JOURNAL OF SECONDARY PSYCHOLOGICAL STUDIES

VOL. 2 ISSUE 1

Table of Contents.

Staff.

Editor in Chief

Jake Stoller

Submission Editor

Kate Weseley-Jones

Content Editors

Feyi Rufai

Gabby Fries

Sophie Fries

Ariana Matarangas

Copy Editors

Andrew Goldberg

Nicole Blattman

Sam Jacobson

Letter from the Editor.

Dear Readers,

The editorial board of the *Journal of Secondary Psychological Studies* is proud to present the second edition of our publication. Despite the difficulties caused by COVID-19, our team has persevered and conducted comprehensive revisions to produce a quality edition.

After such wonderful feedback from our first edition last year, we were excited to find that our reach had broadened and that submissions came from high schools across Long Island as well as one from New York City. This year's submissions were remarkable, which only made our selection process more difficult. It is truly incredible what these students were able to accomplish and goes to show that meaningful research does not need a well-endowed lab, just a curious mind and a hunger for knowledge.

This year's edition is unique as all of the studies included happen to be pertinent to the lives of high schoolers, ranging from how wearing your favorite hoodie might shape perceptions of you to the cost of sleep deprivation. We hope that this publication will not only enlighten students across New York, but also encourage them to join their fellow students in the pursuit of knowledge through psychological research.

Thank you to all the students out there who have joined us in the pursuit of answers and innovation in the field of psychology. We hope that you continue these pursuits and continue to empower students all around the world to leave their mark in academia.

Jake Stoller

Editor in Chief

Hoodies or Hoodlums?

An Investigation of Hoodies on the Perception of Character

Alyssa Dioguardi, Wellington C. Mepham High School

alystar5@verizon.net

Abstract

The everyday effects of stereotyping are frequently discussed by social and behavioral psychologists, and the purpose of this study was to evaluate the effect of clothing on perception. More specifically, this study tested the hypothesis that a preexisting stigma associated with hoodie wearing facilitates biases in judgement. Participants were presented with one of four image sets–hooded male, unhooded male, hooded female, and unhooded female–and were asked to address the personality, behavior, and future goals of the displayed individual in a short paragraph. Pennebaker's Linguistic Inquiry Word Count (LIWC), an online linguistic analyzer, was employed to justly quantify participants' responses. The program enabled the creation of terminology dictionaries separating utilized language into categories of education/career, illegal/socially rejected behavior, and sports terminology. LIWC analyzed responses and calculated the percentage of descriptors from each category as a function of the total word count of each response. Results from an ANOVA across all conditions indicated a significant difference in the usage of illegal descriptors when comparing hoodie and non-hoodie responses ($p<.01$). A one-way within -group ANOVA revealed significant usage of education/career descriptors when presented the unhooded female image ($p=.001$). A one-way within- group ANOVA supported significant usage of sports terminology when presented the unhooded male image ($p=.001$). The results of this study demonstrated that hoodie wearing plays a role in precipitating negative first impressions from others as well as surfacing potential biases toward the perception of contrasting genders.

Keywords: *bias, character, apparel, adolescents*

Introduction

Mom always says, "Don't Judge a Book by Its Cover," but is it inevitable? The average person interacts with approximately 3 people daily, 800,000 in a lifetime, and will encounter thousands in passerby (Vital, 2013). If it is true that a judgement can be made as quickly as 100-ms of exposure, as supported by Princeton psychologists Janine Corinth Willis and Alexander Sunnyvale Todorov (2006), it seems undeniable that this old proverb stands to address some general truth.

Resulting from the relevancy of first impressions in everyday life, researchers of various sciences have attempted to explain their occurrences and the elements that come into play during their formation. From an evolutionary standpoint, the ability to make quick judgements in situations may exist as a survival mechanism to protect an individual from a perceived threat.

Charles Darwin asserts that those most fit for survival live longer and therefore have more time to reproduce and pass on beneficial traits to successive generations (Darwin, 1859). Being able

to identify potential threats allows an individual to avoid confrontation with something harmful (Gibson, 1966). In terms of human nature, being able to identify cues of trustworthiness or lack thereof at first glance can aid an individual in making positive relationships and avoiding others with more ill-natured aspirations (Schaller, 2012).

Psychologists have also weighed in on the issue. It appears that the majority of experts in the field are in agreement that the facial appearance of an individual plays a crucial role in other's' initial perception of their his/her personality and characteristics. For instance, psychologist Frank Schab asserts, "it only takes the duration of an eye blink to size up another person in terms of attractiveness and trustworthiness." Over the next three seconds, we form a more "'complete"' conclusion about a new acquaintance relating to his/her presumed personality and competence. His writing further references the impact of the halo effect on what he referred to as "snap judgements." The halo effect is the tendency of an impression in one area–in this case physical attractiveness–to influence a similar impression in another area–in this case personality. Though it's controversial how accurate a first impression could be, with some papers supporting their accuracy and others rejecting it, it appears evident that first impressions do exist and do have a tendency to stick.

It is hard to pinpoint the exact causes of a first impression, but researchers have attempted to identify significant contenders. Gibson (1972) viewed perception as a bottom-up process, defining an impression as simple sensory information analyzed into a more complex neural understanding. In a later study, Little et al. (2011) specifically focused on the sensory input of facial symmetry and physical attractiveness and concluded that the more beautifully perceived a face was, the more favorable the person was to participants. Howlett et al. (2013) further investigated the impact clothing choices had on the wearer's first impression and found that minor changes in attire can dramatically affect perceived inferences and impressions. A few years later, Civile and Obhi (2017) studied clothing impact on a much grander scale when they conducted a study to see if students wearing police uniforms showed biased attention toward different faces, ethnicities, and the presence of a hoodie on an individual. Surprisingly, their study showed little to no statistical significance differentiating different faces or ethnicities, but rather showed a bias towards hooded individuals. This may have something to do with representative heuristics, or mental shortcuts in which some decisions are made by comparing newly acquired information to preexisting mental prototypes. Both Bawdon (2009) and Gatersleben (2013) found that the word "hoodie" is associated with negative connotations and criminal activity, likely through media portrayals and stereotyping. This further ties in with the tragic death of 17-year-old Trayvon Martin back in 2012. As detailed in Erynn Masi de Casanova and Curtis L. Webb Ⅲ's "A Tale of Two Hoodies" (2017), Trayvon Martin wore a dark gray hooded sweatshirt on his way home from a nearby convenience store when he was shot and killed by a local neighborhood watchman, George Zimmerman, who wrongly suspected that Trayvon was involved in recent bank robberies. People, including TV personality Geraldo Rivera, speculated that the hoodie was to blame for Trayvon's death, and though Rivera's remarks were controversial and were later retracted in a heartfelt apology, this anecdote may be explained by the theory described thus far (Geraldo Rivera, 2012).

The goal of this study seeks to analyze if the presence of a hoodie increases an individual's negative bias in a first impression due to stereotypes based off of preexisting representative heuristics since it appeared that the term "hoodie" carried a negative stigma (Nguyen, 2015). The hypothesis stated that an individual wearing a hoodie would be perceived as more likely to be involved in illegal or socially rejected behavior than hoodless individuals, and the goal of the study

was to see if a simple fashion trend could have detrimental impacts on how others perceived the wearer.

Method

Participants

Participants in this study included 144 students at a suburban, middle class high school in New York. Participants included 86 females and 58 males between the ages of 15 and 18 and all participants in this study were volunteers. Volunteers were recruited through their science classes, and participation did not include incentives or renumeration.

Materials

Informed consent forms were used containing information about procedures, benefits and risks of participating, voluntary participation, and contact information of the researchers. The purpose of this study was clearly explained on the consent form. Throughout the entirety of this study, participants were kept anonymous, and one could only participate after returning a completed participant agreement form. Participants were also able to withdraw their consent and participation at any time during the study. Participants were presented with a brief post-study questionnaire, which collected demographic information, such as age and ethnicity, and presented a 5-point Likert scale asking how often they wear hoodies in their daily life, and when wearing a hoodie, how often they wore them with the hood up. This data was not analyzed statistically but was used to look for the presence of hoodies in current teen fashion. Pennebaker's Linguistic Inquiry Word Count software and Excel Spreadsheets were used to analyze participant responses.

Procedure

This study required the development of four unique image sets–male wearer with hoodie, male wearer without hoodie, female wearer with hoodie, and female wearer without hoodie–with the hoodie conditions as the experimental groups and the no-hoodie conditions existing as a control. To avoid a confounding variable between experimental and control groups, the same male was used to generate both the hoodie and no-hoodie male conditions, and the same female, respectively, as depicted by figure 1. The male and female utilized in the images are of a similar age, ethnicity, and were both asked to wear gray clothing in the images. The four image sets were labeled with the male no-hoodie condition as scenario 1, the male hoodie condition as scenario 2, the female hoodie condition as scenario 3, and the female no- hoodie condition as scenario 4, and the image sets were formatted on separate slides of a Google Slide presentation.

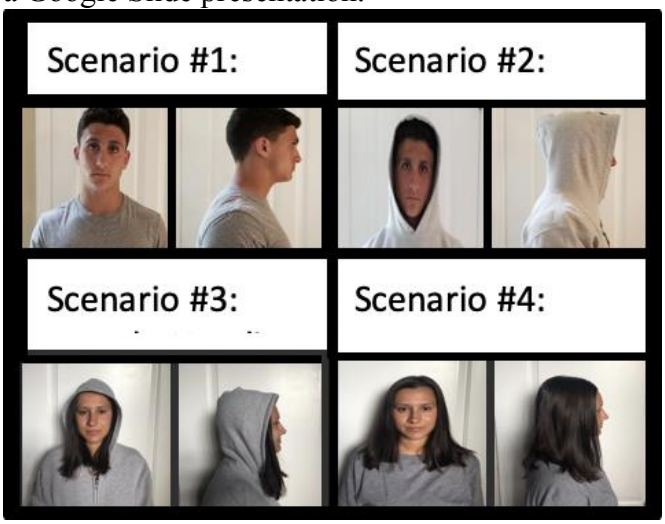

Figure 1. Image Sets Employed

Each participant was given a scenario number and response number to label their work throughout the study. They were randomly assigned one of the four scenarios to respond to and were presented with the same set of directions, which allotted ten minutes for the participant to create a backstory for the individual in the presented image set. Participants were asked to write a synopsis addressing their perception of the presented individual's personality, behavior, and future goals, and recorded their responses in a Google® Doc unique to their survey identifying code during the time given.

After the data collection, three general categories were created and clear-cut terminology was assigned to each of the three categories: education/career terminology, illegal/socially rejected terminology, and sports terminology. To reduce bias while producing this terminology dictionary, words or phrases were only added if they belonged to the category by definition: education/career terminology included career titles and university names, illegal/socially rejected terminology included activities that would result in disciplinary action in schools (Juuling, smoking, underaged drinking), or legal offenses (crimes, robbery, killing, stealing), and sports terminology included terms like athletic and specific sports names.

Pennebaker's Linguistic Inquiry Word Count software, or LIWC, was used to fully analyze the terminology within participants' responses. The terminology dictionary was uploaded to LIWC and, one at a time, each scenario's language was analyzed by the program. LIWC calculated the percentage of language used in each category out of the total word count of each individual response. For example, if 10 words in a 100-word response referenced illegal/socially rejected behavior, 10% of that response focused on illegal/socially rejected behavior. The analyzed information was added to Excel Spreadsheets so graphs and tables could make sense of listed data sets.

Results

Participants responded to one of four scenarios: 37 students responded to scenario 1 (male no—hoodie), 37 participants responded to scenario 2 (male with hoodie), 35 participants responded to scenario 3 (female with hoodie), and 35 participants responded to scenario 4 (female no—hoodie). Table 2 represents the mean number of "illegal or social rejected" terminology as described by participants across each of the four scenarios. The main terminology category analyzed in this study was the occurrence of illegal/socially rejected vocabulary in participants' descriptions.

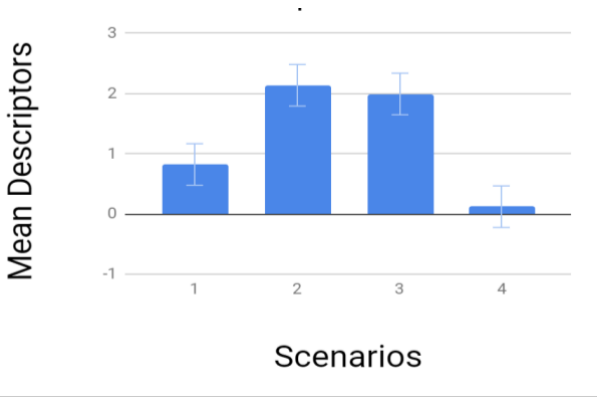

Figure 2. SEM Illegal/Social Rejected Descriptors

Figure 2 indicates that the mean (*M)* number of "illegal" descriptors were greatest for images shown with hoodies (scenario 2 and 3) regardless of image gender. A one-way between-subjects ANOVA was conducted to compare the effect of hoodies on participant usage of "illegal" terms in their descriptions. Results from the ANOVA indicate that there was a significant difference in usage of illegal descriptors when comparing hoodie and non-hoodie images $F(3, 144) = 9.05$, $p<.01$

Table 1 also contains the mean (*M*) number of words recorded for each descriptor when the image shown was a male wearing a hoodie. The results indicate that males with hoodies were more frequently associated with "illegal" descriptors when compared with "career" or "sports" descriptors. A one-way ANOVA revealed a significant difference between each categorical group descriptor, $F(2, 37) = 8.91$, $p < .001$.

In addition, Table 1 identifies the mean differences in terminology used when the image was a female, wearing a hoodie. The results indicate that females with hoodies were more frequently associated with "illegal" descriptors when compared with the two other categories. The effect of "hoodie" was statistically significant

between each categorical group, $F(2, 35) = 5.541$, $p = .005$.

To further examine the data, independent-samples t-tests were conducted to compare differences of male and female participants' usage of "illegal" terminology depending on whether they were viewing a female or male with a hoodie image. Tables 2 and 3 illustrate the results of a t-test when participants viewed the "female with hoodie" image. There was a significant difference in the usage of "illegal" descriptors by both male and female participants when viewing a female hooded image; female participants (M=1.22, SD 2.60), male participants (M=3.15, SD 3.04); $t(33)=2.05$, $p=.048$.

Participant Gender	*N*	*M*	*SD*
Female	21	1.22	2.60
Male	14	3.15	3.04

Table 2. Gender Participant Terminology Viewing Hooded Female Image

t	*Df*	*P one-tailed*	*P two-tailed*
2.05	33	0.0241895	0.048379

Table 3. T-Test for Gender Participant Terminology Viewing Hooded Female Image

An additional t-test was performed investigating the frequency of "illegal" descriptor usage by participants when viewing a male hoodie image. The results of this test did not reveal a statistically significant difference when comparing participants by gender. Female participants had a mean equal to 2.44 (SD = 2.26) while male participants had a mean equal to 1.56 (SD =1.56), $t(33) =1.36$, $p = 0.18$.

Categorical descriptors related to "careers and education" were statistically analyzed between the four image scenarios. Table 1 highlights the mean usage of education/career vocabulary as well as the number of participants in each group. Each of the calculated means and SEM are highlighted in figure 3.

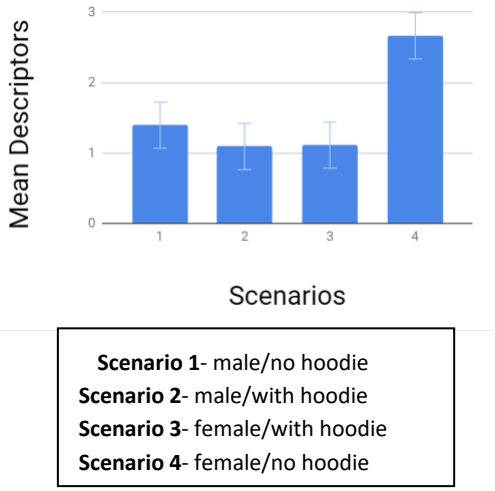

Figure 3. Mean "Career and Education" Descriptors All Conditions

A one-way between-subjects ANOVA was conducted to compare the effect of hoodies on participant usage of "career and education" terms in their descriptions. Results from the ANOVA indicate that there was a significant difference in usage of these descriptors when comparing hoodie and non-hoodie images $F(3, 143) = 5.57$, $p=.001$.

The data in table 1 also contains the mean number of words recorded for each descriptor when the image shown was a female not wearing a hoodie. The results indicate that females without hoodies were more frequently associated with "education/career" descriptors when compared with the two other categories. A within-subjects ANOVA revealed a significant difference between each categorical group, $F(2, 35) = 26.99$, $p < .001$.

An independent-samples t-test was conducted to compare differences between male and female participants' usage of "career/education" terminology for the no-hoodie female image. The results of the t-test did not reveal statistical significance. Female participants had a mean equal to 2.70 (SD = 2.33) while male participants had a mean equal to 2.30 (SD =2.19), $t(34)=0.63$, $p = 0.53$.

Categorical descriptors related to "sports" were statistically analyzed between the four image scenarios. Table 1 reports the mean usage of "sports" vocabulary as well as the number of participants in each group. Each of the calculated means and SEM are highlighted in Figure 4.

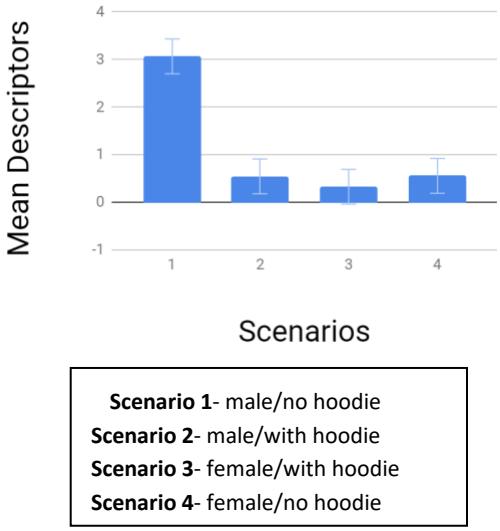

Figure 4. Mean "Sports Descriptors Across All Conditions

A one-way between-subjects ANOVA was conducted to compare the effect of hoodies on participant usage of "sports" terms in their descriptions. Results from the ANOVA indicate that there was a significant difference in usage of "sports" descriptors when comparing hoodie and non-hoodie images, $F(3, 143) = 17.34$, $p<.0001$. The frequency of "sports" descriptors was most prevalent in the male with no-hoodie image.

The data in table 1 contains the mean number of words recorded for each descriptor when the image shown was a male not wearing a hoodie. The results indicate that males without hoodies were more frequently associated with "sports" descriptors when compared with the two other categories. A within-subjects ANOVA revealed a significant difference between each categorical group, $F(2, 37) = 10.75$, $p < .001$.

An independent-samples t-test was conducted to compare differences between male and female participants' usage of "sports" terminology for the no-hoodie male image. The results of the t-test did not reveal statistical significance. Female participants had a mean equal to 2.33 (SD = 1.69) while male participants had a mean equal to 3.726 (SD =3.96), $t(36)=1.39$, $p = 0.17$.

Discussion

The findings of this research supported the initial hypothesis, with the data suggesting an overall perception bias when shown a hooded individual. The findings suggest that hooded individuals are primarily judged as more likely to participate in illegal or socially rejected behavior than unhooded individuals. When the hoodie conditions were examined closer, the use of illegal/socially rejected terminology was significantly favored by participants over education/career and sports terminology. This apparent relationship between illegal/socially rejected terminology and hooded images could indicate that this particular fashion trend may bear its own negative connotation and resultantly prompt more negative first impressions from others. Correspondingly, Rahman (2016) considered the occurrence of stereotyping, stigmatizing, and potential demonizing of a hoodie wearer's intentions.

When comparing the results of this study to the incident between local neighborhood watchman George Zimmerman and Trayvon Martin, the possibility of negative hoodie stereotype seems highly probable. Similar to the judgements made throughout this study, the fundamental attribution error and the halo effect appear to have had an impact on the watchman's views. Rather than concluding that Trayvon was most likely in a hoodie because of the weather, the neighborhood watchman overestimated the dispositional–or personality based–reasoning for Trayvon Martin's appearance by assuming the teen was involved in drugs and local crimes. Similarly, participants in the hoodie-condition scenarios of

this study significantly favored illegal descriptors when describing their group's image supporting the idea that wearing a hoodie precipitates a more illicit first impression.

This apparent stereotype can be concerning, especially with the current integration of hoodies into 2000s fashion trends (2015). In a post-study questionnaire, 86/127, ~68% of the respondents admitted to wearing a hoodie "often" or "always" and out of these 86 participants, 41 of them answered that when wearing a hoodie, they wear it with the hood up "occasionally," "often," or "always" when presented with a 5-point Likert scale asking these two questions. Though just a small sample of the entire high school student population, the responses do suggest the popularity of hoodies in teen fashion and should increase discussion of wearing clothes that produce a suitable first impression.

Though not the initial purpose of this study, the analyzed data further revealed significantly different perceptions of the unhooded images based on the gender of the presented wearer. As detailed by figure 3, the "female no-hoodie image" was described with education/career descriptors more than any other condition and when examined more closely, out of the three terminology categories, the education/career category was significantly favored over sports and illegal/socially rejected language when looking at the unhooded female image alone. Pre-existing research supports the idea that female students outperform males in effort and academic achievement in the classroom and different genders seem to embody different academic cultures (Mieke Van, 2004). Future research may wish to focus on potential gender stereotypes associating females with having stronger work ethics than males and a more defined reasoning behind this occurrence. Interestingly, figure 4 and table 1 present another unintentional stereotyping, indicating that participants favored sports terminology when describing "the male no-hoodie" than when describing any other condition and further that within the one condition, sports terminology was significantly favored over the other descriptor categories. It's interesting that while females are unconsciously perceived as more work-based, public opinion seems to label males as more athletic, and future research may wish to expand upon the idea that women athletes are underrepresented in terms of media coverage as opposed to male sporting events and the consequences this can have on society's perception of women involved in sports (Duncan, 1994).

Throughout the design and conduction of this study, the ultimate goal was to create a realistic situation that could generate a conclusion relevant to today's society. In a world of social media, news feeds, and headlines, unconscious stereotyping is occurring more frequently, and part of the reason behind the still and single image design of this study lies in the idea of attempting to replicate this shallow sense of information gathering (Hooker, 2017). Rather than presenting participants with the background and life story of the people in presented images, participants were solely given the image and asked to make a judgement themselves.

One of the difficulties in this particular study was the limited population to sample from and the small sample size. This research focused on the perspective of students from one suburban New York high school, which may not be the best representation of the entire teenage population. Future research should look to replicate this study with various high school students across the country and look for differences in responses. Similarly, it would be interesting to see if teens from an urban or rural background had a different perception to the four different images than those from suburban neighborhoods. Another approach to future investigation could be to set up a cross-sectional research methodology comparing the terminology used by different age groups to describe the hooded versus unhooded individuals. Further, the wearers in the images presented to

participants in this study were of the same Caucasian race to eliminate speculation of wearer's intentions based on race, but future research may compare the terminology utilized to describe Caucasian hoodie wearers with that used to describe African American hoodie wearers or hoodie wearers of other races.

This study despite revealing significant conclusions regarding perception and potential stereotypes merely scratches the surface of the multitude of research opportunities available in the field of first impressions. If clothing does play a role in perceived persona, individuals need to be aware that dressing the part may play a crucial role in constructing the right impression. Adjusting a wardrobe to depict a safe and appropriate disposition could be a simple way to protect oneself from being interpreted as potentially dangerous or threatening to others without altering one's entire appearance. It's important to stay on top of the impression you portray, because despite trying to avoid it, people really do judge a book by its cover.

References

Ayla, R. (2012). *Trayvon Martin shooting partial police reports*. Report # 201250001136. Sanford Police Department; Division DIS-1, Unit S1312.

Baldwin, S., & Jones, M. (n.d.). Transcript of George Zimmerman's call to the police. Retrieved November 8, 2019, from https://www.documentcloud.org/documents/326700-full-transcript-zimmerman.html

Bawdon, F. (2009). Hoodies or altar boys? What is media stereotyping doing to our British boys? Women in Journalist/Echo Research. London: Echo Research Ltd. Pages 1-24. Retrieved May 8th, 2020, from https://fionabawdon.files.wordpress.com/2011/03/wij_teenboys_report.pdf

Civile C., &Obhi S.S.= (2017) Students wearing police uniforms exhibit biased attention toward individuals wearing hoodies. *Frontier in Psychology, 8 (*62). doi: 10.3389/fpsyg.2017.00062

de Casanova, E. M., & Webb, C. L. (2017). A tale of two hoodies. *Men and Masculinities*, *20* (1), 117– 122. doi: 10.1177/1097184X17696363

Fung, K. (2012, March 25). WATCH: Geraldo Rivera's jaw-dropping comments about Trayvon Martin. Retrieved from https://www.huffpost.com/entry/geraldo-rivera-trayvon-martin- hoodie_n_1375080

Gibson, E.J. (1969). Principles of perceptual learning and development. East Norwalk, CT, US: Appleton-Century-Crofts.

Howlett, N., Pine, K., Orakçıoğlu, I., & Fletcher, B. (2013). The influence of clothing on first impressions. *Journal of Fashion Marketing and Management*, *17* (1), 38-48. doi:10.1108/13612021311305128

Little, A. C., Jones, B. C., & DeBruine, L. M. (2011). Facial attractiveness: Evolutionary based research. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *366* (1571), 1638–1659. doi:10.1098/rstb.2010.0404

McLeod, S. A. (2018). Visual perception theory. *Simply Psychology.* https://www.simplypsychology.org/perception-theories.html

Nauert, R. (2018). First impressions are more lasting than once thought. *Psych Central*. Retrieved on November 8, 2019, from https://psychcentral.com/news/2011/01/19/first- impressions-are-more-lasting-than-once-thought/22769.html

Nguyen, M. (2015). The hoodie as sign, screen, expectation, and force. *Signs* 40, 791–816. doi: 10.1086/680326

Past weather in Orlando, Florida, USA - February 2012. (n.d.). Retrieved November 8, 2019, from https://www.timeanddate.com/weather/usa/orlando/historic?month=2&year=2012

Rahman, & Osmud. (2016). The hoodie: Consumer choice, fashion style and symbolic meaning. Retrieved November 8, 2019, from https://www.ingentaconnect.com/content/intellect/infs/2016/00000003/00000001/art00007#trendmd-suggestions

Rule, N. O., Krendl, A. C., Ivcevic, Z., & Ambady, N. (2013). Accuracy and consensus in judgments of trustworthiness from faces: Behavioral and neural correlates. *Journal of Personality and Social Psychology, 104*(3), 409–426. doi:10.1037/a0031050

Stirrat, M., & Perrett, D. I. (2012). Face structure predicts cooperation: Men with wider faces are more generous to their in-group when out-group competition is salient. *Psychological Science*, *23*(7), 718–722. doi: 10.1177/0956797611435133

The Effects of Open-Book, Closed-Book and Crib-Sheet Quizzes on Anxiety, Performance and Retention

Ariella Hakimi, Roslyn High School

ariellahakimi@gmail.com

Abstract

In the twenty-first century, stress levels of high school students are sky-high. One factor that contributes to the stress of these students is the pressure derived from college becoming increasingly more competitive and having lower acceptance rates. Acceptance rates at elite colleges have been dramatically decreasing. For example, the class of 2001's admission rate to Stanford was 15.5% while Harvard's rate was 12.3%; twenty years later for the class of 2021, Stanford's rate decreased to merely 4.7% and Harvard's to 5.2% (Jackson, 2017). Additionally, students in high school are tested with tremendous frequency, and, unfortunately, many suffer from test anxiety. Previous research suggests that current testing environments may be contributing to student stress and anxiety. The current testing environment may be contributing to student stress and anxiety. The most common way of testing, currently and in the past, is by a closed-book examination in which students do not have access to their learning materials during the examination. However, there are test format alternatives, such as open-book and crib-sheet exams, which may cause students less test anxiety. The problem this study investigated was whether test anxiety and stress can be decreased, and learning increased by altering the test environment. This study also tested the effects of multiple-choice and short answer questions on performance. In a matched-pair design, 64 students in three sections of an AP Psychology course took a series of three quizzes in which every participant saw every condition of the study. While the crib-sheet showed the highest level of performance, these differences were not statistically significant, despite the relatively large effect size. In addition, the open-book and crib-sheet conditions caused the same level of anxiety while the closed-book condition caused a higher level of anxiety. These results were not statistically significant but had an effect size of five percent.

Introduction

In the twenty-first century, stress levels of many high achieving high school students are sky-high **(**Ossala, 2015). One factor that contributes to the stress of these students is the pressure derived from colleges becoming increasingly more competitive and having lower acceptance rates. Acceptance rates at elite colleges have been decreasing throughout the past few decades. The

class of 2001's admission rate to Stanford was 15.5% while Harvard's rate was 12.3%; twenty years later for the class of 2021, Stanford's rate decreased to merely 4.7% and Harvard's to 5.2% (Jackson, 2017). With declining acceptance rates, it is only more crucial that students perform well on their assessments. Students in high school are tested with tremendous frequency, and, unfortunately, many suffer from test anxiety. This study investigated whether or not altering the test environment can decrease stress and anxiety, increase test scores and increase learning.

The current testing environment may be contributing to student stress and anxiety. The most common method of testing, currently and in the past, is by a closed-book examination during which students do not have access to their learning materials during the examination. However, there are test format alternatives, such as open-book and crib-sheet exams, which may cause students less test anxiety. While the traditional closed-book testing environment promotes the memorization of massive amounts of information (Feller, 1994; Jacobs & Chase, 1992), open book exams focus on higher level thinking and synthesizing information (Agarwal et al., 2008; Theophilides & Koutselini, 2000).

Test Types

A closed-book exam generally entails an examination in which the only source of information students rely on is their brain. On the other hand, open-book exams allow students to reference materials during the examination such as course notes, handouts or text books (Gray, 1994). Proponents of open-book exams argue that they relate more to a real-life situation in which an individual would have access to information in making a decision (Theophilides & Koutselini, 2000). An alternative to both the closed-book and open-book exam is the concept of a crib-sheet, most commonly known as a cheat sheet, exam. This is when teachers allow their students to prepare a piece of a paper on which they have written down information they deem important and access it during the exam.

Test Type and Test Anxiety

Research has found that open book exams caused less anxiety than closed-book and crib-sheet exams on a 50-question multiple choice psychology exam and on a 50-question short answer statistics exam (Gharib et al., 2012). It has also been found that most students preferred to take a short answer question open-book exam in comparison to a short answer question closed-book exam on a psychology exam. The same study also found that students who received the highest scores expressed the greatest preference for open-book exams. Students also reported that they approach open-book exams with greater optimism in comparison to closed-book exams in terms of what they predict their test score will be (Karagiannopoulou & Milienos, 2013). In addition, research has shown that students approach open-book exams in a calmer manner and overall demonstrate more confidence in how they will perform (Theophildies & Koutselini, 2000).

Research has also demonstrated that crib-sheet exams also produce less test anxiety among students than on closed-book multiple choice exams on a wide variety of subjects (Cherim, 1981; Vogelweid, Kitchel & Rice, 2014). In a study by Erbe (2007), students created a double-sided 8.5 by 11-inch crib sheet. Students who took a multiple-choice crib-sheet exam on Bloom's taxonomy reported less test anxiety than students who took a multiple choice closed-book version of the exam. On a multiple-choice nursing exam, students created a double-sided half page crib-sheet and reported that the crib-sheets created more security for them and removed the anxiety of having to memorize a lot of information (Drake, Freed & Hunter 2009). Lower test anxiety was also found in a study that tested veterinarians' knowledge in a virology course in which students reported that they were less anxious on a

computerized multiple choice exam using a crib-sheet (half a sheet of an 8.5 by 11 page) when compared to an exam in which they did not use a crib-sheet. They also reported that they would prefer to take future examinations using a crib-sheet (Vogelweid et al., 2014). Cherim (1981) also found decreased anxiety in students on a crib-sheet preparatory chemistry examination. Almost 80 percent of students in a lower division class in developmental psychology said that making double sided 8.5 by 11 crib-sheets reduced their stress during the multiple-choice examinations (Dickson & Bauer, 2008).

Test Type and Test Scores

It has not only been shown that open-book examinations cause less anxiety than closed-book examinations, it has also been found that open-book testing results in higher scores than traditional closed-book testing. A study by De Raadt (2012) found on a computer programming examination that there was a significantly higher average score when students had access to a textbook during a short answer examination compared to when they did not. In another study, the closed-book exam resulted in lower scores than both the open-book and double sided 8.5 by 11 crib-sheet exams on both an Introductory Psychology exam made up of 50 multiple choice questions and a Statistics exam that consisted of short answer problems (Gharib et al, 2012). On the other hand, some studies found that there is no significant difference in test scores between open-book and closed-book examinations. For example, a study by Rakes (2008) with 122 masters-level graduate students found that there was no significant difference in scores on an open-book exam and closed-book exam group comprised of a 100 question online multiple-choice technology questions, although the study did indicate that this may have occurred since the exam was online.

When compared to closed-book exams, crib-sheets have produced similar results to both conditions in terms of test score. One study found that students who produced and used crib-sheets on an exam performed significantly better than those who took a closed-book exam (De Raadt, 2012). Gharib et al. (2012) found that the use of crib sheets led to a marginal improvement in test scores on an Introductory Psychology exam over the closed book condition, although the finding only approached statistical significance. A meta-analysis found that overall, testing aids, including crib-sheets, have a moderate positive impact on exam performance in comparison to open-book exams (Larwin, Gorman & Larwin, 2013).

The same meta-analysis also found that the simple act of making the crib-sheet is an effective learning device that can improve exam scores by increasing student engagement. In addition, a study testing the use of crib-sheets on nursing examinations found that students said they used the crib-sheet during the test but not as often as they expected to use it (Drake et al., 2009). Likewise, Erbe (2007) found that students did not necessarily need to refer to the cheat sheets during the exam (although they were allowed to) but they reported that the process of making them was helpful in terms of doing better on the exam.

While students want to get higher test scores, the real goal of testing is to aid in learning, which is often measured by retention after the initial test. In a study by Agarwal et al. (2008), students took a 7-question short answer exam that was based on a passage from a textbook in either an open book or closed book format. Initially, students performed better on the open-book exam, and in a subsequent closed-book, test students in the two groups performed similarly, suggesting that the use of open book tests does not decrease learning. In a study by Dickson et al. (2008), students were told that they were allowed to create crib-sheets to use on the exam. They took a pre-test without the crib-sheet and then took the exam with the crib-sheet. They performed significantly better on the exam in comparison to the pretest. This difference indicates that producing a crib-sheet does not affect learning, although

performance on a retention crib-sheet test has not been compared to performance on a retention open or closed-book test. Another study found that students performed similarly on a retention quiz regardless of if they took an open-book test or a closed-book test prior (Gharib et al., 2012). While the retention of material has been looked at in terms of open and closed book exams, it has not been tested in terms of crib sheet exams, therefore, crib-sheet examinations cannot be ruled out as a beneficial alternative to open and closed book exams when it comes to learning and retention of material.

Hypotheses

This study sought to determine the best testing environment for high school students in terms of low stress, high scores, and maximum retention by determining the effects of test type (open-book, closed-book and crib sheet) on anxiety, performance, and retention. Unlike past research, this study introduces and examines the effects of question type (multiple choice or short answer) on anxiety and performance. Based on the background literature, the following hypotheses were tested: *Hypothesis 1:* Students will report less anxiety on the crib-sheet and open-book conditions in comparison to the closed-book condition. *Hypothesis 2:* Students will perform better on an open-book exam compared to when they take a closed-book or crib-sheet exam. *Hypothesis 3:* Students will perform similarly on an open-book or and closed book retention quiz.

Method

Participants

	Open-Book	**Crib-Sheet**	**Closed-Book**
Quiz 1	Period 3	Period 8	Period 7
Quiz 2	Period 7	Period 3	Period 8
Quiz 3	Period 8	Period 7	Period 3

Table 1. Quiz format rotation

The sample for this study consisted of 64 high school students from three sections of AP Psychology. The sample contained 46 females and 18 males, with 95% of the sample being Caucasian. The school is in a suburb of New York City and has approximately 1,100 students. To protect the identity of the students throughout the study, prior to its start, students were assigned a number 1 through 64 by which they were identified.

Materials and Procedure

This study used a repeated measures design in which every participant experienced all conditions. In the AP Psychology course, students took a series of three quizzes each consisting of both multiple choice and short answer questions. Each quiz consisted of 15 multiple choice questions each worth 2 points, and one short answer question worth 12 points. The quiz in its entirety was out of 42 points. The quizzes were a part of the developmental psychology unit that they learned in class. The material on each quiz was different (students were not retested on the same material on each quiz). Class sections were set in a rotation of an open-book quiz, a closed-book quiz, and a crib-sheet quiz (see Figure 1). Students were informed prior to the quiz date as to what condition (quiz format) they would be receiving. For the crib-sheet examinations, students were told that the crib-sheets were being collected for a homework grade as an incentive for them to create a crib-sheet.

Prior to each quiz, students took a survey that consisted of a modified version the State Trait Anxiety Inventory (STAI Scale) to assess their current state of anxiety before taking the quiz (see

Appendix). The scale consisted of 6 items, with a Likert-type scale ranging from one (not at all) to 4 (very much). Items 1, 4, and 5 were reverse scored when analyzed. Permission was obtained by the creator of the scale, Dr. Stefan Nilsson. After answering these questions, students were asked a few demographic questions pertaining to grade, gender, and race.

Following the set of quizzes, students took a retention quiz that consisted of 30 multiple choice questions, in which 10 of the multiple choice questions were randomly selected from each of the three quizzes, and randomly ordered in order to assess the retention of material by students based on quiz type.

Results

A repeated measures Analysis of Variance (ANOVA) was run to test the differences in quiz score on each quiz. An ANOVA was used instead of a paired t-test because there were three quizzes each with three conditions. The purpose of this study was to compare the performance of every student based on quiz type.

Overall Quiz Performance

In terms of overall quiz performance, no significant main effects emerged (see Figure 2), $F(2, 62)= 1.62$ $p= .21$, although crib-sheet produced the highest overall score ($M = 83.22$, $SD= 0.14$) with open-book ($M = 81.98$, $SD= 0.12$) following and then closed-book producing the lowest scores ($M =78.80$, $SD=0.16$).

Figure 2. Overall quiz performance in percentage points

Multiple Choice Performance

After analyzing the scores overall, the short answer scores and the multiple-choice scores were analyzed separately to see if there was any difference in the effect of the quiz types on the different types of questions. In terms of the multiple-choice performance, the same trend as the overall trend followed (see Figure 3) although the results were statistically insignificant, $F(2, 62)= 1.78$ $p= .17$. The crib-sheet produced the highest scores ($M = 83.11$, $SD= 0.15$), then open-book ($M = 80.93$, $SD= 0.14$), and then closed-book ($M = 78.75$, $SD= 0.15$).

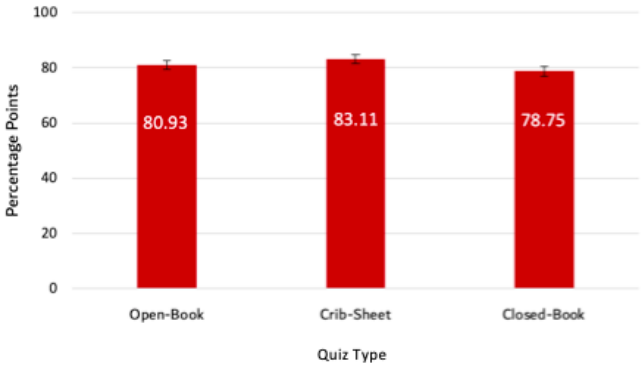

Figure 3. Multiple choice performance in percentage points

Short Answer Performance

In terms of the short answer questions, the results were also statistically insignificant, $F(2, 62)= 0.833$ $p= .163$, although the open-book quiz produced the highest scores ($M = 84.63$, $SD= 0.16$), then crib-sheet ($M = 83.59$, $SD= 0.16$), and then closed-book ($M = 77.99$, $SD= 0.13$) (see Figure 4).

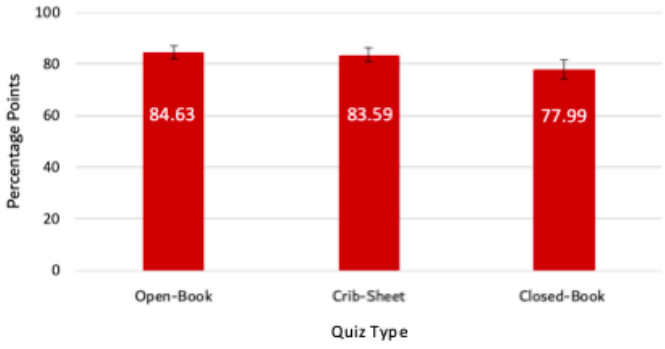

Figure 4. Short answer performance in percentage points

Reported Levels of Anxiety

In addition to the performance on the quizzes, the next subject to examine was the level of anxiety that students faced prior to each quiz. These differences were not significant , $F(2, 62)= 0.63$ $p= .35$; however, as expected, the open-book ($M = 2.21$, $SD= 0.02$) and crib-sheet ($M = 2.21$, $SD= 0.01$) produced lower levels of anxiety than the closed-book condition ($M = 2.41$, $SD= 0.06$) (see Figure 5).

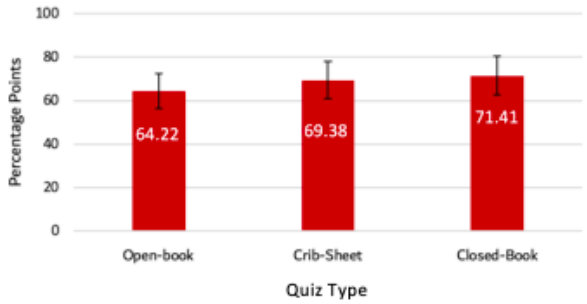

Figure 5. Average anxiety level

Retention

The new aspect present in the study was the addition of the idea of the student's retention in terms of analyzing the retention after the crib-sheet formats. Students took a 30-question multiple-choice quiz to test their retention of the material on the initial three quizzes. The results were not significant, $F(2, 62)=0.78$ $p= .016$,. Interestingly, students performed the best on the questions they originally saw in the closed-book condition ($M= 71.41$, $SD= 0.14$), than the crib-sheet ($M= 69.38$, $SD= 0.16$) and open-book with the lowest retention performance ($M= 64.22$, $SD= 0.15$) (see Figure 6). There was a concern that the order in which the students took the quizzes could have affected the retention rate of the students. This, however, was not the case. An ANOVA found no significant difference in the retention rates of the different class periods.

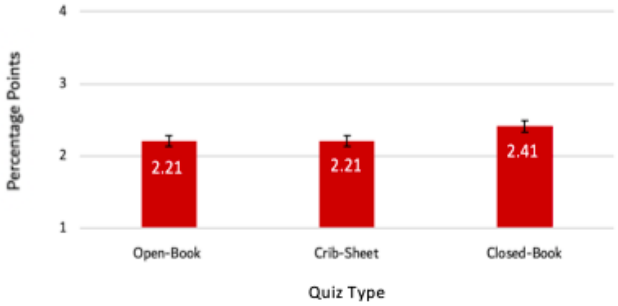

Figure 6. Average retention rate based on original quiz condition

Discussion

Although the hypotheses were not supported due to the lack of statistical significance, it is important to note that the trends present were consistent throughout all measures of test performance. In other words, in each statistical analysis it is clear that both open-book and crib-sheet quizzes produce higher results than closed-book quizzes, and the fact that this trend is consistent suggests that it is likely not random. This, however, was not the case in terms of retention rates as students did retain the most information in the closed-book condition.

One reason for why there may have not been statistical differences between groups is the fact that there were only 64 participants participating in this study. In a more ideal world, more participants are necessary to test this experiment on. More participants were not obtained because of the difficulty in obtaining a class that met the criteria for the sample. The class that had to be used was a class in which there were three class periods all taught by the same teacher, and all the same level of difficulty. For example, a regular biology class and two honors biology classes would not work as a sample for this study.

Test Anxiety

Another possible explanation for why these results may have occurred is the fact that all background literature pointed at higher performances on exams while this study focuses on quizzes. Students may simply have a different

attitude when they approach quizzes which may have caused less of a difference between how students performed. This could have affected the anxiety that students felt prior to taking these quizzes as well. If students put less of an emphasis on the quizzes and cared less about them, they would have experienced lower levels of anxiety regardless of the format of the quiz they were taking. There is no current research on the differences in attitude that students feel on an exam versus a quiz; however, it is possible that there is a difference in students' attitude towards these two assessments. In addition, a four-point scale may have not allowed for enough differences in their responses to find significance.

Test Performance

Although no significant difference was found in terms of test performance, the differences in these grades are noteworthy when considering applying to a university. The mean average quiz performance for the open-book quiz (M= 78.8) translates to a 2.3 grade point average (GPA) while the mean average quiz performance for the crib-sheet quiz (M= 83.22) translates to a 3.0 GPA. While one quiz may seem insignificant, if the switch was made to crib-sheet quizzes and tests, it may be possible to see an increase in the GPA of students. In fact, the AP Psychology teacher was so pleased with the performance of her students on the quizzes of the crib-sheet condition that she decided to implement it into her curriculum by having the students make a crib-sheet before each quiz. Essentially, the difference between a 2.3 GPA and a 3.0 GPA could make or break whether or not a student is accepted to a university. In addition, these results had an effect size of 5%. This indicates that the alternate conditions could have had an effect on the students' overall performance regardless of the sample being small.

Retention

In terms of retention, there is potential in the results of this study. Because the sample was small, it is hard to say that all formats cause the same levels of retention. While it seems as though the open-book format is the worst in terms of retention, the important thing to note is that the closed-book and crib-sheet conditions had almost the exact mean performance on the retention quiz— only about two percentage-points different. Teachers in the past have argued that exams and quizzes should only be in the closed-book condition because otherwise students do not retain as much material **(**Karagiannopoulou & Milienos, 2013). However, this was not the case in this study. In addition, although insignificant, students faced less anxiety when taking the crib-sheet quiz in comparison to the closed-book quiz. If students face less anxiety and retain the same amount of information on the crib-sheet quiz, then isn't the crib-sheet format a beneficial alternative? From this study alone, it is hard to say. But with further experimentation on a larger sample, there is a possibility that this is the case. It is time that the education system is altered. Something as simple as changing the format in which students take their exams can start this alteration, and it is important that we continue to explore these possibilities.

Acknowledgements

I would like to thank Dr. Allyson Weseley for her mentorship throughout this study and my high school years.

References

Agarwal, P. K., Karpicke, J. D., Kang, S. H. K., Roediger III, H. L., & McDermott, K. B. (2008). Examining the testing effect with open- and closed-book tests. *Applied Cognitive Psychology, 22, 861-876.* doi: 10.1002/acp.1391

Cherim, S. (1981) A philosophy of teaching preparatory chemistry. *Education Resources Information Center. https://files.eric.ed.gov/fulltext/ED203937.pdf*

De Raadt, M. (2012). Student created cheat-sheets in examinations: impact on student

outcomes. *Proceedings of the Fourteenth Australasian Computing Education Conference, 123, 71-76.*

Dickson, L., & Bauer, J. (2008) Do students learn course material during crib sheet construction? *Teaching of Psychology,* 35(2), 117-120. doi: 10.10883430/0098628080197

Drake, V., Freed, P., & Hunter, J. (2009). Crib sheets or security blankets? *Issues in Mental Health Nursing,* 19(3), 2910300. doi: 10.1080/016128498249088

Erbe, B. (2007). Reducing test anxiety while increasing learning: the cheat sheet. *College Teaching, 55(3),* 96-98. doi: 10.3200/CTCH.55.3.

Feller, M. (1994). Open-book testing and education for the future. *Studies in educational evaluation,* 20(2), 235-238. doi: 10.1016/0191-491X(94)90010-8

Gauthier, D. M. (2018). The academic pressure of high school students and how parents can help. *Today parenting team*

Gharib, A., Phillips, W. & Mathew, N. (2012). Cheat sheet or open-book? A comparison of the effects of exam types on performance, retention, and anxiety. *Psychology Research, 2(8),* 469-478.

Gray, T. (1994). Open book examinations.

Jackson, A. (2017). It was the hardest year on record to get into elite colleges — admissions experts explain why. *Business Insider*

Jacobs, L., & Chase, C. (1992). Developing and using tests effectively. A guide for faculty. *Education Resources Information Center*

Karagiannopoulou, E., & Milienos, F. S. (2013). Exploring the relationship between experienced students' preference for open- and closed-book examinations, approaches to learning and achievement. *Educational Research and Evaluation, 19(4),* 271-296. doi: 10.1080/13803611.2013.

Larwin, K., Gorman, J., & Larwin, D. (2013). Assessing the impact of testing aids on post-secondary student performance: A meta-analytic investigation, *Educational Psychology Review,* 25(3), 429-443. doi: 10.1007/s10648-013-9227-1

Rakes, G. C. (2008). Open book testing in online learning environments. *Journal of Interactive Online Learning, 7(1),* 1-9. Retrieved from http://www.ncolr.org/jiol/issues/pdf/7.1.1.pdf

Theophilides, C., & Koutselini, M. (2000). Study behavior in the closed-book and the open-book examination: a comparative analysis. E*ducational Research and Evaluation: An International Journal on Theory and Practice, 6(4),* 379-393.

Vogelwied, C., Kitchel, J., & Rice, A. (2014). Veterinary students' use of crib sheets in preparing for learning and reducing stress. *NACTA Journal,* 58(2), 135-139.

Blue Light-Induced Sleep Deprivation Affects Behaviors in *Drosophila melanogaster*

Mir Zayid Alam & Taylor Fox, Manhasset High School

mirzayidalam@gmail.com; tgfox@optimum.net

Abstract

Upwards of 85% of adolescents use blue-light-emitting technologies prior to their bedtime, and there is a strong correlation between electronics use and decreased sleep duration. Sleep deprivation has detrimental effects on learning, locomotion, and other behaviors. Thus, the goal of this study was to investigate how blue-light sleep-deprivation affects behaviors of model organism *Drosophila melanogaster*, as well as potential nutraceutical remediation of expected effects with curcumin. The alternate hypothesis was that learning, motor function, and longevity would be reduced while locomotion would be warped, while curcumin would restore these variables to control levels. Wild-type *Drosophila melanogaster* were exposed to 0.0 or 5.0 mg/mL curcumin and/or sleep-deprivation or lack thereof for negative geotaxis, locomotion (Drosophila Activity Monitor), longevity, and aversive-phototaxic-suppression assays. Means and standard errors were calculated in Microsoft Excel. Statistical tests include a one-way ANOVA followed by a post-hoc Scheffé in IBM SPSS 25 software. The results supported the alternate hypothesis in that sleep deprivation significantly reduced negative geotaxis ($p = 0.010$), the number of nighttime sleep bouts ($p = 0.014$), and memory index ($p = 0.025$), and curcumin exposure restored these behaviors to control levels. Harmful changes are likely due to disturbances of the circadian oscillator and the manipulation of dopaminergic and GABAergic signaling, while curcumin's antioxidative capacity likely explains variable restoration. Sleep deprivation decreased lifespan, whereas curcumin exposure increased lifespan. Sleep deprivation did not have a significant effect on sleep bout length, likely due to the inaccuracy of equipment.

Keywords: *sleep, light disturbance, drosophila*

Introduction

Sleep is still not a completely understood behavior, yet it takes up around a third of human life and has been demonstrated to be critical in maintaining health. (Kripke, 2002) Hence, it is worrying that more than 1 in 3 adults in the United States slept less than 7 hours per night in 2016, a figure recommended to be the minimum sleeping time in order to avoid the onset of chronic health developments such as obesity and diabetes. (CDC, 2016)

Risks of Sleep Deprivation Posed by Electronics

The various risks of sleep deprivation are widespread amongst both adolescents as well as adults and are likely propagated by the overuse of technology; light-emitting diodes (LEDs) have been especially implicated in this phenomenon

(Hysing et al., 2015). According to Hysing et al., in 2015, there is a strong correlation between the use of electronics and diminished sleep duration (Hysing et al., 2015).

Blue light has a relatively short wavelength range of about 430-495 nm, characterizing blue light as high energy visible light radiation. The most common source of blue light is the sun, but light-emitting diodes emit significant blue light as well. LEDs have a wide range of potential uses such as room lighting or, more importantly, electronics. Since the regulation of circadian rhythms is dependent on a recently-discovered photoreceptor that only responds to shorter wavelengths of light, blue light has the most potent impact on the brain's circadian rhythm of the different wavelengths of visible light. Additionally, blue light suppresses the production of melatonin, a hormone responsible for regulating sleep-wake cycles (Kimberly and Phelps 2009). Light exposure at night disrupts circadian rhythms by overstimulating a class of highly photosensitive photoreceptors, called intrinsically photosensitive retinal ganglion cells (ipRGCs), which are responsible for regulating circadian phototransduction (Bedrosian & Nelson, 2017).

Science of Sleep in Drosophila melanogaster

Drosophila melanogaster, or fruit flies, are an ideal model for studying sleep in humans, because the flies exhibit sleep patterns characterized by circadian regulation similar to regulatory pathways in humans (Cirelli & Bushey, 2008). During daytime, a series of signal transductions lead to the transcription of two genes, period (*per*) and timeless (*tim*), through the Clk/Cyc complex, which encode the Timeless (TIM) and Period (PER) proteins (Tataroglu & Emery, 2014). During daytime, these proteins are degraded right after transcription as a result of light exposure. However, at nighttime, TIM is no longer degraded as sunlight is not present. TIM can then heterodimerize with PER, forming the PER/TIM complex, protecting PER from phosphorylation and subsequent degradation. The PER/TIM heterodimer then undergoes nuclear localization and phosphorylates the Clk/Cyc complex in the nucleus of the cell, causing it to stop promoting the transcription of *per* and *tim*. Therefore, a negative feedback loop is evident, as the *per* and *tim* genes inhibit their own transcription after accumulating in the cell. This inhibition continues until sunlight is once again present. The degradation of the PER/TIM complex as a result of exposure to sunlight allows for the Clk/Cyc heterodimer to resume promoting the period and timeless genes, and as a result, the cycle repeats. This system regulates the sleep-wake cycle in *Drosophila* and demonstrates how light exposure is crucial for the differentiation between daytime and nighttime (Tataroglu & Emery, 2014).

Memory Synthesis in Drosophila

The scotophase sleep of *Drosophila melanogaster* is known to include deeper sleep (more force is required to wake them via physical disturbance). Additionally, it has been revealed that *Drosophila melanogaster* emit longer brain waves during periods of heightened quiescence (Cirelli & Bushey 2008; Dubowy & Sehgal, 2017). According to Cirelli and Bushey (2008), disturbances to sleep during the nighttime can preclude deeper-stage sleep from occurring, reducing memory consolidation, which would otherwise occur then. Kasuya et al. (2009) explored this concept by testing how olfactory memory performance changed in response to perturbed circadian rhythmicity. In *Drosophila melanogaster*, the mechanism for olfactory memory formation consists of olfactory neurons receiving olfactory stimuli and transmitting that information through the Antennal Nerve (AN) to the Antennal Lobe (AL), where information is processed and further transmitted to the mushroom bodies of *Drosophila melanogaster*. The projection neurons (PN) and the dorsal paired media (DPM) neurons branch out and transmit the original message to different lobes of the mushroom body. Mushroom bodies (MB) are the parts of *Drosophila melanogaster* brains responsible for learning and memory; the ~2000 dopaminergic Kenyon cells located there synthesize the memory for later recall. This process represents the basic stimulation of the

Drosophila melanogaster brain by an olfactory stimulus (Kasuya et al., 2009).
The synthesis of associative memories occurs when flies are exposed to a conditional stimulus (CS) such as light, and unconditioned aversive stimuli (US) such as odors, at the same time. The administration of the conditional stimulus and unconditioned stimulus at the same time cause information generated by each stimulus to become integrated into olfactory memory at the same time. Alpha/beta neurons are important to this process, as their neurotransmission is required for the retrieval of memory. However, alpha/beta neurons are not crucial for the synthesis or storage of memories (Kasuya et al., 2009).

Aggression and Sleep Deprivation in Drosophila

Kayser et al. (2015) assessed how mechanical sleep deprivation affected aggression between pairs of males. It was found that sleep deprivation significantly decreased the frequency of lunges, as well as increased the time until the first attack. Sleep-deprived flies also were less likely to establish physical dominance. However, all of these parameters were rescued using pharmacological or sleep-recovery interventions, implying that the effects are not long-term. Kayser et al. (2015) demonstrated that aggression was reduced as a result of reduced octopaminergic signaling (octopamine is very similar to the human hormone norepinephrine; both hormones cause increased physical vigor and activity) and that this dysregulation was a result of sleep deprivation.

Effects of Light Interruption on Drosophila Sleep

Liu and Zhao (2014) tested how discontinuous light interruption of *Drosophila* sleep affects sleep patterns in *Drosophila*. They found that sleep was greatly reduced; there was a 48% decrease during daytime, despite the disruption occurring during nighttime. In addition, they found that although the overall sleep was not affected significantly, flies treated with discontinuous light exposure did not adjust to normal cycles easily. Seugnet et al. (2009) tested sleep-deprivation's effect on *Drosophila melanogaster* motor function, locomotion, learning and memory, and found that sleep-deprivation impaired each of these parameters significantly. Regardless, pharmacological treatment was able to restore many of the behaviors prior to sleep deprivation.

Effects of Curcumin on Remediating Sleep Deprivation

Curcumin is an antioxidant, meaning it neutralizes reactive chemical species, or free radicals. Free radicals are unstable molecules that pull an electron from another molecule, destabilizing that molecule and turning it into a free radical, starting a harmful chain reaction that can cause oxidative stress. Antioxidants end the chain reaction by donating an electron to the free radicals without becoming free radicals themselves (Freeman & Crapo 1982). When Liu and Zhao (2014) administered curcumin to older sleep-deprived flies, significantly low memory performance indices increased to performance indices comparable to control flies. Also, the administration of Dopamine receptor D1 antagonists during sleep deprivation effectively counteracted the memory-impairing effects of sleep deprivation.

The purpose of this experiment was to examine how blue light stimulation affects learning/memory capabilities, locomotor behaviors, longevity, and how curcumin remediates these effects. The alternate hypothesis was that blue light based perturbation of *Drosophila melanogaster* would lead to decreased memory/learning capability, reduced motor function, reduced sleep (locomotor behaviors), and decreased longevity.

Method

Wild-type *Drosophila melanogaster* from Carolina Biological were used in this experiment. For each assay, flies were exposed to combinations of 0.0 or 5.0 mg/mL curcumin and sleep deprivation or lack thereof. Sleep deprivation was administered through a custom light-dark cycle using a custom Arduino code and an Adafruit RGB LED light-shield.

Flies were reared on 0.0 mg/mL curcumin or 5.0mg/mL curcumin and exposed to blue-light

sleep deprivation or lack thereof. Each of these four groups were tested in each of the following assays: negative geotaxis to test motor function, longevity to test lifespan, locomotion to test sleep architecture, and aversive phototaxic suppression (APS) to test memory.

Means and standard errors from means were calculated for all data in Microsoft Excel. Statistical tests included a one-way ANOVA followed by a post-Hoc Scheffé with $p < 0.05$ in IBM SPSS.

Culturing Flies

Wild-type *Drosophila melanogaster* were purchased from Carolina Biological. Food was prepared using a 1:1 ratio of spring water with 8 mL of Formula 4-24 Instant *Drosophila* Medium from Carolina Biological with baker's yeast sprinkled on top. Flies were transferred to new mediums one minute after they were prepared (Flagg, 1988).

Drosophila melanogaster were stored in plastic vials with cotton or foam plugs that allow for air circulation as well as firm seals. Flies were transferred via brisk tapping (Flagg, 1988).

Anesthetization

Vials with flies in them were placed in a freezer for about two to four minutes and remained largely immobilized for two to three minutes after. After anesthetization, the flies were placed onto an ice pack so that they remained immobilized for longer. Care was taken to not leave flies in the freezer, and it was taken into account that the older a fly is, the longer it will take to recover from the cold.

Chemical Preparation

Quinine hydrochloride (Sigma-Aldrich) was used for olfactory conditioning. 1 ml of 0.1 M quinine hydrochloride was used to saturate a filter paper (which was placed in a vial during aversive phototaxis assay). To prepare the working solution, 1.98 g of quinine was dissolved in 50 mL distilled water. This can be stored at -20°C for up to a year (Ali et al., 2011).

Sexing

To distinguish *Drosophila melanogaster* based on sex, 2 fresh vials were prepared, one for males and one for females. Then, flies were anesthetized using a freezer. Next, using a fine, soft-bristled paintbrush, males and females were sorted into separate groups. Males were distinguished by their darker, rounder, and smaller abdomens, meanwhile females were distinguished by larger, pointier, and lighter abdomens. Male fruit flies are typically smaller than females, but this was not the sole criterion used to distinguish between males and females. (Flagg, 1988).

Age Synchronization

To age-synchronize flies, parent flies were transferred into a fresh vial, and were then transferred to another vial 24 hours later. The vial in which flies mated for 1 day contained similarly aged *Drosophila melanogaster*. In order to preserve age-synchronized generations, flies used for the generation of age-synchronized generations were transferred daily, because mating periods of more than 24 hours can lead to greater discrepancies in age (Flagg 1988).

Negative Geotaxis

A custom-designed and 3D-printed apparatus (see Appendix, Figure 6) was used for this assay. The apparatus held up to six vials, held in place by a piece of acrylic that screwed into the apparatus.

To set up the negative geotaxis climbing apparatus, two polystyrene vials were vertically joined with tape such that the openings were perfectly aligned. A line was drawn 8 cm up from the bottom surface (Ali et al., 2011). High-throughput negative geotaxis assays were conducted using the rapid iterative negative geotaxis assay (RING assay), as described by Gargano et al. (2005).

For each trial, vials of 10 male flies per vial were transferred into the climbing apparatus. After a one minute acclimatization period, flies were gently tapped to the bottom of the vial, and at 10 seconds after tapping, the number of flies that passed the 10 cm mark were counted. This was repeated 10 times for each group, with a one minute rest period between trials (Ali et al., 2011).

Aversive Phototaxic Suppression (APS)

The t-maze design (see Appendix, Figure 7) had a central column of acrylic with a moveable trapdoor inside it (the PLA 3D-printed trapdoor and its shaft ran parallel to the sides of the central column). On either side, there were openings into which polycarbonate tubes (which contained the fly) were inserted. Tubes were filed down to a gentle gradient on the inner edge to allow for ease of movement. Opaque tape sealed the outer end of the dark chamber, while a small LED light was affixed to the outer end of the light chambers. Two light chambers were created: one for quinine training and one for experimental testing and phototaxic screening. A light source was prepared that was able to be inserted into the lighted chamber for conditioning (Ali et al., 2011). The T-maze design was 3D-printed and laser-cut.

Prior to APS, males were starved in vials (~6 hours) containing water-saturated filter paper to ensure that they were more receptive to conditioning odors. Then, flies were separated into individual centrifuge tubes (Ali et al., 2011).

To begin the assay, a female fly was transferred into the dark chamber without anesthesia. Then, the dark chamber was inserted into the t-maze with the trapdoor down. Lights of the room were turned off and red-filtered lights were turned on (flies are blind to red light), and then flies acclimatized for 30 seconds. Then, the t-maze light source was turned on, and the trapdoor was opened. If flies were phototactic (if they walked into the lighted vial in 10 seconds or less) they would continue to be trained; if not, they were excluded and not used for the experiment. Positively phototactic flies were tapped back into the dark chamber and allowed a 30 second rest period. During this break, a filter paper was placed into the lighted chamber and was saturated with 1 mL of 0.1 M quinine hydrochloride solution. After the quinine-coated light chamber was prepared, the trapdoor was slowly opened, and the fly was allowed to walk into the quinine-coated and lighted vial. The fly was allowed to remain in the lighted chamber for 1 minute, and then it was tapped back into the dark chamber; this training process was repeated nine more times. Wild-type flies typically learned to avoid the lighted chamber after three to five rounds of training because of the presence of quinine. Immediately after training is completed, test trials were conducted. In each of the five test trials, the fly was tapped back to the dark chamber, and the trapdoor was opened. If the fly did not enter the light chamber within 10 seconds, it is considered a "pass." If the fly entered the light chamber, but then walked away from the light source, this was also considered as a "pass." Learning tests right after training were termed PC0 (0 hours postconditioning) and short-term memory tests are termed PCx (x hours postconditioning, where x can be anywhere from minutes to hours after training) (Ali et al., 2011).

Sleep Deprivation and DAM

Sleep deprivation and associated effects of locomotion were measured using a Drosophila Activity Monitor. Sleep depriving flies involved the construction of a light-proof box in which the DAM was placed. Covering the box was a lid with an LED blue light source affixed to it, which was an Arduino Uno programmed with a custom Arduino code to achieve desired times of sleep disturbance. The LEDs were functional during periods of time during scotophase (ZT 13-14, 15.5-16.5, 18-19, and 20.5-21.5; schedule adapted from Liu and Zhao (2014)).

Adult male flies from 1-5 days of age were used to measure locomotor activity, since the egg-laying of females can impede locomotion (Ali et al., 2011).

Drosophila medium was placed on one end of each tube, and tubes were sealed with plastic caps of appropriate size to prevent the food from drying out. (Ali et al., 2011). When assembling the DAM tubes, the plastic caps were placed on both ends of the tube at the same time to prevent the food from moving around due to changes in pressure inside the tube.

After flies were loaded into activity tubes, and these activity tubes were then loaded into the DAM, locomotion of individual flies was assessed by the number of infrared beam breaks over the period of testing time. Flies were kept in the DAM for four to five days, as this allowed for the collection of more data that was a more accurate

representation of sleep structure. Five minutes of inactivity in a row is accepted as sleep/rest in *Drosophila melanogaster* (Chiu et al., 2010).

The monitoring system was housed in a well-ventilated and temperature-regulated room (~25°C) and was in an environment where light could be regulated. It was preferable to have a dark room for the monitor; in order to see in the dark room, a light with red filters was used (Ali et al., 2011).

A PC computer in the laboratory was dedicated to full-time data collection. Data from the DAM was downloaded onto the device, so significant hard drive space or a USB/similar device was also necessary. An uninterrupted power supply was used in the event of a power failure or surge to continue data collection, and any unwanted exposure to LED or any other bright light was minimized (Ali et al., 2011).

Longevity

The longevity of age synchronized, sexed flies exposed to each treatment was assessed in triplicate (or more if possible). Organisms were transferred to fresh vials every 3-4 days, and survivorship (the number of flies that survived) was assessed daily (Linford et al. 2013).

Data Analysis

To analyze climbing data from the negative geotaxis assay, means and standard deviations of climbing pass rates were calculated for each group based on the 10 cm. in 10 seconds criterion (Ali et al., 2011). A one-way ANOVA and a post-Hoc Scheffé ($p < 0.05$) in IBM SPSS 25 were used to assess when and where statistical significance occurred.

Memory indices from the Aversive Phototaxic Suppression Assay were calculated based on the means and standard deviations of pass rates (recall of the memory) for 6-9 trials per group (successful recalls / total trials) (Ali et al., 2011). Statistical significance was assessed in IBM SPSS 25, using one-way ANOVA and a post-Hoc Scheffé ($p < 0.05$).

To analyze data from the Drosophila Activity Monitor, the readouts collected by the DAM system software were exported to Microsoft Excel. The trials were converted to comma-delimited lists using the find/replace function in Microsoft Word. Then, using custom Python scripts, these lists were analyzed to look for 10 zeros consecutively (data collected every 30 seconds; thus, 10 zeros meets the definition of sleep as a period of 5 or more minutes without movement) and for the length of these zero-chains. These results were exported to Microsoft Excel, where means and standard deviations were calculated, and significance was assessed using a one-way ANOVA and post-Hoc Scheffe in IBM SPSS 25.

Longevity data were analyzed by calculating means and standard deviations of survivorship (lifespan) per group. Data was tested for significance using IBM SPSS 25.

Results

For all graphs, groups were represented by the same colors throughout. Green represents the negative control group with no curcumin and a normal 12:12 sleep cycle. Light blue represents the sleep-deprived group with no curcumin. Dark blue represents the sleep-deprived group with curcumin. Purple represents the non-sleep-deprived group that was exposed to curcumin.

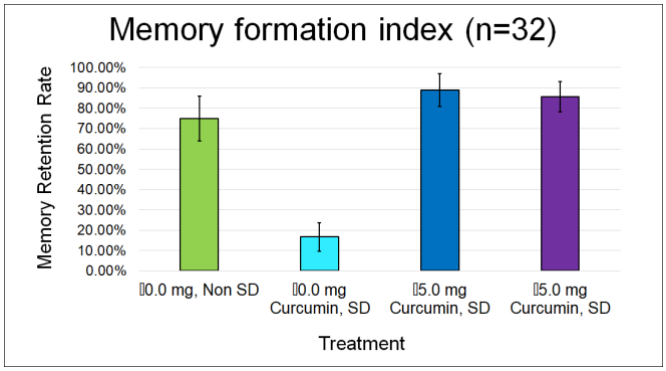

Figure 1: Memory formation index based on data from APS

For APS, Figure 1 shows that sleep deprivation reduced learning significantly. The average pass rate for the negative control was 75.00%, and sleep deprivation reduced the average pass rate to 16.67%, which was statistically significant from the control ($p = 0.025$). However,

curcumin exposure restored memory function to normal levels at a pass rate of 85.71%.

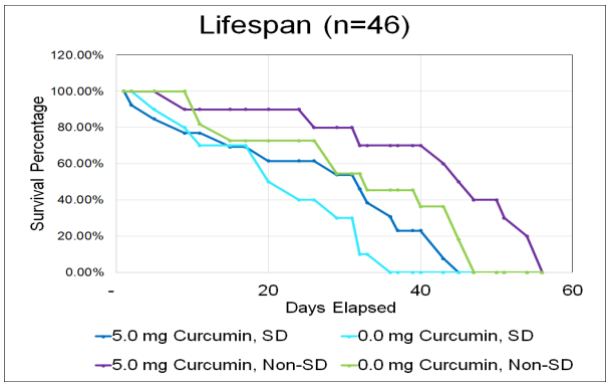

Figure 2: Survivorship of flies over the course of sixty days

For the lifespan assay, the 0.0 mg curcumin sleep-deprived group had significantly lower survivorship than the flies exposed to curcumin that were not sleep deprived (Figure 2). Sleep deprivation decreased lifespan, whereas curcumin exposure increased lifespan.

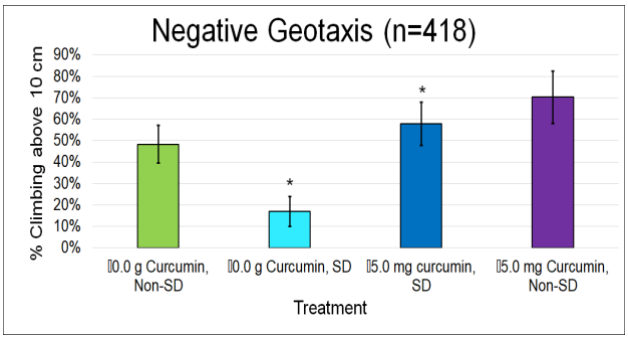

Figure 3. The Percentage of Flies that Climbed Above 10 cm in RING

For the RING assay, Figure 3 shows that sleep deprivation reduced motor function significantly ($p = 0.010$), decreasing from 48.32% climbing above 10 cm to 17.02%, on average. Curcumin exposure restored motor function to non-sleep deprived levels at an average of 57.84%.

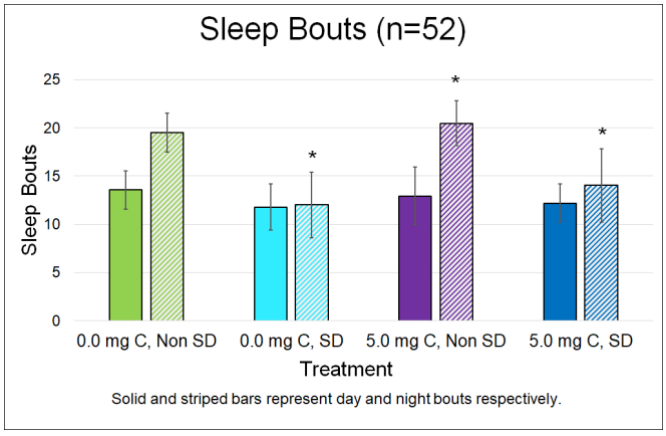

Figure 4. Number of daytime and nighttime sleep bouts

For the locomotor assay, a sleep bout was defined as a period of five minutes without any recorded movement. Sleep deprivation did not affect the number of daytime sleep bouts, but it dramatically reduced the number of nighttime sleep bouts, as shown in Figure 4. Curcumin exposure increased the number of sleep bouts back to control levels.

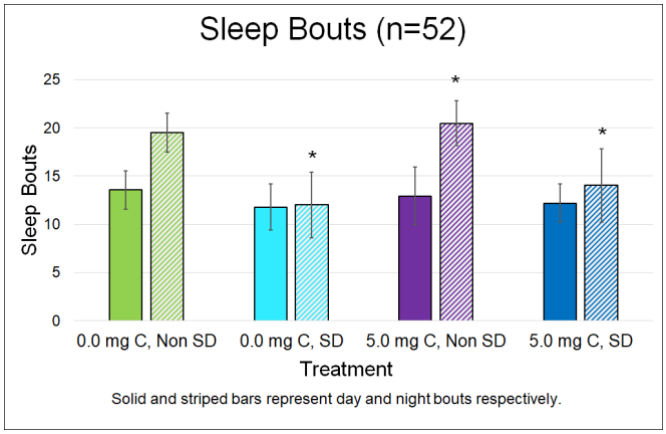

Figure 5. Average length of a sleep bout by day and night

According to the results shown in Figure 5, neither sleep deprivation nor curcumin exposure impacted sleep bout length. However, this could have been because the flies were moving inside the DAM tubes without passing in front of the apparatus' infrared sensor.

Discussion

The purpose of this study was to examine how blue light affects learning/memory, motor function, locomotor behaviors (number of sleep bouts and bout length), and longevity, and to examine how curcumin remediates these effects. The alternate hypothesis, which stated that blue-light-induced sleep deprivation would induce memory deficits, abnormal sleep patterns, motor function reduction, and lower lifespans while curcumin treatment would return these expected deficits to control levels, was mostly supported. Sleep-deprived flies performed significantly worse in the motor function and memory assays, lived for generally shorter periods of time, and

demonstrated disturbed circadian periodicity, although results from bout length analysis were inconclusive.

The reductions observed in negative geotaxis in blue-light-exposed flies can most likely be attributed to the disturbance of normally-running circadian patterns. The metabolic efficacy of vital life functions is largely regulated by processes associated with the regulation of circadian rhythms. Homeostatic hormonal balances, arousal/drowsiness (dopaminergic-GABAergic), cognitive function, and motor function are all regulated by signaling associated with the cycle of waking and sleeping in *Drosophila melanogaster*. For example, motor function degeneration (e.g., reduced negative geotactic behavior, resting tremors, flying, walking, feeding, mating, and aggression) has been demonstrated to be caused by sleep deprivation, as a result of both neurodegeneration and a reduction in brain dopamine (Pathak et al., 2015). Specifically, it is implicated in misregulating neuron firing in the fruit fly's mushroom body (MB) and dorsal fan-shaped body (dFB) neural circuits. The MB, composed of about 2000 dopaminergic Kenyon nervous cells, is upstream to approximately 20 mushroom body output neurons (MBON). The MBONs directly control muscles and locomotion by upregulating calcium activity in the nerves' sodium-potassium equilibrium. This change of chemical equilibrium is responsible for locomotion and motor function. Thus, if brain dopamine is depleted and dopaminergic signaling impaired, the effectiveness of motor functioning will decrease, explaining negative geotactic deficits as a result of sleep deprivation (Pathak et al., 2015).

It is clear that over-stimulation using arousing blue light can lead to lingering ramifications on locomotor activity in *Drosophila melanogaster.* dFB neurons are related to locomotor activity and motor capability and are regulated by stimulatory dopaminergic neurons (DAN). DANs have been observed to react more spontaneously and at higher rates during periods of wakefulness in fruit flies; the downstream effect of this is greater awareness and vigorous movement. However, if dopamine signaling is extended uncharacteristically long (i.e., in the event of sleep deprivation), DANs become less chemically active. Instead, the dFB neurons further downstream begin promoting rest and sleep; sleep-deprivation lowers the threshold for dFB excitation, and as a result, drowsiness-inducing circuits can more easily distort locomotion patterns (Ichinose, 2017). Even then, a reason for why daytime sleep was not simply significantly increased in an attempt at recover sleep is because Cry (conformationally changed by blue-light excitation) continues stimulating the fruit fly. Using blue-light flashes and Western Blot analysis, it was discovered that the active form of Cry has a half-life of 27 minutes (Ozturk, 2011). This demonstrates the relationship between over-stimulation using arousing blue light and locomotor activity in *Drosophila melanogaster*.

The improper expression of pigment dispersing factor (PDF) and its derivative hormones, namely pigment-dispersing hormone (PDH), impair circadian behaviors downstream (Shafer & Yao, 2014). PDF expression is directly related to Cry expression (photopigment involved in light-dependent circadian signaling), and are expressed in dorsal brain neurons. Since blue light also affects Cry activity, and Cry activity is directly related to PDF, the relationship between blue light and abnormal PDF expression is clear, suggesting a biochemical etiology for the negative effects on the behaviors of *Drosophila melanogaster* (Ho & Sehgal, 2005; Yoshi et al., 2009).

Despite these detracting effects on the regularity of sleep, normal sleep was largely restored via curcumin diet supplementation. Phom et al. (2014) revealed that curcumin exposure replenished brain dopamine levels using high-performance liquid chromatography. This lends itself to bringing back normalcy to locomotion in

the organisms, because dopaminergic deficits caused by sleep deprivation are mitigated (Pathak et al., 2015).

Memory consolidation is a behavior of *Drosophila melanogaster* that is also directly related to circadian rhythmicity. The normal activity of dopaminergic neurons facilitates a reward-based learning mechanism (ex. in APS), but sleep deprivation degrades dopaminergic neurons. This decreases synaptic plasticity by reducing the potential of consolidating and pruning neural connections, which would explain the decline in performance for sleep deprived groups in APS. PDF's improper expression results in untimely arousal, precluding the deeper stage of sleep in which memories are synthesized by dopaminergic Kenyon cells in the mushroom body (Yoshi et al., 2009). This may explain the lower memory indices for sleep-deprived flies. It also impairs arousal, overriding GABAergic regulatory mechanisms, which explains why sleep architecture is disturbed.

Curcumin's antioxidative phenol groups allow it to be neuroprotective as part of its antioxidative capacity. Its mechanism in memory restoration also involves activating peroxisome proliferator-activated receptor gamma (PPAR-gamma), which has been demonstrated to be crucial for memory consolidation, thus explaining the nutraceutical remediation of behavioral deficits. Interestingly, PPAR-gamma is also implicated in regulating locomotion (Phom et al., 2014).

It can be postulated that curcumin increased longevity because it is an antioxidant, meaning it neutralizes reactive chemical species like free radicals. . As mentioned earlier, too many free radicals can cause oxidative stress, which causes complications such as cytotoxic lipid peroxidation or even organismal death; however, antioxidants diminish the effects of free radicals by donating an electron while not becoming a free radical themselves. Free radicals are not always harmful; for example, they are used in the immune system to attack antigens and are naturally produced via aerobic respiration. Typically, they are naturally reduced and stabilized during organismal scotophase, which is when the body typically engages in tissue repair, but nighttime disturbance of sleep reduces this phenomenon from occurring, leading to higher free radical concentrations than normal, and thus potentially leading to health complications like those mentioned above, which may ultimately precipitate in premature death, as demonstrated by the longevity assay (Freeman & Crapo, 1982).

One limitation was the potential inaccuracy with DAM data collection. The Drosophila Activity Monitor houses 32 tubes, each of which holds one individual fly. The DAM has infrared sensors that detect when a fly walks past it. It is possible that a fly could have been awake and moving without walking past the infrared sensor, and therefore this movement was not recorded. This could be responsible for the large error bars in the graph of sleep bout length. A second limitation was that only one concentration of curcumin was tested. It would be ideal to test multiple concentrations of curcumin to find an optimal concentration to rear the flies on. Another potential limitation was that no genetic screening was performed in order to verify the relevant pathways manipulated in this study, such as the transcription of PDF and related proteins.

In conclusion, it was successfully demonstrated that when the model organism *Drosophila melanogaster* was exposed to the blue light ubiquitously found in consumer devices, its cognitive function, motor function, lifespan, and sleep patterns were significantly impaired, while the polyphenol curcumin was able to remediate these damages. The results mostly supported the alternate hypothesis. Specifically, it was established that blue light reduces nighttime sleep, impairs motor function, reduces learning, and decreases lifespan, while it was assessed to have an effect on daytime sleep. However, curcumin exposure fully restored all of the impaired

behaviors back to control levels. These conclusions reveal a strong relationship between late night blue-light exposure and adverse effects on health, while maintaining that these effects, at least in the short term, can be rescued using curcumin.

Future studies in this area include long-term memory analysis, various aspects of fertility, electroencephalogram (EEG) analysis of sleep patterns, tracing the exact mechanisms of action via biochemical probing techniques, and potential progression to mammalian models. EEG analysis is particularly interesting, as it can measure the frequency of brain-waves of fruit flies. Slowed-down brain-waves signify a deeper sleep in *Drosophila melanogaster* and can thus be used to more precisely gauge effects of sleep disturbance, as well as gauging locomotion more accurately overall (Cirelli & Bushey 2008).

References

Ali, Y. O., Escala, W., Ruan, K., & Zhai, R. G. (2011, March 11). Assaying Locomotor, Learning, and Memory Deficits in Drosophila Models of Neurodegeneration. *Journal of Visualized Experiments,* (49). doi: 10.3791/2504

Bedrosian, T. A., & Nelson, R. J. (2017, January 31). Timing of light exposure affects mood and brain circuits. *Translational Psychiatry, 7*(1). doi: 10.1038/tp.2016.262

Bushey, D., Hughes, K. A., Tononi, G., & Cirelli, C. (2010). Sleep, aging, and lifespan in Drosophila. *BMC Neuroscience, 11*(1), 56. doi: 10.1186/1471-2202-11-56

CDC - Sleep Home Page - Sleep and Sleep Disorders. (2020, April 15). Retrieved from https://www.cdc.gov/sleep/index.html

Cirelli, C., & Bushey, D. (2008). Sleep and Wakefulness in Drosophila melanogaster. *Annals of the New York Academy of Sciences, 1129*(1), 323–329. doi: 10.1196/annals.1417.017

Freeman, B. A., & Crapo, J. D. (1982, November). Biology of disease: free radicals and tissue injury. *Lab Invest, 47*(5)*,* 412-426. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/6290784

Ho, K. S., & Sehgal, A. (2005). Drosophila melanogaster: An Insect Model for Fundamental Studies of Sleep. *Methods in Enzymology Circadian Rhythms*, *393,* 772–793. doi:10.1016/s0076-6879(05)93041-3

Hysing, M., Pallesen, S., Stormark, K. M., Jakobsen, R., Lundervold, A. J., & Sivertsen, B. (2015, February 2). Sleep and use of electronic devices in adolescence: results from a large population-based study. *BMJ Open, 5*(1). doi: 10.1136/bmjopen-2014-006748

Ichinose, T., Tanimoto, H., & Yamagata, N. (2017, December 11). Behavioral Modulation by Spontaneous Activity of Dopamine Neurons. *Frontiers in Systems Neuroscience, 11*. doi: 10.3389/fnsys.2017.00088

Kayser, M. S., Mainwaring, B., Yue, Z., & Sehgal, A. (2015). Author response: Sleep deprivation suppresses aggression in Drosophila. *eLife 2015*. doi: 10.7554/elife.07643.025

Kripke, D. F., Garfinkel, L., Wingard, D. L., Klauber, M. R., & Marler, M. R. (2002). Mortality Associated With Sleep Duration and Insomnia. *Archives of General Psychiatry, 59*(2), 131. doi: 10.1001/archpsyc.59.2.131

Liu, Z., & Zhao, Z. (2014, August 22). Effects of Light Interruption on Sleep and Viability of Drosophila melanogaster. *PLoS ONE, 9*(8). doi: 10.1371/journal.pone.0105678

Ozturk, N., Selby, C. P., Annayev, Y., Zhong, D., & Sancar, A. (2010). Reaction mechanism of Drosophila cryptochrome. *Proceedings of the National Academy of Sciences, 108*(2), 516–521.

doi: 10.1073/pnas.1017093108

Pathak, T., Agrawal, T., Richhariya, S., Sadaf, S., & Hasan, G. (2015, October 7). Store-Operated Calcium Entry through Orai Is Required for Transcriptional Maturation of the Flight Circuit in Drosophila. *The Journal of Neuroscience, 35*(40), 13784–13799. doi:10.1523/jneurosci.1680-15.2015

Phom, L., Achumi, B., Alone, D. P., Muralidhara, & Yenisetti, S. C. (2014). Curcumins Neuroprotective Efficacy in Drosophila Model of Idiopathic Parkinson's Disease Is Phase Specific: Implication of its Therapeutic Effectiveness. *Rejuvenation Research, 17*(6), 481–489. doi: 10.1089/rej.2014.1591

Seugnet, L., Galvin, J. E., Suzuki, Y., Gottschalk, L., & Shaw, P. J. (2009). Persistent Short-Term Memory Defects Following Sleep Deprivation in a Drosophila Model of Parkinson Disease. *Sleep, 32*(8), 984–992. doi: 10.1093/sleep/32.8.984

Shafer, O. T., & Yao, Z. (2014, July 1). Pigment-dispersing factor signaling and circadian rhythms in insect locomotor activity. *Current Opinion in Insect Science, 1*, 73–80. doi:10.1016/j.cois.2014.05.002

Tataroglu, O., & Emery, P. (2014). Studying circadian rhythms in Drosophila melanogaster. *Methods, 68*(1), 140–150. doi: 10.1016/j.ymeth.2014.01.001

Yoshii, T., Wulbeck, C., Sehadova, H., Veleri, S., Bichler, D., Stanewsky, R., & Helfrich-Forster, C. (2009 February 25). The Neuropeptide Pigment-Dispersing Factor Adjusts Period and Phase of Drosophila's Clock. *Journal of Neuroscience, 29(*8), 2597–2610. doi:10.1523/jneurosci.5439-08.2009

It's All in the Name

A Study on Perceived Nutrition and Likelihood to Purchase Based on Product Name

Eliza Garmise, Amanda Liswood, and Sara Rosenbaum, Roslyn High School

egarmise23@roslynschools.org; aliswood23@roslynschools.org;
srosenbaum23@roslynschools.org

Abstract

In society, the prevalence of obesity and overweight people are on the rise. According to the World Health Organization, 1.9 billion adults suffer from obesity. Previous literature reveals that nutrition labels on products can impact the extent to which consumers perceive a product as nutritious (Kim, 2009). The purpose of our study was to investigate if the name of a product affects the perceived nutrition of and the likelihood to purchase that product. Fifty participants were recruited at a local supermarket and were asked to read a short description and examine the logo of a new cereal. They were then asked to answer questions about their perceptions. Participants were randomly assigned one of two cereal names: Fruiti-O's or Sugar-O's. Only participants that passed the manipulation check were included in our results. Analyses revealed that participants rated Fruiti-O's as significantly more nutritious than Sugar-O's ($p<.001$); in addition, participants reported that they were significantly more likely to purchase Fruiti-O's than Sugar-O's ($p<.001$). In a follow-up experiment, we added an identical nutrition facts panel to all versions of the stimulus to see if the effect would persist despite the availability of actual nutrition facts. Thirty-four participants were recruited at the same local supermarket. Analyses revealed that Fruiti-O's was still seen as significantly more nutritious and likely to be purchased than Sugar-O's; however, Fruiti-O's were perceived as significantly more nutritious when no nutrition facts were presented compared to when nutrition facts were presented, whereas Sugar-O's were perceived as significantly more nutritious when a nutrition label was present compared to when it was not ($p<.01$). In addition, participants perceived Fruiti-O's as more likely to be purchased with no nutrition label compared to a nutrition label, whereas Sugar-O's was perceived more likely to be purchased with a nutrition label ($p<.07$). Product names can often mislead customers to believe that product is healthy.

Keywords: product name, nutrition, purchasing

Introduction

Companies who use misleading advertising contribute to the growing problem of obesity (American Psychological Association, 2018). A factor that affects the obesity epidemic is aggressive marketing, or the use of bold or unique words in order to grasp the customers' attention (Estrada, 2017). The use of aggressive marketing makes people think that they are buying a healthy product even though they are not. The food industry can easily change the way the consumer thinks about their product which can affect people negatively, such as in terms of their health

(Chandon & Wansink, 2012). The advertising business affects the growth of obesity negatively.

Product Mislabeling and Nutrition

Often, a product is labelled in a way that is misleading to customers. This means that a customer may think that they are eating something that is better for their health than it is. Another study explored how companies make misleading claims towards children. A product may contain phrases such as "made with real fruit." This leads both the child and their parent to believe that this product has a healthy element to it (Kim, 2009). Our study sought to examine how manipulating a product name would affect a customer's perception of nutrition and likelihood to purchase a product. We wanted to see how the study done on children would differ if we gathered adult participants. Based on past literature we created our hypotheses. Our first experiment tested two main hypotheses: Compared to a product name with "Sugar" in it, a product with the name "Fruiti" in it will: a) be perceived as more nutritious; and b) be more likely to be purchased. During our first experiment many participants asked questions such as "What ingredients are in this product," "I need more information," "Can I try the product?" To reduce the number of questions we decided to conduct a modified experiment. In order to do this, we added a nutrition label to both Fruit-O's and Sugar-O's (our products in the experiment). This nutrition label displayed the exact same information for both cereals. Everything about the experiment was the same except both versions of the survey had the same nutrition label.

Product Mislabeling and Likelihood to Purchase

Previous literature suggests that nutrition labels influence likelihood to purchase of products. A study revealed that consumers who looked at nutrition labels purchased healthier products than those who did not (Mhurchu, Eyles, Jiang, & Blakely, 2018). Only 27% of UK shoppers tend to look at nutrition labels when purchasing products, but it influences how they purchase those products (Grunert, Wills, & Fernandez-Celemin, 2010). We added a nutrition label to our modified experiment to see if participants would look at the nutrition label and if this would impact if people would likely purchase the products in the experiment.

Nutrition labels have an influence on how the consumer views the product as nutritious (Grunert & Wills, 2007). A study revealed that the use of a nutrition label had an effect on the consumer: they decreased calorie intake by 6.6%, unhealthy products by 13%, and increased vegetable intake by 13.5% (Mozaffarian & Shangguan, 2019). We wanted to see if when presented with a nutrition label, participants would view the product as more or less nutritious.

A nutrition label can be impactful on the consumer's view of a product. Many people read specific parts of a nutrition label which determines their overall view of the product. Sugar content is the number one item looked at on a nutrition label in America (Gervis, 2018). We wanted to see if by manipulating the name of the product it would cause participants to feel differently when viewing the nutrition label, even though the labels are the same.

For our second experiment, we hypothesized: 1) Compared to Fruiti-O's without a nutrition label, Fruiti-O's with a nutrition label will be perceived as more nutritious; 2) Compared to Sugar-O's without a nutrition label, Sugar-O's with a nutrition label will be perceived as less nutritious; and 3) Regardless of the cereal name, a product without a nutrition label will be more likely to be purchased.

Method

Participants

Participants were recruited from a local supermarket on a Friday afternoon. Potential participants were asked to complete a survey about cereal for a local high school project and were told that it was anonymous, and participation was voluntary. Participants were randomly assigned to one of two versions of the survey and told that we were testing product names on perception of nutrition and likelihood to purchase. A raffle to win a $25 gift card to the local supermarket was offered as an incentive for participation. We recruited a total of 84 participants (50 for the first experiment and 34 for the second). All participants were over the age of 18. The study was done over

two separate days (one day per experiment), both on Friday's, at the same time in the afternoon, to minimize confounding variables.

Independent Variable

Our first experiment compared two conditions: Fruiti-O's and Sugar-O's. The independent variables manipulated the name of a breakfast cereal. There was also a description of the cereal: "(Sugar-o's/Fruiti-O's) is a new brand of cereal released by Chippy and more. It is very delicious, and it is very filling. (Sugar-O's/Fruiti-O's)'s has a well-balanced ratio of high-quality protein, vitamins, minerals, fat, and it only contains 160 calories per serving! Sugar-o's/Fruiti-O's) is a product like no other and a great way for people of all ages to begin their day." Everything on the flyer was kept constant, only changing the name of the cereal. Our second experiment compared four conditions: Fruiti-O's without a nutrition label, Fruit-O's with a nutrition label, Sugar-O's without a nutrition label, and Sugar-O's with a nutrition label. Everything included on the flyer from the first experiment was kept the same, except for the two conditions that contained the nutrition label. This nutrition label was the exact same for both conditions (Figure 1).

Figure 1. Nutritional Label for Cereals

Dependent Measures

We examined two dependent variables: perceived nutrition and likelihood to purchase. Our survey had 2 scales, each measuring one of these variables. Our first scale measured the perceived nutrition on a 7-point Likert scale. We obtained this survey from a study done by Suzuki in 2019. This scale had 4 items and a Cronbach's alpha of 0.95, indicating it is reliable, because it is over 0.7. A sample item from this scale includes, "I believe this product is good for your health." Our second scale measured likelihood to purchase also on a 7-point Likert type scale. This scale only had 1 item and was created for this study, as no existing scale could be found.

Procedure

Before beginning our data collection for our experiment, we received permission from the Institutional Review Board (IRB) at our high school. We created a flyer, which contained an image of the cereal logo, instructions to read to participants, a description of the cereal, a series of 7-point Likert scales, and demographic items, such as gender. We asked every third person at the local supermarket to follow the instructions and complete the survey based on a script we wrote. After the participants handed in their flyer, they were administered a manipulation check ensuring that they took note of the name of the product. Participants who failed the manipulation check were excluded from the data analysis. After all the data was collected, we entered our data into SPSS for analysis.

Results

Experiment 1

Our first experiment tested the effect of product name on the perception of nutrition. Fruiti-O's were perceived as more nutritious than Sugar-O's. We ran a one-way ANOVA to analyze our data, *Figure 2* shows that there was statistical significance F (1,48) = 31.20, p <.001. For Sugar-O's the mean was 2.81 and the standard deviation was 1.46. For Fruiti-O's the mean was 5.12 and the standard deviation was 1.49. This supported our hypothesis.

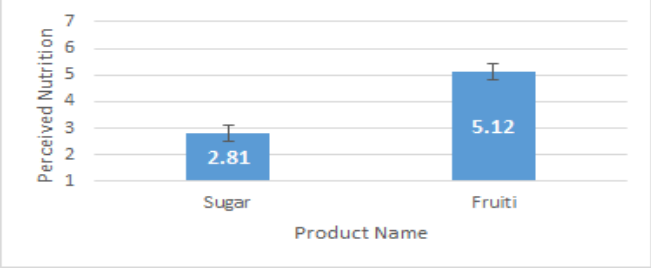

Figure 2. Product Name and Perceived Nutrition

Although we did not hypothesize about gender, we were interested in how it would impact peoples' perceptions. Past research has shown that males are more easily tricked compared to women (Loveride, 2019). *Figure 3* shows that both males and females perceived Fruiti-O's as more nutritious compared to Sugar-O's, but there was a bigger difference between Fruiti-O's and Sugar-O's in males compared to females. Females perceived Sugar-O's as more nutritious than males did. Our results were statistically significant, F (1,46) = 34.76, p <.001. Male Sugar-O's mean was 2.13 and standard deviation was 1.63. Male Fruiti-O's mean was 5.47 and standard deviation was .78. Female Sugar-O's mean was 3.13 and standard deviation was 1.31. Female Fruiti-O's mean was 4.96 and standard deviation was 1.72.

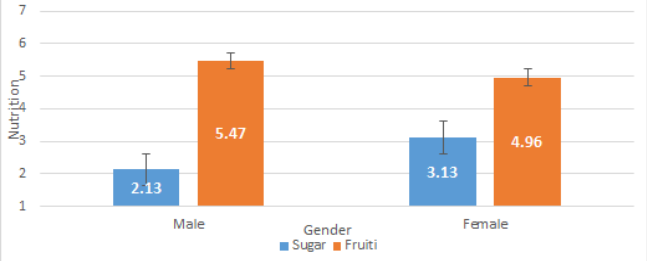

Figure 3. Gender and Perceived Nutrition

We additionally tested likelihood to purchase based on product name, which supported our hypothesis that Fruiti-O's had a greater impact on likelihood to purchase than Sugar-O's. Our results were statistically significant, F (1,48) = 27.35, p <.001. For Sugar-O's the mean was 2.48 and the standard deviation was 1.92. For Fruiti-O's the mean was 5.12 and the standard deviation was 1.64. This supported our hypothesis.

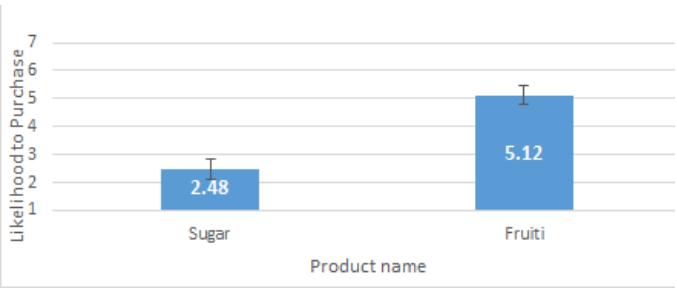

Figure 4. Product Name and Likelihood to Purchase

Seen in *Figure 5*, the likelihood to purchase is higher in Fruiti-O's than in Sugar-O's. This graph is statistically significant. F (1,46) = 28.63, p <.001. We ran a one-way ANOVA. Males show a higher likelihood to purchase either cereal compared to females. Both males and females would more likely purchase Fruiti-O's than Sugar-O's. There is a greater difference between males with Fruiti-O's and Sugar-O's compared to females. The male Sugar-O's mean was 2.50 and standard deviation was 2.14. The male Fruiti-O's mean was 6.00 and standard deviation was 1.41. The female Sugar-O's mean was 2.47 and standard deviation was 1.87. The female Fruiti-O's mean was 4.70 and standard deviation 1.61.

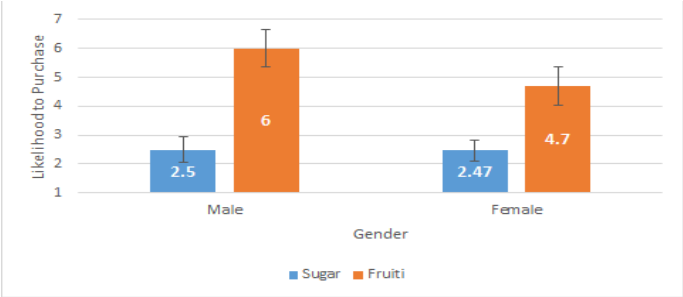

Figure 5. Gender and Likelihood to Purchase

Experiment 2

Figure 6 shows the results of the modified experiment with the nutrition label. It compared Fruiti-O's and Sugar-O's with and without a nutrition label. The perception of nutrition is higher in Fruiti-O's than in Sugar-O's regardless of the presence of the nutrition label. In Fruiti-O's, the perception of nutrition is higher when no nutrition label was given, whereas Sugar-O's were perceived as more nutritious with a nutrition label. There was a greater difference between Sugar-O's with and without a nutrition label than Fruiti-O's with and without a nutrition label. Our results were statistically significant, F (1,32) = 8.75, p <.01. The mean for Sugar-O's with a nutrition label was 2.75 and the standard deviation was 1.58. The mean for Fruiti-O's with a nutrition label was 4.22 and the standard deviation was 1.47. Our hypothesis regarding Fruiti-O's was not supported, but our hypothesis regarding Sugar-O's was

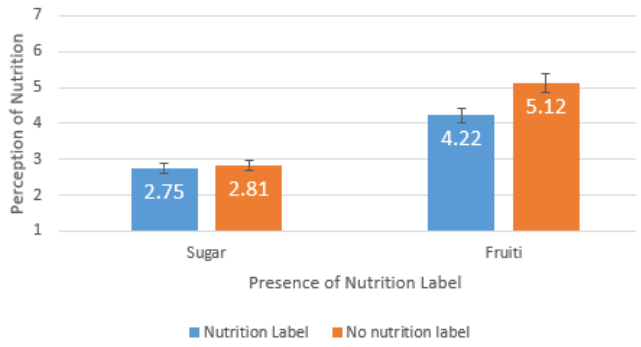

Figure 6. Nutritional Label Preference and Perceived Nutrition

Our modified experiment also tested likelihood to purchase based on product name and presence of nutrition label. *Figure 7* shows that the likelihood to purchase is higher in Fruiti-O's than in Sugar-O's regardless of the presence of the nutrition label. In Fruiti-O's, the likelihood to purchase is higher when no nutrition facts are given, compared to with given nutrition facts. In addition, Sugar-O's with a nutrition label has a higher likelihood to purchase compared to Sugar-O's without a nutrition label. There is a greater difference between Sugar-O's with and without a nutrition label than Fruiti-O's with and without a label. This is not statistically significant, F (1,32) = 3.48, p .07. The mean for Sugar-O's with a nutrition label was 3.24 and the standard deviation was 1.95. The mean for Fruiti-O's with a nutrition label was 4.47 and the standard deviation was 1.91. Our hypothesis was supported for Fruiti-O's, but not for Sugar-O's.

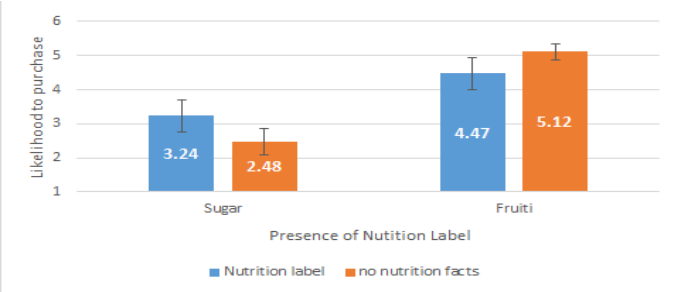

Figure 7. Nutritional Label Preference and Likelihood to Purchase

Discussion

Product Labelling and Perceived Nutrition

Misleading product names play a big role in the growing problem of obesity. These names allow customers to perceive a product as healthier than it is and influence that customer to purchase that product. "The Effects of Nutrition Knowledge on Food Label Use: A Review of the Literature" (Miller & Cassady 2015), and "The Food Industry's Influence In Nutrition Research" (2016) show the effect of product name on nutrition. In addition, studies such as "Influence of brand name on consumer decision making process - An empirical study on car buyers" (Alamgir, Shamsuddoha, Nasir, & Nedelea, 2010) and "Influence of Brand Name on Consumer Choice & Decision" (Shahzad, Iqbal, Ahmad, & Nawaz, 2014) were done showing the effect of product name on likelihood to purchase. These studies supported our findings which showed that Fruiti-O's had both a higher perception of nutrition and a higher likelihood to purchase compared to Sugar-O's. The participants likely assumed that a product with the phrase "Fruit" is generally perceived as healthier than a product with the phrase "Sugar" in it. The participants viewed Fruiti-O's as more nutritious and more likely to purchase without even knowing what was in the cereal. In reality, Sugar-O's could have been healthier or just as healthy as Fruiti-O's.

Effects of Nutrition Labels and Perceived Nutrition

In order to collect data for our second experiment, we retrieved background literature to support our study. "A review of nutrition labeling and food choice in the United States" (Dumoitier, Abbo, Neuhofer, & McFadden, 2019) and "What's new with the Nutrition Facts label" (McManus, 2020) revealed that the addition of a nutrition label can affect a consumer's perception of nutrition. Additionally, "Consumer Misinformation and the Brand Premium: A Private Label Blind Taste Test 9" (Bronnenberg, Dube, & Sanders, 2020) and "Consumer effects of front-of-package nutrition labeling: an interdisciplinary meta-analysis" (Ikonen, Sotgiu, Aydinli, & Verlegh, 2019) explore the idea of the effect of nutrition labels on likelihood to purchase.

Limitations and Further Study

Our study supports the study done by Kim (2009) that product names do have an effect on

how people perceive products to be healthier than they actually are. It is possible that our results would have differed if we had a greater sample size. In the future, we would like to increase our sample size in order to ensure our results are reliable. Additionally, we were only able to gather data at one supermarket due to time restrictions. Collecting data at more than one supermarket could have affected our results as well as testing in different neighbourhoods. Future studies should also evaluate the effect of our experiment on children. Also, experiments could be conducted using different products. In order to do this, we could change the independent variable. This would mean changing the names of the new product used. Another future research idea could include changing the dependent variable, such as perception of taste. An interesting extension of the research could assess the effect of ethnicity on perception of nutrition and likelihood to purchase. Our interest to show the relationship of these with gender was found from a few resources, "Nutrition and human health from a sex-gender perspective." (Marino et al., 2011) and "Nutrition and Gender" (Oniag & Mukudi, 2002). Based on our findings, we would expect that ethnicity would display an effect.

Conclusion

Our significant findings can help our world greatly. Many people are unaware of the effect that misleading product names can lead to obesity. Based on our study, the product Fruiti-O's is overall considered healthier and more likely to be purchased than the product Sugar-O's, even though there is no real difference between the two others than the name. Our findings can be used to educate people in local community centers and health classes to teach people about the importance of misleading product names and how they influence peoples' perception of it, to try to reduce the obesity epidemic.

Acknowledgements

We would like to thank Dr. Weseley for serving as our mentor and for her invaluable help.

References

Alamgir, M., Shamsuddoha, M., Nasir, T., & Nedelea, A. (2010). Influence of brand name on consumer decision making process - An empirical study on car buyers. *Va Trimitem Atasat, 10*(2),142-153. Retrieved from http://www.seap.usv.ro/annals/arhiva/ANNALS%20vol.10,nr.2%2812%29,2010%20fulltext.pdf

Bronnenberg, B. J., Dube, J., & Sanders, R. E. (2020). Consumer Misinformation and the Brand Premium: A Private Label Blind Taste Test. *Marketing Science, 39*(2), 381-406. doi: 10.1287/mksc.2019.1189

Dumoitier, A., Abbo, V., Neuhofer, Z., & McFadden, B. R. (2019). A review of nutrition labeling and food choice in the United States. *Obesity Science and Practice, 5*(6), 581-591. doi: 10.1002/osp4.374

Feloni, R.(2014). Experts explain what makes the best brand names so good. Retrieved from https://www.inc.com/richard-feloni/what-makes-the-best-brand-names-

Gervis, Z. (2018). Most people think food labels are misleading. Retrieved from https://nypost.com/2018/06/07/most-people-think-food-labels-are-misleading/

Grunert, K. G. & Wills, J. M. (2007). A review of European research on consumer response to nutrition information on food labels. *Journal of Public Health, 15*(5), 385-399. doi: 10.1007/s10389-007-0101-9

Grunert, K. G., Wills, J. M., & Fernandez-Celemin, L. (2010). Nutrition knowledge, and use of understanding of nutrition information on food labels among consumers in the UK. *Appetite, 55*(2), 177-189. doi: 10.1016/j.appet.2010.05.045

Ikonen, I., Sotgiu, F., Aydinli, A., & Verlegh P. W. J. (2019). Consumer effects of front-of-package nutrition labeling: an interdisciplinary meta-analysis. *Journal of*

the Academy of Marketing Science, 48, 360-383. doi: 10.1007/s11747-019-00663-9

Kim, W (2009). A study on the consumer's perception of front-of-pack nutrition labeling. *Nutrition Research and Practice, 3*(4)*,* 300-306. doi: 10.4162/nrp.2009.3.4.300

Kolenda, N.(n.d.) Brand names. Retrieved from https://www.nickkolenda.com/brand-names/

Lovereide, E. (2019). Men are more often fooled by women by placebo. Retrieved from https://sciencenorway.no/forskningno-gender-gender-differences/men-are-more-often-than-women-fooled-by-placebo/1553990

Marino, M., Masella, R., Bulzomi, P., Campesi, I., Malorni, W., & Franconi, F. (2011). Nutrition and human health from a sex-gender perspective. *Mol Aspects Med*, *32*(1), 1-70. doi: 10.1016/j.mam.2011.02.001.

McManus, K. (2020). What's new with the nutrition facts label? Retrieved from https://www.health.harvard.edu/blog/whats-new-with-the-nutrition-facts-label-2020022718948

Mhurchu, C. N., Eyles, H., Jiang, Y., & Blakely, T. (2018). Do nutrition labels influence healthier food choices? Analysis of label viewing behavior and subsequent food purchases in a labelling intervention trial. *Appetite*, *121*(1). 360-365. doi:10.1016/j.appet.2017.11.105

Miller, L.M.S. & Cassady, D.L (2015). The effects of nutrition knowledge on food label use: A review of the literature. *Appetite*, *92*(2015), 207-216. doi:10.1016/j.appet.2015.05.029

Mirabi, V, Akbariyeh, H & Tahmasebi Card, H. (2015) A study of factors affecting consumers purchase intentions. Retrieved from https://pdfs.semanticscholar.org

Mozaffarian, D. & Shangguan, S. (2019). Do food and menu nutrition labels influence consumer or industry behavior? Retrieved from https://www.statnews.com/2019/02/19/food-menu-nutrition-labels-influence-behavior/

National Institute of Health. (2010). NIH Study Identifies Ideal Body Mass Index. Retrieved from https://www.nih.gov/news-events/news-releases/nih-study-identifies-ideal-body-mass-index

NPR. (2016). The food industry's influence in nutrition research. Retrieved from https://www.npr.org/2016/09/17/494360187/industry-influence-in-nutrition-research

Nystrom. (2017). The research behind how brand names impact customers and what name we've changed at buffer. Retrieved from https://open.buffer.com/names-impact-customers/

Oniag, R. & Mukudi, E. (2002). Nutrition and gender. Retrieved from http://www.unscn.org/files/Publications/Briefs_on_Nutrition/Brief7_EN.pdf

Shahzad, U., Iqbal, K., Ahmad, S., & Nawaz, M. (2014). Influence of brand name on customer choice and decision. *Journal of Business and Management, 16*(6), 72-76. doi: 10.9790/487X-16637276

Sneed, A. (2016, May). The Sound of a Brand Name Matters. Retrieved from Fast Company website:https://www.fastcompany.com/3060175/why-the-sound-of-a-brand-name-matters

Sollid, K. (2018) Has perception of sugar become reality? Retrieved from https://foodinsight.org/has-perception-of-sugar-become-reality/

Sukazi, T.(2019). Questionnaire on consumer perception and purchase intent. Retrieved from

https://www.researchgate.net/figure/Questionnaire-on-consumer-

Suzuki, T. (2019) Which aspects of food value promote consumer purchase intent after a disaster? A case study of salmon products in disaster-affected areas of the great East Japan earthquake. *Foods, 8*(14), 1-17. doi:10.3390/foods8010014

World Health Organization (2018). Obesity and Overweight. Retrieved from https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Sleep Restriction Leads to Increased Production of False Memories in STM

Sreeya Bobby, Valley Stream South High School

sreeyabobby@gmail.com

Abstract

Previous studies have focused on the effects of sleep deprivation on the learning process. The novel purpose of this study was to determine the effects of sleep restriction on the production of false memories within suburban high school students. Ten suburban high school students participated in the experiment. Subjects were randomly assigned to one of two groups: a well-rested (WR) group (eight hours of sleep) or a sleep-restricted (SR) group (four hours of sleep). The morning after rest, the subjects took the Deese-Roedigger-McDermott (DRM) false memory task, consisting of listening to a recording, a free recall test, and a recognition test. The results of the recall test were not significantly different, indicating that neither group simply wrote down random words. For the recognition test, the SR group circled a significantly higher percentage of critical lures, suggesting the formation of more false memories. However, the SR group did not have a significantly different percentage of studied words nor foil words circled, allowing for the conclusion that the increase in false memories were generated due to the sleep restriction. There were a few limitations to this study. However, if the study were to be repeated, it would ideally have a larger sample size. In addition to the small sample size, the subjects were not randomly chosen, nor was the quality of sleep monitored. However, these can be remedied with the use of a sleep lab in a future study. Nonetheless, these results add to the growing body of research regarding the importance of sleep to the learning process of students.

Keywords: *sleep, memory, adolescents*

Introduction

A false memory is a mental experience that is mistakenly taken to be a true representation of an event from one's personal past (Johnson & Raye, 1998). False memories can be categorized as either a long-term memory or a short-term memory. Long term memory (LTM) is a subject's ability to obtain, retain, and retrieve information form events that occurred hours, days, months, or even years ago (Guarnieri, 2019). Short term memory (STM) refers to a cognitive system that is used for holding sensory events, movements, and cognitive information, such as digits, words, names, or other items for a brief period of time (Kolb & Wishaw, 2009). Recent research has shown that the generation of false memories is correlated with sleep deprivation, which is defined as less than 7 hours of sleep for children and less than 6 hours for adults (Lo et al., 2016). Sleep is needed to focus attention optimally and learn efficiently; as a result, sleep deprivation is a common problem for high school students. Long term sleep deprivation has been correlated with

depression, anxiety, impaired brain function, and memory loss (Havekes et al., 2016; Palmer & Alfano, 1998). Even one night of sleep deprivation can greatly impact the cognitive processes of encoding and recalling new information. In fact, the recovery process of cognitive functioning seems to take longer after chronic partial sleep restriction than after acute total sleep deprivation (Alhola & Polo-Kantola, 2007). Thus, a sleep-restricted student's impairment in learning (encode) new information in class and retaining (recall) that information may be negatively compounded with the formation of false memories.

Various studies suggest that sleep plays a key role in learning and memory (Maquet, 2001). Memories are created through three stages: the encoding phase, consolidation phase, and the retrieval phase. During the encoding phase, information is received, processed, and combined through our senses. It is in this first stage that information is altered so that the memory can begin the encoding process. The consolidation phase creates a permanent record of the encoded information which enables information to be maintained over periods of time. Lastly, in the retrieval phase, also known as the recall or recognition phase, the information that was once stored *is placed back into our consciousness.* During these phases of memory, the thalamus and frontal lobe of the brain regulate working memory neurons to help encode the memory. Sleep deprivation robs the neurons of the ability to function properly, making it difficult for brain cells to communicate effectively which can lead to attentional lapses, or brief moments of inattentiveness. These lapses have been considered the main reason for the decrease in cognitive performance during sleep restriction (Williams, 1959). Thus, being sleep restricted can interfere with the neuron's ability to encode information. This is because neurons' responses are slower and weaker. Research has shown that failing to get a seven to nine hours of sleep not only interferes with cognitive functioning, but also may lead to creating false memories. And those who get five hours of sleep or less are more likely to form these falsehoods (Lo et al., 2016).

While many studies have focused on the effect of sleep deprivation on false memory, there are a few studies that experiment the role of sleep restriction on the formation of false memories. In numerous experiments, subjects encoded information prior sleeping and recalled the information post sleep. This is considered a long-term memory, because subjects are recalling after a 24-hour time period. On the other hand, very few experiments had subjects encode and recall new information after sleep, which is a short-term memory.

Therefore, the purpose of my experimentation was to determine whether the amount of sleep would play a role in the generation of false memories in short term memory in teenagers. The null hypothesis was that there would be no relationship between amount of sleep and amount of false memories generated. It was hypothesized that the sleep restricted group would generate false memories at a higher rate than well-rested group, while maintaining the same capability of remembering studied words as the well-rested group.

Methodology

Participants

The sample of this study consisted of a total of ten high school students from a New York suburb. The ten students were randomly assigned to either the sleep restricted group or the well-rested group. The sleep restricted group slept for 4 hours while the well-rested group slept for 8 hours. All students slept overnight at a house where a certified nurse was present at the site of the experiment to minimize any risk and monitor both groups. The morning after being sleep restricted, all subjects were given a ride home and warned not to operate any heavy machinery. Subjects were also warned of all the side effects of being of sleep

restricted and were recommended to take rest when arriving home.

Protection of Privacy

Any identifying information that connects the participant to the recognition test, recall test, survey, and Perceived Stress Scale (PCC) test was kept confidential. Students were assigned numbers at the beginning of the study. This was how they were identified by the researcher.

Materials

One widely used method to induce false memories in a laboratory setting is known as the Deese-Roediger-McDermott (DRM) paradigm (Roediger & McDermott, 1995). In the DRM task, participants learn lists of words (e.g., bed, rest, awake, tired) that are semantically related to the non-presented word—the critical lure (sleep). On the recognition tests, participants often recall seeing the non-presented critical lures, which is considered a false memory. The top 18 lists that had the highest probability of generating a false memory in a free recall test were from Stadler, Roediger, and Mcdermott, 1999, and were used in a recording for the encoding task. The 18 lists were recorded onto audio tape in an unfamiliar male voice at the rate of 1 word every 2 seconds. The items in each list were presented in the order shown in the Appendix (i.e., in order of strongest to weakest associative strength). At the end of each list, there were 12 seconds of silence, followed by a 1 second tone, 2 seconds of silence and then the start of the next list. This helped participants phrase the individual lists. The 108-item recognition test included 54 studied words, 18 critical lures, 36 randomly selected words. The studied words were selected from positions 1, 8, and 10 from each of the 18 lists included in the encoding task. A Perceived Stress Scale test, anonymous survey, and consent form were administered as well. The PSS test is a widely used psychological instrument that measures the perception of stress. This test consisted of questions about feelings and thoughts during the last month. Subjects had to rank each question on a scale from zero to four ranging from never to very often (Cohen & Williamson, 1998). The anonymous survey also asked questions regarding age and academic ability.

Procedure

Subjects were given a consent form prior to the experiment. Subjects then took the PSS test prior to sleeping. After sleeping, subjects took an anonymous survey. In the first task, the encoding task, subjects were listened to a list of words. Immediately after subjects were told that they had 10 minutes to type all of the words that they remembered from the encoding task. After the 10 minutes, subjects were given directions before the recognition test. They were asked to read each word carefully and to circle it if they thought it had been presented on any of the 18 lists in the encoding task. Subjects worked through the recognition test at their own pace.

Results

This experiment sought to determine whether any generation of false memories could be attributed to sleep restriction for the volunteers. Based off of the survey and PSS test responses, an ANOVA showed that there was no significant difference in age, academic ability, and stress between the well-rested (WR) and sleep restricted (SR) group.

The results of the recall test can be seen in Figures 1 and 2. It was seen that the subjects in the SR group, on average, typed a significantly greater number of words (WR: 38 +/- 5.1 SR: 58.4 +/- 5.0, $p<0.05$) and critical lures (WR: 7.6 +/- 1.4, SR: 14.8 +/- 4.1, $p<0.05$) from the listening recall test compared to the WR group.

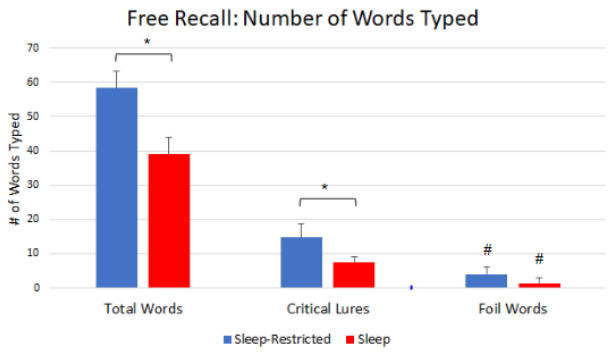

Figure 1 The overall number of words recalled immediately after listening to the list of words. Error bars represent SEM. Asterisk denotes a significant difference between the control and sleep-restricted groups ($p < 0.05$).

Subjects in the SR group, as compared to the WR group, typed a similar percentage of both correct words (WR: 76.67 +/- 5.2, SR: 68.45 +/- 9.16, $p>0.05$) and critical lures (WR: 20.25 +/- 3.1, SR: 24.79 +/- 6.2, $p>0.05$).

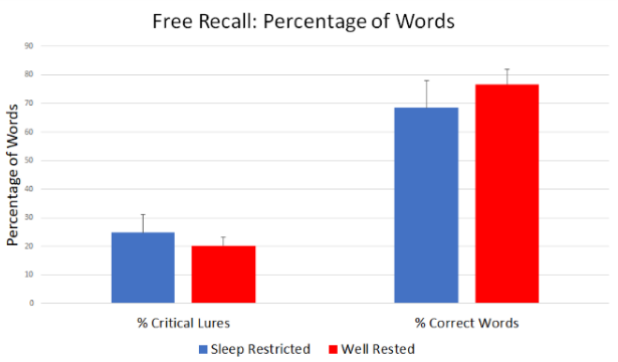

Figure 2. The overall percentage of words recalled immediately after listening to the list of words. Error bars represent SEM.

The results from the recognition test which included the studied words from the recording, foil (random) words, and critical lures are seen in Figures 3 and 4. Both the sleep-restricted and well-rested group spent an approximately equal amount of time on their recognition test, as shown by the insignificant difference (WR: 2.27:25 +/- 0:13:42, SR: 2:45:27 +/- 0:40:26, $p>0.05$) between the two groups.

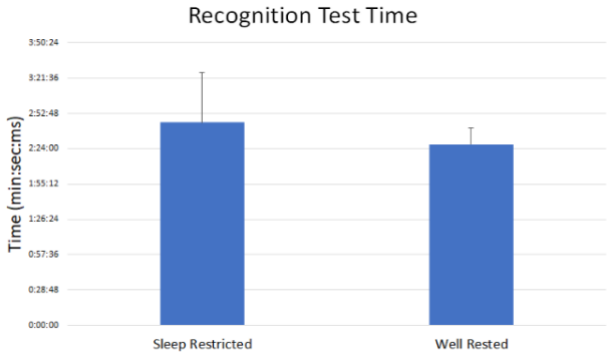

Figure 3. The amount of time spent on the recognition test. Error bars represent SEM. Differences were insignificant ($p>0.05$).

The overall percentage of words circled immediately after listening to the list of words. Subjects in the SR group, as compared to the WR group, circled a similar percentage of both studied words (WR: 48.52 +/- 2.7, SR: 58.52+/- 6.8, $p>0.05$) and foil words (WR: 16.11 +/- 3.7, SR: 22.22 +/-3.5, $p>0.05$). However, there was a significant difference in the percentage of critical lures circled (WR: 56.67 +/- 2.1, SR: 74.44 +/- 6.5, $p<0.05$).

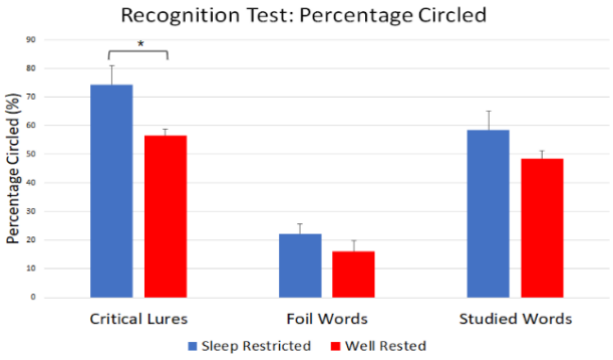

Figure 4. The percentage of circled words on the recognition test. The circled words were separated into critical lures, foil words, and studied words. Error bars represent SEM. A single asterisk denotes a significant difference between the control and sleep-restricted groups ($p < 0.05$).

Discussion

Recall

In the recall test, for both groups, the percentage of critical lures typed was significantly higher than the foil words typed ($p < 0.05$). These results indicate that both groups did not simply

write down random words and were trying their best. The sleep restricted group typed out approximately 50% more total words and 100% more critical lures than the well-rested group, *a significant increase.* This would suggest that the sleep-restricted group generated significantly more false memories. However, this result requires precaution as *Figure 2* showed that the percentage of critical lures to total words, and the percentage of correct words to total words were only slightly significant. Still, a larger sample size would have helped to determine if this result is actually significant.

Recognition

There was no significant difference between the time that the two groups had spent on the recognition test, about 2 and a half minutes. This helped confirm that the differences in the next figure were not due to subjects simply circling fewer words, or randomly guessing. Although the groups spend a fairly equal time on the test, their results significantly differed. In the recognition test, subjects were presented with a list containing 3 types of words, which were the original studied words, foil or random unrelated words, and critical lures which were random related words. They were asked to circle as many words they recognized from the list. Critical lures i.e. related but, non-presented words would indicate the development of a false memory according to the DRM paradigm, if circled. Thus, as the SR group circled a significantly higher percentage of critical lures, the results suggest that more false memories were created ($p < 0.05$). Looking at Figure 4, it is interesting to note that a two factor ANOVA showed no significant differences between the two groups. However, when analyzing each type of circled word individually, there was still no significant difference in the percentage of foil words and studied words between the two groups. Nevertheless, there was a significant increase in critical lures, from 57% to 75%, between the well-rested and sleep-restricted groups, which suggests an increased production of false memories.

A chi-square was used to analyze the results regarding un-circled critical lures between the well-rested and sleep restricted groups (Figure 5). The sleep restricted group had significantly less un-circled critical lures, which suggests that the sleep type did have an effect on the production of false memories. However, it is possible that the poor performance of the sleep-restricted group could have been due to the participants simply circling more incorrect words. For that reason, foil words, i.e. unrelated and non-presented words, were mixed into the recognition test. The sleep restricted group did not have a significantly different percentage of foil words circled ($p > 0.05$); therefore, it could be concluded that more false memories were generated due to the sleep restriction. It is especially interesting to note that the sleep restricted group also circled a significantly higher percentage of studied words on the recognition test, and therefore had a higher percentage of accuracy ($p < 0.05$). This matches the results of the recall test, in which the sleep restricted group had typed a significantly greater number of words.

Conclusion

There were a few limitations to this study. However, the sample size was rather small, which potentially affected the results. In addition, the subjects were not randomly chosen, nor was the quality of sleep monitored. However, these can be remedied with the use of a sleep lab in a future study as a sleep lab could provide deeper analysis on how sleep quality correlates with the generation of false memories. In addition, utilizing sleep or fitness trackers to measure the amounts of deep sleep and REM sleep would be beneficial. Another limitation of this study was that the subjects' sleeping habits leading up to the study were not controlled. Future research should aim to determine how greatly habitual sleep restriction may affect the production of false memories. Overall, the novel results of my

study add to the growing body of research on sleep and student learning. False memories can be very disruptive to the learning process, and this research clearly shows that the lack of sleep can disrupt the learning process as early as the encoding process of our short-term memories, not just our long-term memories.

References

Alhola, P., & Polo-Kantola, P. (2007). Sleep deprivation: Impact on cognitive performance. *Neuropsychiatric Disease and Treatment*, *3*(5), 553–567.

Cohen, S., Spacapan, S., Oskamp, S., & Williamson, G. (1998). Perceived stress in a probability sample of the United States. *The Social Psychology of Health.* Newbury Park, CA: Sage, 1988.

Guarnieri, R.V., Bueno, O.F., & Tudesco, I.D. (2019). True false memories: Neuropsychological and neuropharmacological approaches. *Eat, Learn, Remember, 4*, 45-64. doi:10.5772/intechopen.80918

Havekes, R., Park. A. J. Tudor, J. C., Luczak, V. G., Hansen, R. T., Ferri, S. L., Bruinenberg, V. M., Poplawski, S. G., Day, J. P., Aton, S. J. Radwańska, K. Meerlo, P., Houslav, M. D., Baillie, G. S., & Abel, T (2016). Sleep deprivation causes memory deficits by negatively impacting neuronal connectivity in hippocampal area CA1. *eLife, 5*(2016), 1-22. doi: 10.7554/eLife.13424

Johnson, M. K., & Raye, C. L. (1998). False memories and confabulation. *Trends in Cognitive Sciences*, *2* (4), 137-145.

Kolb, B., & Whishaw, I. Q. (2009). *Fundamentals of human neuropsychology.*New York, NY: Worth Publishers.

Lo, J.C., Chong, P. L., Ganesan, S. Leong, R. L., & Chee. M. W. J. (2016) Sleep deprivation increases formation of false memory. *Sleep Research, 25*(6), 673-682.

Maquet, P. (2001) The role of sleep in learning and memory. *Science, 294*, 1048-1052.

Palmer C. A., & Alfano, C. A. (1998). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews, 31(*2017), 6-16. doi: 10.1016/j.smrv.2015.12.006

Roediger, H. L., & McDermott, K. B. (1995). Creating false memories: Remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21(*4), 803-814.

Williams, H.L., Lubin, A., & Goodnow, J. (1959). Impaired performance with acute sleep loss. *Psychological Monographs*, *73* (484).

JOURNAL OF SECONDARY PSYCHOLOGICAL STUDIES

Submissions: All submissions to the Journal of Secondary Psychological Studies must be emailed to jofsps@gmail.com. Please visit our website https://jofsps.weebly.com for more information regarding our requirements and formatting preferences for submissions.

Feedback: We would love to hear any feedback on our journal. Please email jofsps@gmail.com to help us improve our publication.

JOFSPS