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Influence of Primary Colors on Memory Retention of Student Gamers

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ABSTRACT

The intricate relationship between colors and memory has been a widespread interest in human psychology. The present study sought to better understand the influence of primary colors on memory retention among student gamers in Higher Education Institutions (HEIs). Applying a quantitative research approach, specifically an experimental research design, examined two independent variables and a control condition. Respondents were composed of 30 student gamers. Most of them were undergraduate students who were exposed to video game experiments and were chosen purposively. In analyzing the collected data, one-way ANOVA and Mauchly's Test of Sphericity were utilized. Results revealed that primary colors do not significantly influence memory recall. This implies that better memory performance cannot be attributed to the facets of primary colors. Limitations were acknowledged regarding the chosen sample size and the research instruments' procedural use. Hence, further studies may be conducted by minimizing the confounding variables and other external distractors in the same environment.

INTRODUCTION

Cognitive psychologists have increasingly studied interest in the relationship between color and memory. Important association humans make with colors is noticeably embedded in their daily lives. It is evident in areas of study like art and marketing. The study of Labrecque and Milne (2012), revealed that high saturation of color in products increases arousal and excitement among consumers. Color is also one of the most predominant stimuli that can elicit an emotional response. Kurt and Osueke's (2014) study on colors and mood, red evokes entertainment and attention and has the most potential for arousal in comparison to cool tones like blue and green. These findings show how color can affect different psychological functions.

People are constantly exposed to stimulations, especially in the advent of technology. They learn through their interactions with their environment, one of which is done using the senses. Asare *et al.* (2023) disclosed how social media extended its reach regarding the interconnection among individuals. This is because the provision of fascinating visual stimuli allowed them to be more responsive to each other. Facilitation of colors in different mediums of learning is seen in different visual aids, highlighters, and sticky notes enhancing memory performance through the execution of colors. In the current educational landscape, the commencement of online learning in the recent past has paved the way for stakeholders in the academe (i.e., students and teachers) to process, transfer and retain learning systems by recalling them effortlessly (Sariakin *et al.*, 2023). The process of memory retention and recall is represented through different models proposed by different scientists. In the present study, the researchers are following Atkinson

and Shiffrin's (1986) model. In its most basic principle, information is acquired through learning and retention is dependent on how the memory is processed. In the process of learning, there are three widely accepted components of memory proposed by Atkinson and Shiffrin (1968) namely: sensory memory, short-term memory or the working memory, and long-term memory. Further, the acquisition of knowledge is a representation of memory (Amin & Malik, 2013).

Indeed, numerous studies have taken interest in finding out the relationship between color and memory. However, the researchers noticed the lack of studies that caters to primary colors. Further, most of the studies are conducted in a way where information is presented in a face-to-face setting. With the current challenges that hinder students' learning and the rapid rise of information technology where one can already access information online, researchers aim to study how color may influence memory retention, most especially through a virtual presentation of information. The present study will be focused on the medium of information where texts will be displayed on colored backgrounds and shown through computer screens. Taking into consideration that not all colors are sustainable to investigate, the researchers decided to narrow down to the most basic of colors: primary colors, namely red, blue, and yellow. With this, researchers also redound to enrich future works of literature and research, further narrowing down the color that affects memory performance, if not possibly even specifying it.

Statement of the Problem

The study aimed to provide an in-depth understanding and discovery as to whether there is an influence of

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primary colors on memory retention among HEI student gamers.

Further, current study sought to answer the following questions:

1. Is there a significant difference, in terms of the numbers of words retained to memory, in using different types of colors as a visual aid in a memory test?

1.1 Primary colors

1.2 Non-primary colors

1.3 White

2 Does using primary colors as visual aid help in achieving better memory retention performance?

LITERATURE REVIEW

Color

Color can be defined in numerous ways. In art, color is objectively defined as an element that is produced when light strikes an object resulting in a reflection that can be perceived by the eye. Indeed, color is a powerful element, one color can be combined to create another. One of the basic colors that predates modern scientific color theory is red, blue, and yellow – which are considered primary colors in subtractive models of colors. According to Sir Isaac Newton, color possesses causal powers and can cause themselves to be seen (Code, 2008). For instance, in psychology, color has also been an interest of many scholars in finding out its relationship in causing different psychological responses (Elliot, 2015). It has been present since 1810. Goeth (1810) coined his “Theory of Colors” in which he linked colors to emotional responding. Throughout the decade, advancements have been made with the empirical and theoretical framework of this topic. However, works of literature have shown weaknesses that make this topic an ongoing field of interest until the present day. For instance, a recent review by Cherry (2024) stated that color can be a powerful communication tool that can be used to signal action, influence one’s mood, influence physiological reactions, and even performance. With the general perception of colors in the spectrum-- like how warm colors (yellow, orange, and red) elicit emotions from warmth or comfort to anger and aggression, cool colors (green, blue, and purple) draw a feeling of calmness but can also be sadness and demotivation, it can influence performance. It is even pointed out that exposing students to color red before taking an exam negatively affects their academic performance.

In support of Cherry’s 2020 review that claims color can elicit certain emotions that influence performance is a study by Joosten *et al.* (2012) which studied colors and emotions in video games. They hypothesized that the specific identified emotion-linked colors (Plutchik, 2001) would elicit emotional responses which were classified as: arousal (physiological and psychological state of proactive and reactive to a stimulus) and valence (intrinsic feeling that is experienced because of an event, object, or situation) in a condition. They also hypothesized that there was a difference in scores between experienced and

inexperienced participants. To test this, they created a video game in which there were five conditions. In four of the rooms, the researchers manipulated the ambient light to the following colors: light blue, dark green, yellow, red, and then a control room. The participants went through each room to collect five items from NPCs that they had to use to acquire a key to “win” the game. To assess the emotional responses, Joosten *et al* used the Self-Assessment Manikin (SAM), which measures arousal, valence, and dominance score (used to determine the perceived control of the participant and the condition). The participants were asked to answer using SAM about their current emotional state after each room. In examining scores for the inexperienced participants, they found out they scored significantly lower on valence than the experienced participants. They also scored lower in dominance in colors yellow, red, and the control group. The inexperienced participants, therefore, gained less pleasure and felt less control in the conditions. However, they found no significant difference between the scores of experienced participants in any of the dimensions and colors. In examining the dimensions, red proved to have the highest emotional arousal among all the colors. Yellow scored significantly higher in eliciting valence in comparison to red which scored significantly lower. Finally, they found no significant effects of dominance among the conditions. In conclusion, the significant effects of colors in eliciting emotional responses were only seen in the inexperienced participants.

Memory

Human memory is a crucial notion in cognitive psychology and neuroscience that has been an increasing field of interest in numerous studies. According to Atkinson and Shrifin’s (1968) Multi-Store Model, there are three types of memory namely: short-term memory, long-term memory, and sensory memory. These memory stores are considered to have their characteristics in terms of encoding, capacity, and duration to store information. Short-term memory has the capacity to store small amounts of information. Long-term memory on the other hand can store information over a more extended period, hence considered to be more stable and long-lasting. Lastly, sensory memory has the shortest-term element of memory - simply retaining information after a stimulus has ended.

Despite the differing capacities, memory performance has been studied throughout the years and is tested using different approaches and yielding contradicting results. Several studies reviewed by the researchers include testing memory with color, interweaving it with learning and retention. For instance, a study by Finn *et. al.* (2011) hypothesized that undergraduate medical students would learn better when bright-colored body painting was involved in teaching anatomy. With 117 undergraduate medical students, participants were divided into two conditions: block color (CLR) and black color (BLK). Before the experiment, the participants had completed a

pretest before the body painting session on abdominal pain. After that, the students used a mapped outline with their corresponding conditions. After four weeks, students took a post-test to compare retention. Noting that after teaching, there was no difference in knowledge between the two groups. Results showed that there was no discernable difference in long-term memory retention among the BLK and CLR students.

Influence of Primary Color on Memory

Having established color and memory from the previous sections, the following studies focus on the relationship between the two. A study by Singg and Mull (2017) involved college students' performance on tests printed on differently colored papers which yielded interesting but conflicting results. The paper color did not have any significant results that coincides with the previous claims. However, it was seen that men and women had a significant difference in their word recall regarding yellow and blue colors. Women did better in the blue paper while men did better in yellow paper. It is noted that cultural conditions might have affected the result. In Texas, yellow is considered a culturally positive condition which might have enhanced their word recall. While women associate color with anxiety which could have interfered in their word recall. It is concluded in this study that cool colored papers such as blue are more suitable to be used by women and warm colors such as yellow might be better for men (Singg & Mull, 2017).

Galvez (2015), on the other hand, expected to find a correlation between color and cognitive performance among university students seeking credit for a psychology course. In his study, the stimuli were manipulated by putting target letters in an n-back task into either Baker-Miller pink, blue, red, or black to test the effect of color on working memory performance. With the increase of load, there will be a decrease in working memory performance. Galvez (2015) predicted that there will be a positive correlation between color red and total working memory accuracy, blue working memory accuracy for the 3-back, and no effect of either pink or black on working memory accuracy. It is concluded in the results and discussion that color has no effect on accuracy and the colors red and blue have no significant difference with other colors in affecting working memory performance. It is assumed that there are variables in the preceding studies that are not present in this one such as the difference between society and culture which presents certain colors with different meanings.

METHODOLOGY

Research Design

The present study utilized a within-subjects experimental design with two levels of independent variables and a control condition. The two levels of independent variables consisted of primary colors (red, blue, and yellow) and non-primary colors (green, orange, and violet) applied as text backgrounds. The control condition

was the traditional black and white presentation of text. The dependent variable was memory retention and was derived from test scores. In analyzing the scores between conditions and finding whether there is a significant influence between primary colors and memory retention, one-way ANOVA was used.

Participants

The participants of this study consisted of 15 male and 15 female higher education institution (HEI) students from the age of 18 to 23, the majority was 21 years old, residing in the Philippines. Participants were derived through purposive sampling. The respondents were mostly undergraduate students, and one was on masters. 15 of them put in more than 1000+ hours in FPS video games, followed by the other 15 ranging from 100-900+ hours. To completely participate in the experiment, one is sent a consent form first that discusses the procedure and implications of the study. If one agrees to join and finishes the whole procedure, they are promised to be a part of a raffle that will possibly win 1000 Valorant points or Php 350 sent through GCash.

Research Instruments

The tools that were used in the study were purely online and virtual. The whole procedure was utilized via Google meet and responses were elicited through Google Forms. In presenting the texts on primary-colored or non-primary-colored backgrounds, a video containing all the instructions and pool of texts presented as slides were readily made by the researchers to keep the time of the procedure standardized. The words written on the blocks were taken from a list from an article in Reading Rockets featuring words that are "schwa" or those that have unstressed syllables. To test memory retention, after each slide that contains the text, the participants were sent Google forms to recall the words they have read within one minute. To prevent the participants from editing their answers, one Google form will be provided for each slide to answer. A strict schedule was consistently followed by the researchers while experimenting to guarantee that each participant has an equal time duration in viewing the slides and answering the forms.

Data Gathering Procedure

The researchers selected HEI gamers who were asked to take part in this experiment; the gamers were informed that this is all voluntary and that they are not forced to participate. Through Facebook Messenger, the participants were sent a Google form link that contained the informed consent form. A brief introduction about the study as well as its purpose was indicated in the form. The ones who were willing to join received an informed consent form to fill out and send back to the researchers. Those who did not turn in a signed informed consent were not able to participate. The participants also had to fill in a form regarding their demographics such as name, age, gender, location, etc. To lessen the gap between

the participants' personal devices and location, the researchers asked to turn their screen brightness level to 50%. Before the experiment, the researchers performed a pilot run to test the efficacy. A speed test was taken by the researcher responsible to share screens in Google meet. Those who were eligible to proceed to the testing received a link through Facebook Messenger redirecting them to a Google Meet. The researchers showed (through screen share) a 5-minute and 25-second video containing slides with instructions as to how the experiment will go and 3 slides with a 3 x 5 grid (15 blocks in total) to the participant for 30 seconds. The slide is 16.5 x 11" with blocks that are 2.58 x 1.82" in size. Each block has a 2- syllable English word from an article in Reading Rockets. 5 of the blocks are filled with primary colors as background, 5 for non-primary colors, and the last 5 with white as the control condition. This is to see whether the participants will be able to retain information longer when influenced by primary colors.

After each slide, the participants were sent a Google link through the chat box and were asked within 1 minute to write down the words they can recall then go back to the Google meet for the next batch of words as they hear the countdown which indicates the end of the time given. This part was repeated three times. The subjects were debriefed after the experiment since they did not fully know the entirety of the research title-- for them to avoid prioritizing the words written with the primary-colored blocks. As the experiment was coming to an end, the researchers sent out another form asking for their details and what they preferred as a reward for the raffle. From there, the researchers checked the listed words and counted the terms associated with primary colors and those that were not.

Ethical Considerations

With the title stating the independent variables of the study, a small level of deception was used to avoid confounding the data. The title "Influence of Colors in Memory Retention Among Student Gamers" was temporarily disclosed during the collection of data. This was done to prevent the participants from prioritizing the text on primary colors during the text presentation. Furthermore, the researchers made sure to observe ethical standards throughout the rest of the study. Participants were guaranteed that their personal information will be

treated with confidentiality and that their responses will be disclosed with anonymity. Participants will also be informed that their participation is voluntary and that they have the freedom to withdraw their participation from the study if they wish to do so. Informed consent forms were handed as well to each of the participant before they were asked to participate in the whole procedure, with the conditions. After their participation, each participant was fully debriefed about the nature and the purpose of the study being conducted and the whole title of the study was fully disclosed.

Data Analysis

Since the collection of data was done using Google Forms, it was made easier for the researchers to monitor the percentage and frequencies of the demographic profile of the participants. Furthermore, the rest of the data was encoded on Microsoft Excel where additional graphs were also created for analysis. The scores are then exported to SPSS IBM 25 for better analysis.

In terms of a deeper analysis of data with consideration of the design used by the researchers, the present study utilized One-way Repeated Measures Analysis of Variance (ANOVA). Since the experiment utilized a within-subjects design, the researchers had to make sure that the data used is valid. This is also made to minimize the possibility of Type 1 error. Hence, as part of the Analysis of Variance, a test of Sphericity is used. The researchers used Mauchly's Test of Sphericity as provided by the IBM SPSS 25.

Provided that the test of sphericity has shown that the data has not violated the assumption, the researchers have proceeded on relying on the data provided by the SPSS. Tables and statistics shown upon presenting the findings are based on the results found on the software.

RESULTS AND DISCUSSION

Test of Sphericity

Since the study utilized the within-group participant design, repeated-measures ANOVA was utilized to test the difference between the scores of the three tested variables (primary colors, non-primary colors, and control group). Considering that the data came from the same group of people, a measure of sphericity is to be done to assess whether the data gathered is considered valid for further analysis.

Mauchly's Test of Sphericity ^a							
Measure:							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon ^b		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
color	0.829	5.267	2	0.072	0.854	0.902	0.500
Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed							
a. Design: Intercept							
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.							

Figure 1: Test for the Assumption of Sphericity

Table 1 Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been violated, $X^2(2) = 5.267$, $p = 0.072$. With the significance level set at 0.05 results state that $P > 0.05$ which means that the test is nonsignificant, therefore indicating that the variances of differences are equal, which implies that the standard analysis of variance is not positively biased.

One-Way Repeated Measures ANOVA

With Mauchly's Test indicating that the data has not violated the assumption of sphericity, further analysis

could be done with the use of the data in One-way within-subjects ANOVA as indicated in Figure 2.

A one-way within-subjects ANOVA indicated that primary colors do not have a significant influence on memory recall during the test. As shown in the table 2, $F(2, 58) = 0.43$, $p = 0.65 > 0.05$, partial $\eta^2 = 0.02$. Furthermore, this is supported upon presenting the tables of the mean scores which indicates that it was the control group (black text on white background has the highest mean score ($M = 7.57$) compared to Primary Color ($M = 7.1$) and Non-primary Color ($M = 7$) as indicated in Figure 3.

Tests of Within-Subjects Effects									
Measure:									
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power ^a
color	Sphericity Assumed	5.489	2	2.744	0.430	0.652	0.015	0.861	0.117
	Greenhouse-Geisser	5.489	1.707	3.215	0.430	0.621	0.015	0.735	0.111
	Huynh-Feldt	5.489	1.803	3.044	0.430	0.632	0.015	0.776	0.113
	Lower-bound	5.489	1.000	5.489	0.430	0.517	0.015	0.430	0.097
Error(color)	Sphericity Assumed	369.844	58	6.377					
	Greenhouse-Geisser	369.844	49.511	7.470					
	Huynh-Feldt	369.844	52.297	7.072					
	Lower-bound	369.844	29.000	12.753					
a. Computed using alpha = .05									

Figure 2: One-way within-subjects ANOVA

color	Independent Variable	Mean	Std. Deviation	N
1	primary	7.1000	4.18824	30
2	nonprimary	7.0000	3.74166	30
3	control	7.5667	4.27247	30

Figure 3: Mean and Standard Deviation

CONCLUSION

Memory is one of the most sought topics when it comes to the field of cognitive psychology. Studies involving the capacity of human memory and focusing on how memories are acquired, stored, and retrieved have been one of the most developed aspects throughout the years (Lu & Dusher, 2007). Associative learning can be tested by pairing one stimulus (text) with another (color) and later testing whether a subject has learned to make the association between the two stimuli (Byrne, 2017). This can be used as an explanation when students remember information when highlights are used to incorporate certain colors into important information. Moreover, there is no indication that primary colors help in achieving better memory performance when it comes to visual aids. According to Yaffe (2019) visual aids need to be less visual as they are usually guides for the audience to be in

tune with the speaker. There are many factors that should be considered when making one such as font size, font style, consistency of color scheme, and number of words per slide. conducting the study and thorough analysis of data through One-way Repeated Measures ANOVA, the researchers have found that Primary Colors (red, blue, and yellow) have no significant influence on memory retention among student gamers with the result: $F(2, 58) = 0.43$, $p = 0.65 > 0.05$, partial $\eta^2 = 0.02$. However, a trend was noticed by the researchers. Overall, the most recalled word (90%) is from the first row, the first column with a white background, another within the first row, and the first column with a yellow background (70%). One of the possible explanations of the phenomenon is the Serial Position Effect. According to Troyer (2011), the recall of the item is dependent on the position of the study set. Hence, this may open a new possibility of future study.

LIMITATIONS

Although the study has failed to reject the null hypothesis, the findings however still contribute to the pool of knowledge in the respective field. This creates a springboard for further improvements in future research. Hence, the researchers suggest noting the following limitations in the study and recommendations.

The present study focused the sample participants on FPS

student gamers derived from purposive sampling, which is considered a representative sample for people involved in heavy virtual 3D environment exposure. Researchers suggest for future studies focus on samples exposed to text-related games or simply students, focusing the stimulus on text and colors.

The researchers recommend studying another area of memory in people who are consistently exposed to 3D virtual environments. Further research can focus on spatial navigation working memory to test visuospatial memory skills, which would fit the study of student gamers.

Due to the current situation where resources are also limited, the researchers have encountered a limitation on the research participants. The research was only able to cater to 30 respondents. The researchers recommend a greater sample size as it would better affect the research with more diverse responses through a larger data set. Moreover, the data is more concentrated on student gamers residing in Cebu City- providing 20 responses out of 30.

Another recommendation revolved around the instrument used in the procedure. The present study used texts on different colored blocks as background. Furthermore, researchers suggest applying colors on bodies of texts as highlights instead to instigate a realistic tool for reading and applications of treatments.

Researchers also recommend minimizing the confounding variables by experimenting in the same environment. Considering the possibility that distractions such as noise and light on their surroundings may have affected the encoding of information by the participants. In the present study, experimenting with a specific time slot was also not observed. The time could have affected how the participants view the color despite making sure their screen brightness was the same. Natural and artificial light depending on the environment could have influenced the participants' engagement. Furthermore, researchers suggest conducting a study in a more controlled environment.

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