Hue Got It Right: An Experimental Research on Tone of Lights and its Influence on Memory Retention

Anacleto, Azrael Rex

Catalan, Cris Bannie

Cordova, Edlie Joyce

Dizon Jr, Ronaldo

Fernandez, Shiela Mae

Gimena, Francelle Marie

College of Social and Behavioral Sciences, Bataan Peninsula State University - Balanga Campus

PSYC0723: Experimental Psychology

Lawrence D. Balana, LPT, RPM, RPsy

Abstract

Lighting plays a crucial role in our daily lives, shaping our environment and influencing various aspects of our cognitive functions. Even though there are different education systems, all of them find keeping the things students learn in their minds essential as their performance will be measured by activities that show how these learnings are kept and used in different ways. The objective of this research is to explore whether varying tones of light can impact an individual's ability to retain information. The study used a controlled environment, employing different tones of light to examine their effects on memory performance. Participants were asked to study under different lighting conditions, and assessments were conducted afterwards to evaluate their memory retention. This study found that even though there is a slight difference in the average scores of those who studied under the two different tones of light (warm and cool), it was not statistically significant.

Introduction

Brainscape (n.d.) says that long-term memory retention is “a battle with our tendency to forget.”. Research has demonstrated that light can have a significant impact on our mood, attention, and performance. In recent years, studies have focused on the effects of different lighting conditions on memory retention, recognizing the potential of light as a tool to enhance learning and memory processes. (Dzulkifli & Mustafar, 2013).

One particular aspect of lighting that has gained attention is the tone or color temperature of light. Color temperature refers to the perceived warmth or coolness of light, measured in Kelvin (K). Warm-toned light, characterized by lower color temperatures (e.g., 2000K to

3000K), appears more reddish or yellowish, resembling the glow of a candle or sunset. In contrast, cool-toned light, with higher color temperatures (e.g., 5000K to 6500K), has a bluish or whitish tint, similar to natural daylight or electronic screens. (plottedlights, 2023).

There is a wide variety of literature that studies the impact of lighting in classrooms on the performance of students, as well as how different tones of lights affect their environment. Some of these studies have established a relationship between lighting conditions and cognitive performance. For instance, a study has found that warm lighting in educational settings can promote relaxation and a calm atmosphere, leading to improved focus and information recall while cooler lighting makes people more alert and able to concentrate better. Additionally, warm light has been associated with increased engagement and reduced fatigue, which may contribute to enhanced memory consolidation. (Bao, Song, & Bou, 2021). Yang & Jeon (2019) found that color temperature of lighting has an effect on cognitive performance. Another study by Singh (2019) showed that schools with brighter lighting had positive correlation with their performance scores and that classroom lighting has a significant impact on the students' concentration and performance that lead to higher scores.

Souza (2019) compared warm and cooler lights wherein they found that cooler lights made the environment more stimulating and productive while warm lights made the environment more welcoming and relaxing. In addition to that, Alkozei, Smith, Dailey, et al. (2017) concluded in their study that brief exposure to blue light can boost alertness and attentiveness, resulting in faster reaction times and potentially attributed to the activation of the noradrenergic system. They stated that their findings point to a potential application of blue wavelength light to

optimize memory performance in healthy individuals. The goal of this experiment is to compare the differences in the memory retention of the participants when studying under the two lighting conditions in preparation for an exam.

Operational Definition of Terms

The researchers will use terms that might have different meanings compared to other studies, hence the definition of these terms will be given.

Warm Light - Light that ranges from yellow to orange

Cool Light - Light that ranges from white to bluish

Memorization - the action or procedure of acquiring knowledge in such a way that it is retained exactly how it was presented in the memory.

Memory retention - ability to both store and retrieve information understood by a person for a prolonged duration in one's mind.

Statement of the Problem

In one study about modulation of recognition memory performance by light, they found that different luminosity of light affects the recognition memory performance in mice, they also proved that the tests conducted on mice are broadly similar to humans (Hasan et al., 2021). The researchers found that there is a lack of study regarding the influence of different tones of lights on memory retention. Hence, one of this study’s goals is to explore, understand, and analyze the

distinct effects of warm and cool lighting on the memory retention of students who will study under the said conditions. This study also aims to find out which of the two lights is more effective for memory retention in study sessions, especially before taking examinations to help them improve their academic performance. The researchers did not look at any biological effects of light in their participants, they only looked at the effect of the said lighting conditions on the scores of the participants in the examination that they will take in the trials that will be conducted for this study.

Methodology

Participants:

A sample population of 8 first year students from the College of Social and Behavioral Sciences of Bataan Peninsula State University - Balanga Campus were recruited as participants for this study. The researchers used simple random sampling as the sampling method for this study to help the researchers randomize their participants. They will be asked to fill out a consent form giving them the idea of the study that they will participate in.

Experimental Design:

The study will use between-subjects design, where the participants will be subject to testing under one specific tone of light only depending on the group that they will be included in.

Apparatus:

Short bond paper - the material where the handouts and the questionnaire were printed on

Ballpoint pen / pencil

Lamps - used to power the light bulbs that will be used for the experiment

Light Bulbs - 2 warm light bulbs (450lm) and 2 cool light bulbs (470lm); both at 5 watts

Procedure:

1. Pre-testing: Before the experimental session, participants will be oriented about what they need to do during the experiment and they will also be asked for their consent through the consent form that will be provided by the researchers.

2. Experimental Session: Each participant visited the laboratory for a single experimental session. The session was conducted in a dark and quiet room with only the lampshades being the source of light to minimize distractions. The participants were given 20 minutes to study the handouts provided by the researchers and 5 minutes to rest before answering the questionnaire in 20 mins in a total of 45 minutes per session.

3. Manipulation in the Tone of Lights: Participants were exposed to 1 tone of light (warm or cool) depending on the sample group they belong in. The researchers assigned them randomly to the specific condition that they will be tested in. Two sets of light bulbs were used, warm and cool tone lights, and the said lights were close to each other in terms of lumens at 470 lm (white) and 450 lm (yellow) to avoid having the brightness of light becoming a distraction for the experiment sessions. There is still a 20 lm difference between the two light bulbs despite having the same wattage of 5W. HPWinner (n.d.) explained that the high color temperature light will appear brighter to the human eye because color temperature is an important indicator of lighting fixtures. As mentioned, the researchers will provide lampshades and the light bulbs will be

replaced according to which group is currently under the experiment session to ensure that they will study under the expected lighting conditions in the study.

4. Memory Task: Following exposure to each tone of light condition, participants will be asked to answer a questionnaire from Britannica about the American Civil War. The participants were expected to use memorization as their way of studying to prepare for the questionnaire because the topic of the information sheet that they will be given is about history. Memorization will help the researchers measure the memory retention of the participants through the said apparatus that will be provided. The researchers chose the American Civil War as the topic for the questionnaire of this study because it is a subject that is highly unlikely to be studied by the participants because it is not included in the curriculum being taught in the Philippines and that it is another country's local history that doesn't have a connection with the country of the potential participants' local history. Blinding participants to the topic of the questionnaire helps mitigate bias by not allowing previous knowledge or learnings on the topic to interfere and manipulate the goal of the study, which is to measure memory retention while studying under the different tones of light on the study sessions that will be given to the participants during the trials. This measure also helps ensure more genuine and unbiased data that will be generated from the study.

5. Post-testing: Upon completion of the experimental session, participants were debriefed about the purpose of the study and provided with an opportunity to ask questions or express any concerns. They will also have the option to receive a summary of the study's findings upon its completion.

6. Data Analysis: The dependent variable will be memory performance, which will be measured by the number of the correct answers that the participants will get in the said questionnaire. The data will be analyzed with the software Microsoft Excel through the data analysis toolpak using t-test for independent samples as there are two different groups that will answer the questionnaire.

By employing this experimental design and methodology, we aim to uncover valuable insights about the tone of lights and its influence on memory retention. The findings of this research have the potential to contribute to the development of practical applications that optimize memory performance and enhance learning outcomes in various real-world settings.

Review of Related Literature

1. Title: HOW DOES LIGHT EXPOSURE AFFECT MEMORY?

Publication: Mills, 2023, How does Light Exposure Affect Memory?

Summary:

The circadian rhythm, which is the daily cycle of light and darkness affecting human beings bodies, plays a significant role in their health. Disruptions to this cycle can have adverse effects.

Based on the results of this study, it is stated that the amount and color of light an individual receives impacts their daily rhythms, and their brains are most receptive to learning during

daylight hours. When light exposure is mistimed, it can disrupt hormone production, leading to increased stress and mood disorders.

In this particular study the researchers wanted to find out if the circadian rhythm truly does affect one's humans' physical health. In order to do this, they did an experimental research on sixty healthy young adults who were around age 25 to 50 years old. The experimental group underwent a simulated circadian rhythm disruption protocol, which involved delaying their bedtime by 3 hours and waking them up 3 hours earlier than their usual schedule for three consecutive nights. The control group maintained their regular sleep-wake routine. Independent sample T-test was used to compare baseline characteristics between groups with the repeated measures Anova used to examine changes in cognitive performance over time.

The results showed the participants in the experimental group demonstrated a significant decline in cognitive performance compared to the control group. On the other hand, the control group showed signs of stable cognitive performance over the study period.

Now the recommendations of the researchers were to realign an individual's rhythms with the natural sun cycle, it is recommended to prioritize bright blue-rich light in the morning, minimize evening light exposure (especially blue light), and adopt practices like sleeping in darkness and using nightlights strategically. By following these habits, human beings can improve their overall health and well-being throughout our lives.

2. Title: The Influence of LED Lighting on Attention and Long-Term Memory

Publication: Lee, Kim, 2020, The Influence Of LED Lighting On Attention And Long-Term Memory

Summary:

The Researchers have conducted several studies to understand how the brightness of LED lights affects human attention and long-term memory. However, there is no agreement among the studies on the effectiveness of lighting.

In this particular study, the researchers wanted to investigate the effects of LED lighting on attention and long-term memory in a systematic way. In order to do this, they asked 18 students to participate in the experiment and used different brightness levels being, 300lx, 400lx, 500lx, and 1,000lx respectively, to see how LEDs impact the participants attention and memory.

They measured attention using a special device and tested memory using a word completion task. The results showed that the brightest light being 1,000lx had the best effect on attention, while the moderate brightness that being 400lx had the highest impact on long-term memory. These findings suggest that the brightness of LED lights can influence the participants ability to pay attention and remember things, which is important for future research on how light affects their memory.

3.) Title: Do Attention and Memory Tasks Require the Same Lighting? A Study in University Classrooms

Llinares, Castilla, Higuera-Trujillo, 2021

The researchers believed that lighting plays a fundamental role in learning spaces because it has an influence on students' performance. Their study aimed to look at the impact in the levels of brightness and correlated color temperature of classrooms on the cognitive functions of university students.

In this study, they used virtual reality to put the participants in classrooms with no natural lighting and different light illuminances. 90 participants took part in the study with 55% male and the other 45% females. These participants were asked to perform different actions and then answer a questionnaire at the end of these trials.

They found that the three levels of illuminance does have an effect on the attention and memory of students, with high illuminance improving their attention, low illuminance improves their memory while the highest level of illuminance improves both the memory and attention of their participants.

Discussion:

The results of the experimental trials have shown that all participants belonging to the experimental group had a perfect score of 15 while the score of the ones from the control group ranged from 5 to 15 as shown in Figure 1. The mean of the scores of the two groups are 15 for the experimental group, and 11 for the control group as seen in Figure 2.

Experimental Group Scores	Control Group Scores
15	13
15	5
15	15
15	11

Table 1 (raw scores of the participants for the questionnaire)

In the analysis of the data collected for this research, the researchers used "Data Analysis Toolpak" through the Microsoft Excel software for the interpretation of the data they have gathered. The statistical treatment used was Independent T-Test because the participants of the experiments were separated into two groups, experimental and control.

The main purpose of the researchers using the T-test independent was to examine if the two groups of respondents had a significant difference in their test scores and memory retention when exposed to two different tones of lights.

t-Test: Two-Sample Assuming Unequal Variances		
	Experimental Group Scores	*Control Group Scores*
Mean	15	11
Variance	0	18.66666667
Observations	4	4
Hypothesized Mean	0	
df	3	
t Stat	1.8516402	
P(T<=t) one-tail	0.080580924	
t Critical one-tail	2.353363435	
P(T<=t) two-tail	0.161161847	
t Critical two-tail	3.182446305	

Table 2 (Analysis of the raw scores of participants for the questionnaire)

The experiment was conducted in order to uncover if there was a significant difference between the tone of light that a student will use during their study session and their memory retention capabilities upon answering an examination. It is important to note that the test utilized here by the researchers which was the American Civil War is a test that is unbiased and was suitable for the study as it prevented preconceived factors that where outside the researchers control such as prior knowledge, retention and recalling abilities and overall familiarity of the respondents to the test questionnaire being used in the study.

According to the results, the value of T Statistic (1.85) of both the experimental and the control group are both greater than the alpha of 0.5 as well as the P-value (0.16). This led to the researchers' conclusion to accept the null hypothesis, and that there is not a statistical significance between the two groups' scores when exposed to different tones of light they were required to study in during the experiment. One possible influence for the conclusion of this research is the "ceiling effect" which is a situation wherein most of the values obtained for a variable is close to the upper limit of the scale used in its measurement (APA, n.d.).

Another study in the setting of workplaces found that the use of warm light is the better suited one for office settings out of the three lighting options they used, this is because of the lowest mental workload it requires from the employees. However, their data showed that there was no significant interaction between the color temperature and illuminance for mental workload (Bai, Bao, Li, Song, Zhou, 2021) and their findings were similar to this study conducted on first year psychology students.

There were limitations to this study: the state of mind of the participants were not asked before the experiment sessions began. The IQ of the participants were not taken into consideration while the temperature of the room where the experiment was conducted as well as the noise were not constant due to the researchers having only limited equipment and authority.

Conclusion:

With the results of the experiment conducted, the researchers have concluded that there is no statistically significant difference between the use of warm light and cool light. However, even though the raw scores of the participants had a slight difference, the researchers are recommending that another study be conducted under the same conditions and treatments, but with more participants to help determine which of the two lights are better suited for studying for examinations.

One of the takeaways by the researchers from this study is that there are other variables affecting the memory retention while studying that are more relevant compared to the tone of lights in the study area. One of these variables is the temperature of the room which was found to influence the ability to absorb information (Klima Therm, 2021).

Another recommendation for future researchers is that the IQ of the participants be taken into consideration as well as their study habits. Cohen & Sandberg (1977) showed that people with higher IQ showed stronger predictive power for recalling recent items because those who had lower IQ used less effective strategies compared to ones with higher IQ. Their study recommended that individual differences in rehearsal, item persistence, and accessing information in short-term memory may contribute to these results. This recommendation was

backed up by another study where they found that students don't seem to know the way of studying that suits and helps them become more efficient. Nearly half of their participants in the study used the same method of their studying even though they found it not effective (Grnaz, 2022) and this can influence the memory retention of their participants.

Lastly, noise can also have a significant impact on working memory according to Khajehdehi (2018). The study stated that it can have negative effects on the working memory no matter the origin of the sound.

References

Alkozei, A., Smith, R., Dailey, N. S., Bajaj, S., & Killgore, W. D. (2017). Acute exposure to blue wavelength light during memory consolidation improves verbal memory performance. *PLOS ONE*, *12*(9), e0184884. https://doi.org/10.1371/journal.pone.0184884

APA Dictionary of Psychology. (n.d.). https://dictionary.apa.org/ceiling-effect

Bao, J., Song, X., Li, Y., Bai, Y., & Zhou, Q. (2021). Effect of lighting illuminance and colour temperature on mental workload in an office setting. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-94795-0

Castilla, N., Llinares, C., Bisegna, F., & Blanca-Giménez, V. (2018). Affective evaluation of the luminous environment in university classrooms. *Journal of Environmental Psychology*, *58*, 52–62. https://doi.org/10.1016/j.jenvp.2018.07.010

Cohen, R. C., & Sandberg, T. (1977). Relation between intelligence and short-term memory. *Cognitive Psychology*, *9*(4), 534–554. https://doi.org/10.1016/0010-0285(77)90019-6

Dzulkifli, M. A. (2013). *The Influence of Colour on Memory Performance: A Review*. PubMed Central (PMC). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3743993/

Grnaz, A. (2020). Students' Forgetfulness as a Learning Problem: Some Reasons and Solutions. *www.academia.edu*.https://www.academia.edu/42051008/Students_Forgetfulness_as_a_Learning_Problem_Some_Reasons_and_Solutions

Hasan, S. S., Ske, T., Foster, R. G., Vyazovskiy, V. V., Bannerman, D. M., & Peirson, S. N. (2021). Modulation of recognition memory performance by light and its relationship with cortical EEG theta and gamma activities. *Biochemical Pharmacology*, *191*, 114404. https://doi.org/10.1016/j.bcp.2020.114404

Khajehdehi, K. (2018). Effects of noise on memory performance in adults. *Umea Universitet*. *https://www.diva-portal.org/smash/get/diva2:1289686/FULLTEXT01.pdf*

Lee, C., & Kim, J. (2020). The Influence of LED Lighting on Attention and Long-Term Memory. *International Journal of Optics*, *2020*, 1–6. https://doi.org/10.1155/2020/8652108

Schön, N. (2021). How long-term memory retention works. *Brainscape Academy*. https://www.brainscape.com/academy/how-long-term-memory-retention-works/

Unknown (2021). Classroom Temperature: How it Affects Learning. *Klima-Therm*. https://klima-therm.co.uk/news/classroom-temperature-how-it-affects-learning/#:~:text=Research%20shows%20that%20studying%20in,classroom%20could%20affect%20student%20performance.

Unknown. (n.d.). *The Civil War Quiz*. Encyclopedia Britannica. https://www.britannica.com/quiz/american-civil-war-quiz

Zac. (2023). Warm Vs Cool White: Why The Difference Matters | Plotted Lights. *Plotted Lights*. https://plottedlights.com/warm-vs-cool-white/

Appendices

American Civil War Handouts

Reconstruction Era - named after the “reconstruction” of the Union with the defeated Southern states. It started after the Civil War.

Confiscation Acts (1861 - 1864) - a series of laws passed by the federal government during the American Civil War that were designed to liberate enslaved persons in the seceded states. It was passed on August 6, 1861.

Appomattox Court House - the site of the surrender of the Confederate forces led by General Robert E. Lee to those of the North in Virginia on April 9, 1865.

John Brown’s Body - an epic poem in eight sections about the American Civil War by Stephen Vincent Benet that was published in 1928. Its narrative begins just before John Brown’s raid and ends on the assassination of Pres. Abraham Lincoln, the poem later won the Pulitzer Prize.

1865 - the year when Abraham Lincoln was assassinated, just days after the end of the American Civil War.

Reconstruction Acts of 1867 - divided the South into five military districts and outlined how the states were required to craft new constitutions, which had to include universal male suffrage, and needed approval by the U.S. Congress.

George H. Thomas - a Union general in the American Civil War (1861-65), known as “the Rock of Chickamauga” after his unyielding defense in combat near that stream in northwestern Georgia in September 1863.

Ulysses S. Grant - commanded the Union armies during the Civil War and became president soon after the war ended.

Carpetbagger - a derogatory term for an individual from the North who relocated to the South during Reconstruction Period (1865 - 1877) following the American Civil War and accused of coming to the South to use the newly enfranchised freedmen as a means of obtaining office or profit.

Trent Affair (1861) - happened in November 8, 1861 wherein Captain Charles Wilkes, commanding the Union frigate San Jacinto, seized from the neutral British ship Trent two Confederate commissioners, James Murray Mason and John Slidell, who were seeking the support of England and France for the cause of the Confederacy.

American Civil War - also known as the War Between the States, lasted four years between the United States and 11 Southern States.

Gatling gun - was a hand driven machine gun that was first to solve the problems of loading, reliability, and the firing of sustained bursts. It was invented in 1862 by Richard Jordan Gatling during the American Civil War.

John Brown - led the raid on the federal arsenal at Harpers Ferry, Virginia in 1859. It made him a martyr for the antislavery cause.

Montgomery - One of the 11 southern states that seceded from the Union in 1860-61. Montgomery became the first capital of the Confederacy in February 1861.

Winfield Scott - was a union general early in the American Civil War that proposed the military strategy called “The Anaconda Plan”.

Appendices

The American Civil War Questionnaire (Britannica)

Instruction:

Write the best answer from the word box in the blank provided before the question.

Montgomery	John Brown's Body
4 years	Appomattox Court House
George H. Thomas	7 years
Reconstruction Era	Carpetbagger
Confiscation Acts	Trent Affair
Winfield Scott	1861
1865	Gatling gun
John Brown	Reconstruction Acts of 1867
Ulysses S. Grant	Gilded Age

_____1.) Under which legislation was the South divided into five military districts after the war?

_____ 2.) Which city was the first capital of the Confederate States of America?

_____ 3.) What name was given to people who relocated to the South from the North during the Reconstruction period, and were accused by Southerners of exploiting the newly enfranchised freedmen?

_____ 4.) Who proposed the "Anaconda plan" military strategy during the American Civil War?

_____ 5.) For which poem was Stephen Vincent Benét awarded the Pulitzer Prize?

_____ 6.) Who led the raid on Harpers Ferry in 1859, an event that was instrumental in heightening the animosities that led to the American Civil War?

_____ 7.) Which general in the American Civil War earned the nickname “the Rock of Chickamauga”?

_____ 8.) Where did Confederate General Robert E. Lee surrender to Union General Ulysses S. Grant at the end of the Civil War?

_____ 9.) Which machine gun was invented during the American Civil War?

_____ 10.) Which acts were passed by the federal government during the American Civil War to liberate enslaved persons in the seceded states?

_____ 11.) How many years did the American Civil War last?

_____ 12.) Which era immediately followed The American Civil War?

_____ 13.) During which incident did Captain Charles Wilkes unlawfully seize two Confederate commissioners from a neutral British ship?

_____ 14.) In what year was Abraham Lincoln assassinated?

_____ 15.) Which American Civil War general later became president of the United States?