testing element of stimulus equivalence. Further, there seems to be an additional lack of research regarding the difference between sleep quality and sleep quantity and whether one or both have a significant effect on relational memory, therein producing the purpose of this study. Sleep quantity in the context of this study was defined as the amount of sleep that a participant got, and sleep quality was defined as how good or bad the sleep that the participant got was. It was hypothesized that sleep quality would have more of a significant effect on relational responding as determined through a match-to-sample stimulus equivalence task.

Materials

Participants

Requirements for this study were that participants must be current students at Youngstown State University, able to read, write, and understand English, and be at least 18 years old. Out of 110 total survey attempts, 51 were used in the final analysis. All 51 participants were between the ages of 18 and 24 years old. Participants may have received extra course credit from their individual professors for participation in this study. Students were informed about their right to earn such points through alternative assignments. This project was approved by the Youngstown State University Institutional Review Board (IRB Application Number 2022-141)

Materials

Participants were recruited using the SONA system at Youngstown State University. The response recording software called Qualtrics was used to develop and distribute the survey and raw data was collected from the same. Excel was used to prepare and reduce the data derived from Qualtrics.

Sleep Questionnaire

A self-developed sleep questionnaire was used in this study and consisted of 10 questions. It was based on questions frequently used in various sleep studies. In particular, the Epworth Sleepiness Scale (Johns, 1991), the Sleep-Related Behaviours Questionnaire (SRBQ) (Ree & Harvey, 2004), and the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) were three of the existing sleep surveys that were looked at but ultimately not used in this study. The Epworth Sleepiness Scale was generally vague in comparison to the information that was the target in this study and appeared to be more of a self-diagnostic tool to determine whether an individual should seek medical guidance about potential sleep issues. The SRBQ was not used in this study because it focused more on what types of behaviors individuals were participating in to either promote sleep or to cope with tiredness rather than to determine quality of sleep and therefore also did not fit the target information for this study. The PSQI was a good candidate for use in this study and had similar questions to the self-developed questionnaire in this study; however, this study was being conducted online and the University of Pittsburgh had not yet developed a method of online conversion for administering their survey, ultimately making the PSQI not viable for the needs of this study. There were also concerns that participants may view the PSQI as a diagnostic tool for sleep problems, adding to the final decision to not use the PSQI as an official sleep measure in this study. Questions 1 and 2 were sleep-quantity-based questions and asked the participants to estimate the amount of sleep they achieved overall in the past 24 hours and in the past 7 days. Questions 3 through 10 were sleep-quality-based, inquiring on if the participants achieved their sleep through multiple or singular sessions, the length of time it takes for participants to fall asleep, how they perceive their sleep to be, etc. Questions 1 through 5 and questions 8 through 10 were multiple choice. Questions 6 and 7 were open-ended and required the participant to type their own answer.

Data Collection

Data were collected using Qualtrics. All survey questions were set to randomize in the pre-test, training, and post-test sections. Participants were presented with an informed consent and given the chance to opt out of the study before moving to the demographic questions. Demographic questions were used solely to exclude participants who were not at least 18 years old, able to read, write, and understand English, and current students at Youngstown State University. Participants who did not meet the criteria were immediately taken to the survey's end.

Participants who met the criteria were presented with instructions for the pre-test section and then the pre-test questions. After the pre-test section, participants were given instructions for the training section and then the training questions. Training questions were presented in a way that if the participant answered the question correctly, they were presented with a screen that said “Correct!” in large, green letters and allowed them to move on to the next question. If the participant answered the question incorrectly, they were presented with a screen that presented the question again with a directing statement at the top specifically telling them which symbol correctly matched the sample. Participants were not able to leave the page until they selected the correct answer. After all training questions were completed, participants were made to wait for a mandatory ten-minute delay before being given instructions for the post-test section and then presented with the post-test questions. Participants then moved on to the sleep survey and finally a debriefing that explained the full purpose of the study.

Results

Data Collection and Reduction

There were 110 survey attempts on Qualtrics for this study. Three respondents chose not to participate in the study after being presented with the informed consent. Five were not allowed to participate in the survey and therefore excluded from the study for not meeting the required minimum age. One respondent stated they were not currently enrolled as a YSU student and therefore were not allowed to participate. 33 were repeat-attempts and were excluded from final analysis. One attempt was excluded because the participant had two completed attempts; the first attempt was the one included in the final analysis. 40 of the 110 attempts were incomplete and of those, 31 were excluded in addition to the previously mentioned excluded attempts. Two attempts were excluded because that participant began the training portion in their first attempt but did not complete the entire survey before attempting a second survey, effectively tainting the second survey's data. Of the 110 survey attempts, 51 were used in the final analysis.

After data collection, survey record reports were downloaded to prepare for data analysis. Participant IDs and answers were recorded in an Excel spreadsheet which was then used to interpret coding that Qualtrics used in the exported data files to identify selected answers by participants. Eight participants did not have an associated ID number nor a record report to download. The interpretation of the coded data was used to retrieve participant responses in those instances where there was no record report in Qualtrics. Quality checks for accuracy were done by decoding the data in 3 separate Excel spreadsheets. Participants' answers to questions were recorded as 0s and 1s with 0s being used for incorrect answers and 1s being used for correct answers. This was done in preparation for using analysis software such as SPSS or JASP. In some instances, a question was presented to the participants but an answer was not recorded and Qualtrics allowed the participant to move forward in the study. These questions were treated as incorrect responses in calculations and analysis but coded separately as 9s in the Excel spreadsheets. Data sets were then reduced to only those that completed the entire study and participants who met the required demographics to participate. If a participant made several attempts at the survey, only the first completed survey attempt was used and the remaining data sets were excluded. Data was also excluded if a participant began a survey attempt, began the training portion of the survey, and did not complete the survey. Any subsequent attempts were considered to be tainted since the participant had begun the training portion resulting in their pre-test data in subsequent attempts being the result of exposed rather than unexposed experience with the stimuli.

Data Preparation

Prior to the final analysis of data, several preparatory calculations were necessary.

Sleep Questionnaire

The sleep questionnaire given to participants at the end of the study was scored on a Likert-type scale with the most ideal answer being given a 0-value and the least ideal answer being given a 4-value. Question 7 was the only exception to this rule, where an answer that disclosed no diagnoses or disorders being present was given a 0-value and an answer that did disclose a diagnosis or disorder was given a 1-value. Answers for quantity of sleep were scored based on research for the recommended amount of sleep for adults. Answers for participants' average time to fall asleep were compared to the average time obtained from research. A percentage value was obtained by dividing the participants' average time to fall asleep by the national average time to fall asleep. Values between 0 and 1 were given a 0-value. Those that were greater than 1 and up to 2 were given a 1-value. Values greater than 2 up to 3 were given a 2-value. Those greater than 3 up to 4 were given a 3-value. All values that were greater than 4 were given a 4-value. Sleep quantity Likert values were then added together for a total sleep quantity score. The same was done for the sleep quality Likert values. The total sleep quantity and sleep quality values were used in the final analysis of data.

Pre-Test and Post-Test Scores for Relational Responding

Pre-test and post-test totals were taken for each participant being used in the final analysis by adding the number of questions answered correctly for each test. Totals for correct answers on questions testing symmetry and transitivity were also obtained, but not analyzed.

These totals were then converted to percentage values by dividing the number of questions answered correctly by the total number of questions for each test, which was 90. The percentage values were used in the final analysis of the data.

Table 1

DESCRIPTIVE STATISTICS OF SLEEP QUANTITY, SLEEP QUALITY, AND THE DIFFERENCE

	SLEEP_QUANTITY	SLEEP_QUALITY	Difference
VALID	51	51	51
MISSING	8	8	8
MEAN	0.941	6.431	0.339
STD. DEVIATION	0.925	3.523	0.186
MINIMUM	0.000	1.000	-0.033
MAXIMUM	4.000	16.000	0.722

Descriptive Statistics

All participants (N=51) were given a sleep questionnaire containing two questions about perceived sleep quantity and eight questions about perceived sleep quality. Table 1 shows descriptive statistics for total scores on sleep quantity (M=0.941, SD=0.925, n=51), sleep quality (M=6.431, SD=3.523, n=51), and the difference between the two (M=0.339, SD=0.186, n=51). Sleep quantity had a maximum achievable score of 8.0 and sleep quality had a maximum achievable score of 29.0, with lower scores on each signifying a higher quantity or quality of sleep. Minimum and maximum scores were recorded for both sleep quantity (minimum=0.00, maximum=4.0) and sleep quality (minimum=1.00, maximum=16.00) using an interval scale. Distribution plots show scores falling on the lower end for both sleep quality and quantity and distributed in the middle for the difference between the two. As these plots show an approximately normal distribution, the use of inferential statistics is justified.

The data were analyzed for a correlation between the self-reported sleep quantity and sleep quality scores using both Pearson (r=0.063, p=0.660) and Spearman (rho=0.089, p=0.553) analyses. A lack of significance ($p>0.05$) on both tests shows that there was no correlation between scores achieved on the sleep quantity and sleep quality scales, indicating that the variables are independent of each other and scores for one variable had no effect on the other.

Table 2

Correlation between sleep quantity and sleep quality

		Pearson		Spearman	
		r	**p**	**rho**	**p**
SLEEP_QUANTITY	- SLEEP_QUALITY	0.063	0.660	0.089	0.533

Note: The lack of significance shows that there is no correlation between sleep quantity and sleep quality

This was a prerequisite step prior to running the linear regression models for both variables.

A one sample t-test was also conducted to show that there was a significant change between the pre-test and post-test scores. The difference between the two (t=13.035, p<.001) showed significance, indicating that the training portion was effective in improving participants' pre- to post-test scores.

Regression Model

The perceived sleep quality and sleep quantity scores were entered as predictors in a linear regression analysis with the difference score as the outcome measure for relational responding. The ANOVA showed that the overall regression model was significant (SS=0.215, df=2, MS=0.107, F=3.411, p=0.041) with the null model including both sleep quantity and sleep quality. The overall model being significant indicates that the model fits the data well. Descriptive statistics were also run for the linear regression model to determine the amount of covariance accounted for (R^2=0.124, adjusted R^2=0.088). This means that approximately 12% of the variability was accounted for by the variables in the model.

Each of the predictors were examined for their contribution to the overall model. This analysis revealed that although the self-reported sleep quality statistics (t= -1.398, β= -0.189, p=0.169) did not show significance, participants' perceived sleep quantity (t= -2.113, β= -0.286, p=0.040) did. This indicates that the sleep quantity reported by participants affected their performance during this study.

Discussion

Sleep has many implications on an individual's life, from biological consequences to mental health issues to memory impairments. Many college-aged people are not getting the recommended amount of sleep, whether it be from a full class load, technological addiction, caffeine consumption, or poor time management. This study sought to determine if sleep quantity and sleep quality had effects on relational responding, and through a stimulus equivalence-like match-to-sample task, it was discovered that self-reported sleep quantity did in fact significantly effect participants' performance on the relational responding task. Sleep quantity versus sleep quality in effectiveness against relational responding has very little, if any, research conducted and thus, this study serves as a steppingstone to future research on the subject.

Implications

Research is only as good as the populations it can serve. So, what are the implications of determining whether sleep quantity or sleep quality have an effect on relational responding? With sleep quantity rather than sleep quality being significant in its effect on relational responding tasks, organizations can focus on ensuring that the populations it serves are getting the recommended amount of sleep before tackling the issue of getting better quality sleep. College students are one such group that could greatly benefit from this focus. Studies have shown time and again that college students are simply not getting enough sleep. This affects their schoolwork which ultimately affects their grades. It also affects how much they learn while in class and how much of that information is retained. A person cannot expect to adequately perform a job that they are trained for if they cannot retain new information that is taught to them and form proper inferences in the absence of direction. Although minimal at this point in time, there are several collegiate organizations focusing their energy on ensuring college students achieve a workable amount of sleep through “nap stations.” Chant (2014) discusses University of Michigan’s move towards sleep hygiene with its students. They opened a napping station in Shapiro Library in 2014, providing cots to sleep on and lockers for students’ belongings to keep them secure. Shortly thereafter, the cots were replaced with MetroNaps Energy Pods. These provided a semi-reclining feature, a curved privacy shield, music, and gradual awakening via sound, lights, and vibrations (Draplin, 2014). A few other universities have also followed suit including Washington State University, who opened the Nap Zone in the Chinook Student Center in 2017. The Nap Zone, like University of Michigan’s nap station, offers nap pods and recliners for student use (“Chinook Student Center first floor opens,” 2017). Aside from offering nap stations, research on an adolescent’s shifting circadian rhythm has prompted some school districts to follow suit and shift their schedules. Edina School District in Minnesota delayed the start of their school day which resulted in higher test scores with students (Dement & Vaughan, 1999). The Deerfield Academy in Massachusetts also chose to delay the start of the school day by 35 minutes. They saw a reduction in illnesses, increased breakfast consumption, and a significant increase in GPA (Pope, 2012). These examples show that altering lifestyles to better suit sleep-needs have proven successful.

College students are not the only group that could significantly benefit from the implications of research such as this study. Children with Autism Spectrum Disorder (ASD) often suffer from sleep problems as well. In Ashraf et al. (2022), a majority of children with ASD that participated in the study suffered from some degree of sleep problem over varying periods of time. Jamiol-Milc et al. (2021) showed over 40% of the study group as having insomnia as a comorbidity to ASD. The research on children with ASD and sleep problem comorbidities is extensive. Children with ASD also may participate in some type of behavior therapy such as Applied Behavior Analysis, and in these behavior therapy sessions, they may be exposed to relational responding tasks such as stimulus equivalence match-to-sample tasks. With the research on the prevalence of sleep problems in children with ASD combined with the research conducted on how sleep (or lack therefore) affects relational responding performance, it seems prudent that professionals in the behavioral field encourage families and caretakers to focus on these sleep issues. If the importance of treating sleep issues is not prioritized, it may affect the subject's ability to perform long term on relational memory tasks.

Limitations

Several limitations existed within this study. Being unable to manipulate the amount of sleep that subjects get was a shortcoming in the study and resulted in a majority of participants falling near one end of the sleep quantity curve. Limited demographic information was taken from participants to protect their privacy and identity as much as possible, so differences in gender or culture were not able to be taken into account. Cheung et al. (2021) found in their study that cultural differences may not make a difference in the amount of sleep that a person gets, however. The Japanese-Canadians tended to acclimate to the cultural norms in the local area when it came to sleep duration, so even those from other cultures may report similar numbers to native cultures.

The time of day that participants took the survey and whether it was immediately post-sleep or after a sleep-delay was another thing that was not able to be controlled with the online environment of the study. Several studies refute the possibility of the time of day having an effect, however. Ellenbogen et al. (2007) found offline periods containing sleep were beneficial regardless of the circadian test time. Similarly, although Tandoc et al. (2021) found a time-of-day effect in Experiments 1 and 3, they did not find such an effect in Experiment 4 with the Morning group and, overall, they were unable to replicate the time-of-day effect.

With the survey being conducted online, it was also difficult to monitor participants as they completed the study. Participants' attending to the task at hand was not able to be controlled, nor was their ability to take notes and essentially "cheat" through the training and post-test sections of the survey. Online surveys also heavily rely on reliable internet connections which were not able to be controlled here.

Lastly, the study was not conducted in a sleep lab, monitoring devices were not used, and sleep was self-reported by participants. This means that information collected in the sleep questionnaire was simply perception and not necessarily accurate. People perceive that their sleep was of good quality but in reality, they were restless or woke up several times throughout the night. This could also affect the quantity of sleep they are actually getting. The self-reported nature of the questionnaire does not necessarily negate the findings of this study but should be taken into consideration when citing the results.

Future Research

Because this study was a novel research topic, there are many avenues for future research. Suggestions on modifications for the current study would include conducting the study in person rather than online, using the PSQI in lieu of the self-developed sleep questionnaire, using a tracking tool for sleep such as a Fitbit or Apple Watch, and pooling a larger sample of participants. There are also several additional calculations with the data collected in this study that could be made as well as improvements on the questionnaire via clarification or additional questions. Such calculations include: 1) determining whether symmetry and transitivity were achieved, 2) ensuring mastery is achieved in the training phase before allowing participants to move on to the post-test phase, 3) calculations in post-test performance in those that achieved mastery versus those that did not, 4) splitting the participants into 4 groups (good quantity/quality, good quantity/bad quality, bad quantity/good quality, bad quantity/quality) instead of the current within-subjects calculations determining if sleep quantity or sleep quality was a better predictor of performance, and 5) calculating if there was a difference in performance between those that reported multiple sleep sessions and those that did not.

There are also opportunities to expand on existing research by combining the idea of sleep quality versus sleep quantity with other concepts already being studied such as dividing participants into two groups and having one conduct the survey in the morning and the other conduct it in the evening. Lastly, an idealistic study similar to this current study would involve manipulating the amount of sleep and the quality of sleep that subjects get to control for all aspects of the research.

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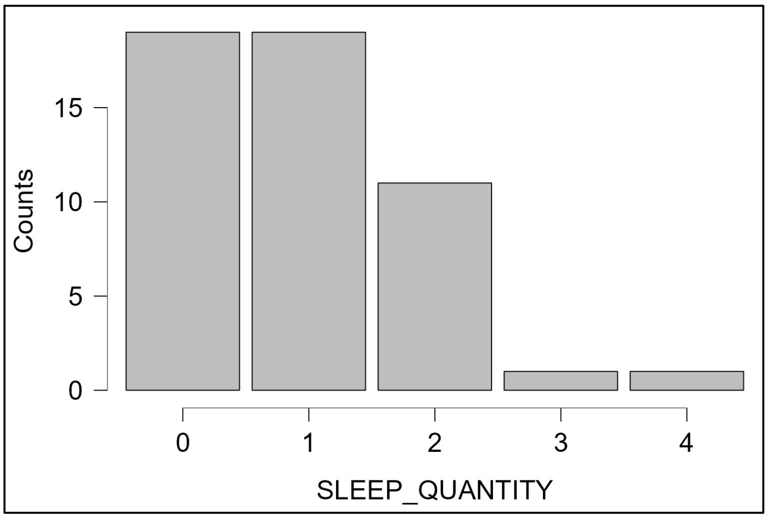
Appendix 1. Tables and Graphs

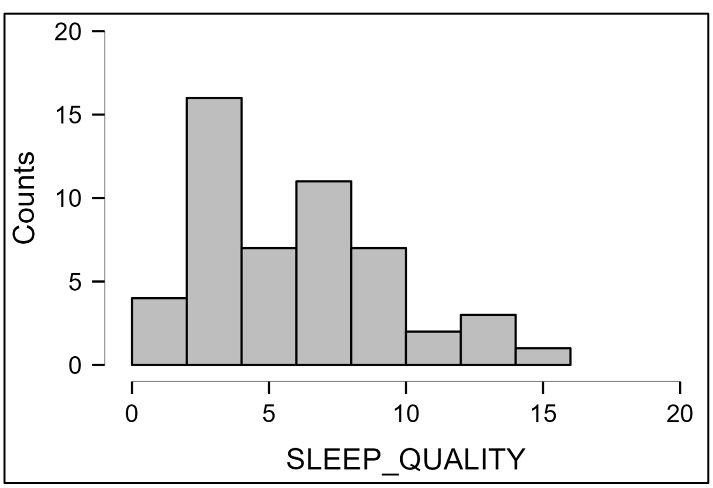
Graph 1

Sleep quantity distribution graph



Graph 2

Sleep quality distribution graph



Graph 3

Distribution between sleep quantity and sleep quality difference

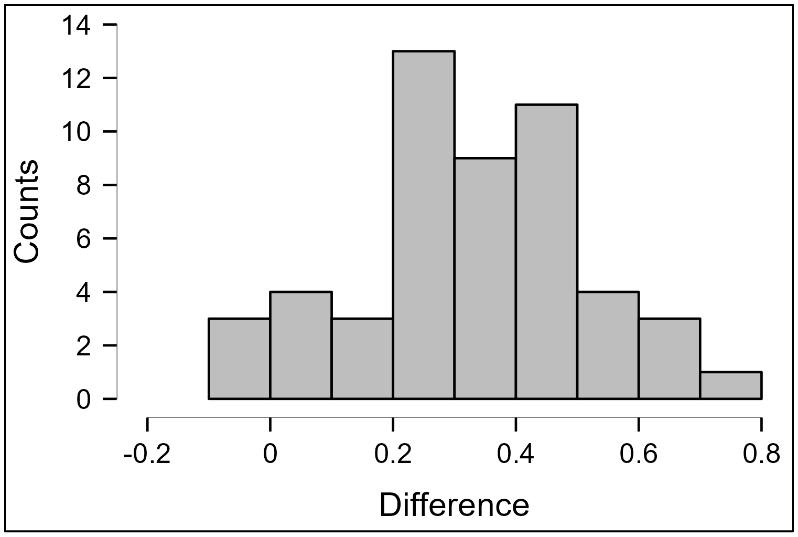


Table 3

Linear regression summary of difference

Model Summary - Difference				
Model	**R**	**R^2**	**Adjusted R^2**	**RMSE**
H_0	0.000	0.000	0.000	0.186
H_1	0.353	0.124	0.088	0.177

Table 4

One-way ANOVA for the difference between covariates

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**p**
H_1	Regression	0.215	2	0.107	3.411	0.041
	Residual	1.510	48	0.031		
	Total	1.725	50			

Note. **The intercept model is omitted, as no meaningful information can be shown.**

Table 5

Linear regression coefficients for sleep quantity and sleep quality

Coefficients

							Collinearity Statistics	
Model		**Unstandardized**	**Standard Error**	**Standardized**	**t**	**p**	**Tolerance**	**VIF**
H_0	(Intercept)	0.339	0.026		13.035	< .001		
H_1	(Intercept)	0.457	0.057		8.047	< .001		
	SLEEP_QUANTITY	-0.057	0.027	-0.286	-2.113	0.040	0.996	1.004
	SLEEP_QUALITY	-0.010	0.007	-0.189	-1.398	0.169	0.996	1.004

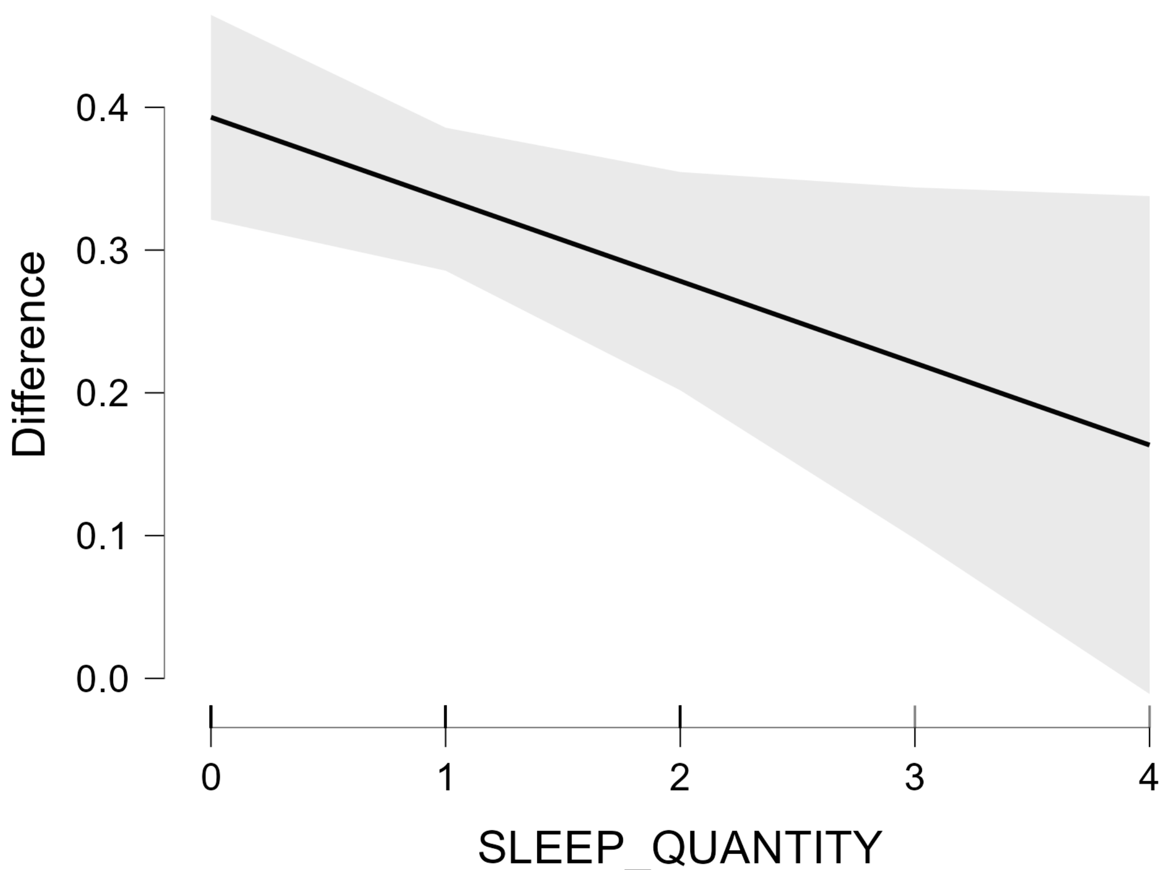
Table 6

Descriptive statistics for linear regression of covariates

Descriptives				
	N	Mean	SD	SE
Difference	51	0.339	0.186	0.026
SLEEP_QUANTITY	51	0.941	0.925	0.130
SLEEP_QUALITY	51	6.431	3.523	0.493

Graph 4

Marginal effect of sleep quantity on the difference



Graph 5

Marginal effect of sleep quality on the difference

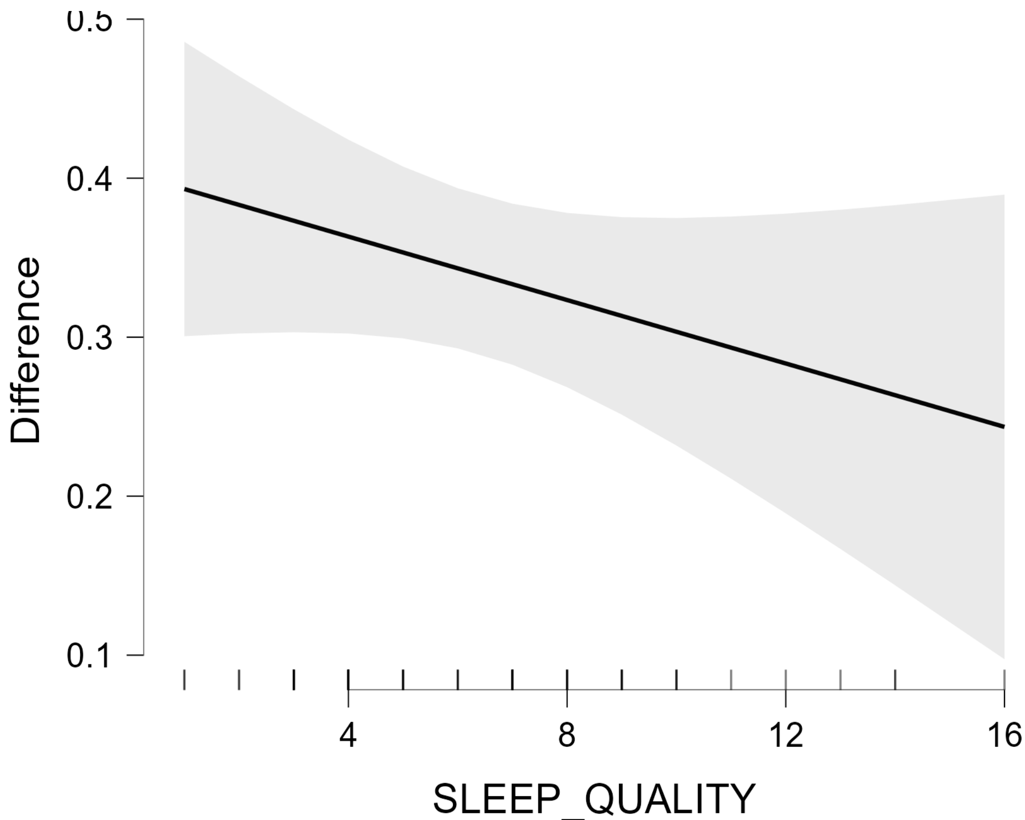


Table 7

One sample T-test of the difference

	t	df	p
Difference	13.035	50	< .001

Note. For the Student t-test, the alternative hypothesis specifies that the mean is different from 0.

Note. Student's t-test

Appendix 2. Figures

Figure 1

Sleep Characteristics Questionnaire

1. How many total hours of sleep did you get in the past 24 hours?
   a. Over 9 hours
   b. 7-9 hours
   c. 5.5-7 hours
   d. 3.5-5.5 hours
   e. Less than 3.5 hours

2. How many hours of sleep did you get, on average, per day over the last week?
   a. Over 9 hours
   b. 7-9 hours
   c. 5.5-7 hours
   d. 3.5-5.5 hours
   e. Less than 3.5 hours

3. On most days, do you get all of your hours of sleep at once or are they broken up into several "naps"?
   a. I get my sleep all in one session.
   b. I get my sleep in multiple sessions; one in the morning and one in the evening.
   c. I get my sleep in multiple sessions; one in the morning and one in the afternoon.
   d. I get my sleep in multiple sessions; one in the afternoon and one in the evening.
   e. I get my sleep in more than 2 sessions per day.

4. How do you perceive the quality of your sleep to be, on average?
   a. My sleep is great! I sleep the entire night with no tossing and turning or waking up.
   b. My sleep is pretty good! I wake up once or twice and/or toss and turn occasionally.
   c. My sleep is ok. I am asleep more than half the night but often wake up and/or toss and turn.
   d. My sleep isn't that good. I spent most of the night awake and/or tossing and turning.
   e. My sleep is terrible! I get little to no sleep and/or toss and turn all night.

5. Over the past month, how often do you believe you have had trouble falling asleep or staying asleep?

a. Every night
b. Most, but not all, nights
c. About half of the nights
d. A few nights
e. Not at all

6. Approximately how long does it take for you to fall asleep once you lay down to do so?

7. Have you ever been diagnosed with, or do you or a doctor suspect that you have, a sleeping disorder of any kind? What is it?

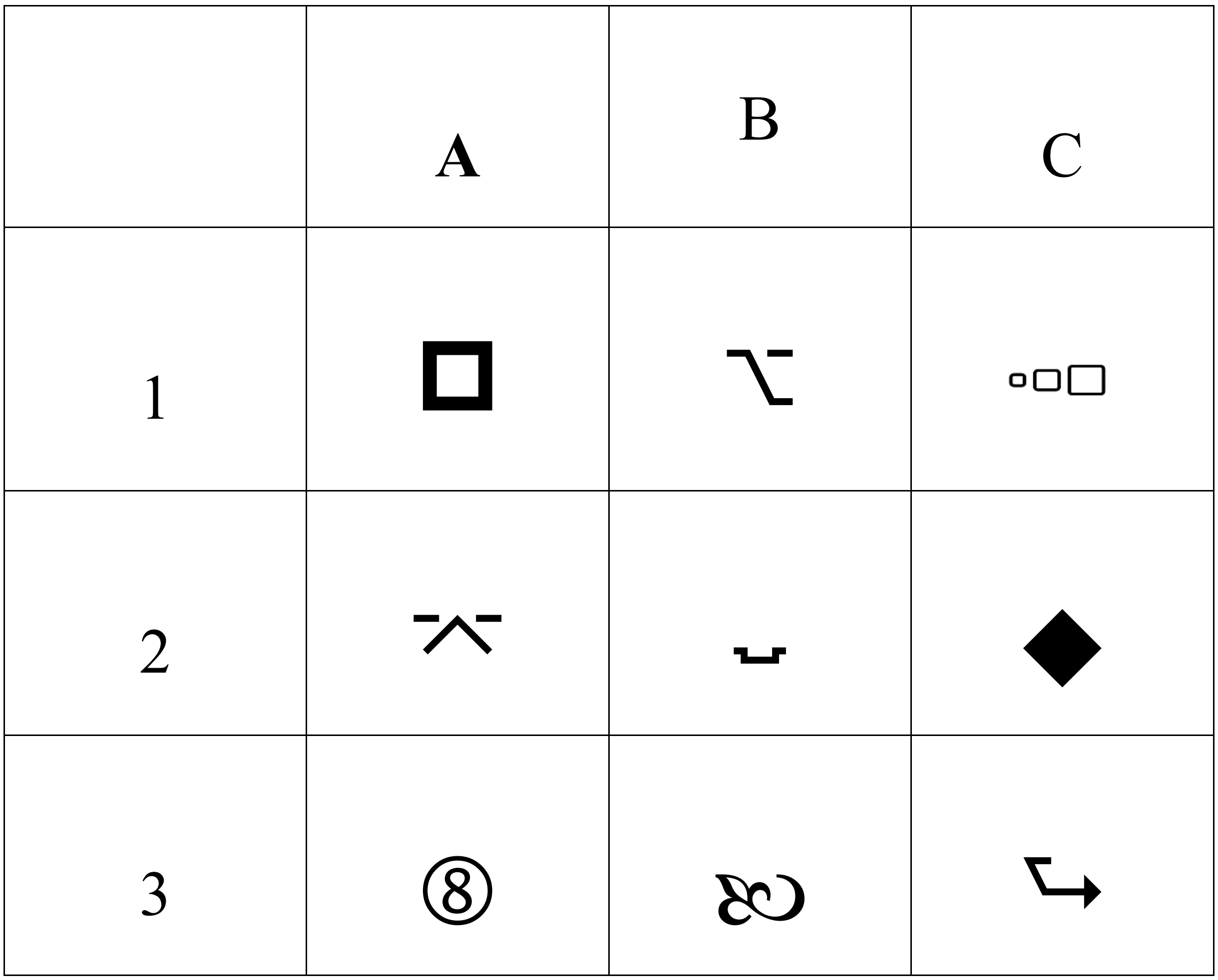
8. Do you feel refreshed in the morning after sleeping at night? How often?
   a. No, never.
   b. Yes, but rarely.
   c. Yes, about half the time.
   d. Yes, most of the time.
   e. Yes, all of the time.

9. Do you take doctor-prescribed sleep aids? If so, how often?
   a. I do not take doctor-prescribed sleep aids.
   b. Yes, less than twice a week.
   c. Yes, 2-4 times a week.
   d. Yes, 5-6 times a week.
   e. Yes, every night.

10. Do you take legal over-the-counter sleep aids? If so, how often? (Please do not disclose any illegal sleep methods or those not specifically designed for sleep such as alcohol, marijuana, or other medications not designed for sleep but that may cause drowsiness such as Benadryl, cough medicines, etc. regardless of if you use them to sleep.)
    a. I do not take over-the-counter sleep aids.
    b. Yes, less than twice a week.
    c. Yes, 2-4 times a week.
    d. Yes, 5-6 times a week.
    e. Yes, every night.

Figure 2

Match-to-sample pairs



Date: 4-20-2024

IRB #: 2022-141
Title: The Effects of Self-Reported Sleep Characteristics on Relational Responding
Creation Date: 3-7-2022
End Date:
Status: Approved
Principal Investigator: Jeffrey Coldren
Review Board: YSU IRB Board
Sponsor:

Study History

Submission Type	Initial	Review Type	Exempt	Decision	Exempt
Submission Type	Modification	Review Type	Exempt	Decision	Approved

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