Science PBAT

Neuroscience: Colorful Patterns

Assessment: Outstanding/Good

Neuroscience:
Performance Based Assessment Task

Description: You will first generate an experimental question and hypothesis based on background research. Next, you will design and execute an experiment that tests your hypothesis. Then you will apply statistical analysis to your results in order to evaluate your hypothesis. Finally, you will write a primary research article following the conventions of science writing.

Formatting Basics:

- Use Times or Times New Roman, 12 pt. font
- Single space
- Label and center main section heading
- NO PERSONAL PRONOUNS (I, you, we, our, etc). Methods section must be in third person

Neuroscience Performance Based Assessment Task
Section Guidelines

ABSTRACT

Abstract: An abstract is a concise summary of the key points of the experiment that the lab report is describing. Like the title, it allows the reader to review the content of the article quickly. This is why the abstract may be the most important single paragraph of the entire lab report. The abstract needs to be densely packed with information that accurately presents the key points of each section the lab report in a coherent and concise manner (*250 words or less*).

1. Background information about the research "problem"
2. The hypothesis
3. Characteristics of participants (only essential features, for example age, number of participants, etc)
4. Essential features of methods (only essential features)
5. Basic findings (results) / Include P Value
6. Conclusions & interpretations / Reject or fail to reject the null hypothesis
7. Implications/applications/future research ideas

INTRODUCTION OVERVIEW

Introduction Objectives: The introduction provides the reader with background information that communicates the importance of your investigation, and the prior knowledge/research that led you there. A good introduction *builds* a hypothesis from start to finish – starting with the basic concepts and theories underlying your topic, and ends with results from prior studies that directly relate to your research question. By the time your hypothesis is stated in the final paragraph, the reader should have no question about why you are making this hypothesis.

Writing Conventions: Write in complete sentences, use formal language and do not use contractions. Each paragraph must have a topic sentence. Each topic sentence should be related to the last sentence of the paragraph that comes before it. Each paragraph should be connected in style and substance.

First Paragraph: The first paragraph of your introduction should serve as an outline for your entire introduction by introducing the reader to the general topics that you will cover throughout the introduction of your paper.

Pages 1-5: The first four to five pages of your introduction should establish the broad context of the topic(s) you are exploring by discussing KEY TOPICS that are related to each of your variables. You should also discuss how your topic relates to neuroscience by explaining neurotransmission and how one of your variables impacts neurotransmission. You should summarizes previous research that relates to your topic by outlining the aims, methods and results of multiple experiments (primary sources) that led you to your hypothesis and influenced your experimental design. Remember that you are *building* a hypothesis, so these topics and experiments should relate, but not be identical to your future experiment.

Pages 6-7: The last one to two pages of your introduction should provide the reader with a very brief explanation of your experiment, your hypothesis and your null hypothesis. You should explain how your r what you seek to learn from your experiment contributes to, fits in with, or differs from other available work on this subject (Hay, 1996)

Outline Checklist: You are responsible for organizing and outlining your paper so that it meets the objectives of the introduction as outlined in the first paragraph of this handout. I have provided you with some general guidlines above, however, because each paper is unique you should write a detailed outline of your introduction so that it is well organized and covers all of the topics outlined in the checklist below.

Introduction (3-5 pages)
Neuroscience PBAT: In Further Detail

First paragraphs: General outline for your whole introduction

- Give background information about your independent and dependent variables.

    - For example, what is memory? Describe the different types of memory and compare and contrast them. Do the same for pain.
- Explain neurotransmission and connect your independent and dependent variables to neurotransmission.
    - What is neurotransmission?
    - For example, how does pain impact neurotransmission and memory? (Note: refer back to the page you wrote about how neurotransmission works) That paragraph should be included.

Next paragraphs: Summarize previous research (*Use your BROs and RSSS forms and mini-PBAT document). Write one paragraph per source. Include at least 3 primary sources and 3 secondary sources.

- For each paragraph:
    - Describe the aim, methods, and results of the experiments from the primary sources and do the same for the secondary sources when applicable. When your secondary sources do not review research paraphrase and connect the information to your work.

Next paragraph: Synthesize the research to create a hypothesis

- Summarize the key learnings from these previous experiments
- Describe how this information helped you create your research question as well as your hypothesis. State clearly your research question and your hypothesis.
- How did these previous experiments influence the design of your experiment? Give a one or two sentence description of your experiment.

Next paragraph:

- How do the objectives of your experiment contribute to, fit in with, or differ from other available work on this subject?
    - For example: Is your test population different in any way than subjects of previous research? (gender, age, ethnicity, race, health, etc) Why is this important? How might this impact or improve society?

Basic Checklist

My Introduction…

___ **includes** general background information about multiple aspects of my topic

___ contains detailed background information about the specifics of my reseach question

___ **contains information about neurotransmission and how my topic impacts neurostransmission**

___ explains the potential scientific and societal importance of my research topic

i.e make sure your reader knows why this problem is worth investigating

___ includes a discussion about the key topics that are critical to understanding my investigation

___ includes **a review of the background research that led me to my hypothesis**

___ includes **my complete hypothesis**

___ inlcudes a **brief** description of my research design

___ includes a brief explanation of h**ow my research design tests my hypothesis**

___ has been compared to the consortiuum rubric

___ uses professional language and DOES NOT use contractions and avoids the use of personal prounouns

Materials & Methods

Materials & Methods:

Appropriately identifies and describes participants, materials and procedures. Provides enough detail to allow the reader to fully understand and replicate the experiment. The Materials and Methods section of your PBAT should provide the reader with a detailed summary of how your experiment was carried out and what calculations you performed to "crunch" your data. Your reader should be able to clearly understand the procedure of your experiment and the different variables that have been considered. In your methods, you should clearly:

1. Identify your test subjects
2. Identity your independent and dependent variables
3. State what variables will be kept constant
4. Identify a control group and explain why it is your control group.
5. Describe your experimental set up-
6. THIS SECTION MUST BE WRITTEN IN PAST TENSE
7. Must mention the actual tests, materials and surveys you used

8. Inform your reader that they can be found in Appendix A

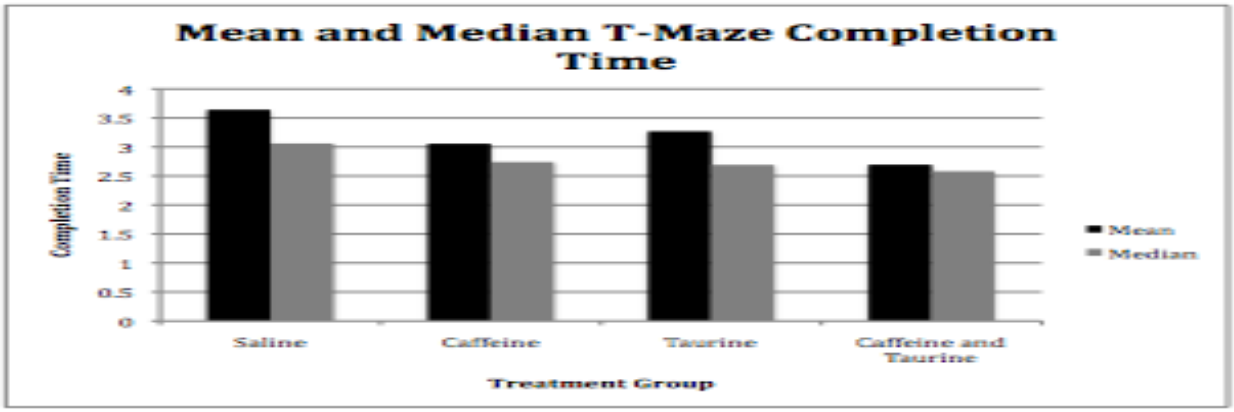
RESULTS

Results: This section describes **but does not explain your results**; it provides the reader with a factual account of your findings (Hay, 1996). You can, however, draw attention to specific trends or data that you think are important. Your aim in your results section is to make your results as comprehensible as possible for your readers/markers (Hay, 1996). To that end you must include figures, graphs and charts that show important data, number those figures, graphs and charts sequentially and include brief descriptions of those figures, graphs and charts. ***After you present your results via graphs, tables, chats, etc. you must write a paragagraph that describes, but does not explain, your results.***

Guidlines for graphs, charts, tables:

1) RAW DATA TABLE.
   - ➢ Present all raw data, for each participant, in a typed data table *with black border lines.*
   - ➢ Make sure that all column headings are clear, specific, and contain units (if this applies).
   - ➢ Underneath the table, label this **Figure 1.** Include a title and a brief summary describing what is represented in the table. (EXAMPLE: **Figure 1.** Raw data for each bird call, including length of audio file, location where recordings were taken, time of recordings, type of call, and overall pitch of call for each audio file.)

2) TABLES and FIGURES
   - ➢ Raw Data
   - ➢ Include a brief figure summary* (a few sentences or less) under the table describing the distribution of your data, general trends, and comparisons. Make no conclusions here, just describe the data.
   - ➢ Here's an example of how this this could look



Treatment Group	Mean	Median
Saline	3.64180556	3.06
Caffeine	3.055196198	2.74
Taurine	3.269979	2.69
Caffeine and Taurine	2.693693	2.58

Figure 1: Mean T-maze Completion Timefor all treatment groups. Caffeine, and Caffeine-Taurine treated roaches showed improved overall completion time, with Caffeine-Taurine treated roaches showing the fastest maze completion time of all categories. Taurine treated roaches showed slight improvement.

*<u>Suggestions for writing figure summaries</u> (ideas for what to include)

Discuss the shape and variability of your graphs (for frequency, etc)

- Identify outliers
- Provide a reason for choosing mean vs. median vs. mode (describe why one measure of center was chosen over another)
- For scatter plots, describe the relationship between 2 variables (if any)
- Provide a description of what happened, in general
- Include any observations (anecdotal data) that were not included in the data table but which apply to the results shown in the figure

2a.

- ➢ Think carefully about the second figure that you choose to present.
- ➢ If your first figure was a frequency analysis, then your second figure should probably show the measure of center that you selected (informed by your analysis of the frequency chart).
- ➢ Follow the same guidelines shown for Figure 1.

3a. FIGURES 3 and beyond.

- ➢ Again, think carefully about the order in which you present figures.
- ➢ The first figures should relate directly to the experiment's purpose and your hypothesis.
- ➢ Any additional analyses (age, gender) should come later.
- ➢ Follow the same guidelines shown for Figure 1.

DON'T FORGET

<u>After you present your results via graphs, tables, charts, etc. you must write a paragagraph that describes, but does not explain, your results.</u>

<u>Analysis and Discussion</u>

<u>Discussion</u>: Here you are interpreting the data to make conclusions, relating your findings to those of other scientific studies, identifying the limitations of your investigation, and proposing ideas for further research.

Length: Five to seven paragraphs.

I. First paragraph: INTERPRET RESULTS AND RELATE RESULTS TO HYPOTHESIS

- Analyze your results to draw conclusions. Here are some guiding questions you can use.
  - Which group had the highest mean? mode? median?
  - Does that support your hypothesis? Why or why not? Explain using evidence.
  - Which group has the highest and lowest standard deviation?
  - What does the standard deviation mean about your data spread?
  - If the data is very spread out, look back at your data. What might explain the spread? Are there outliers? Was your experiment administered consistently? Did anything go wrong that day?

- Next paragraph: REJECT OR FAIL TO REJECT THE NULL HYPOTHESIS
  - Examine your t-scores and p-values. Is your p-value greater than or less than 0.05? Should you reject or fail to reject the null hypothesis? Rewrite your null hypothesis and explain why you reject or fail to reject it.

II. Next paragraph(s): RELATE RESULTS TO BACKGROUND RESEARCH

- How do these results relate to your background research? (How do your results compare to those presented in the journal articles cited in your Introduction?) To what extent do your results support or contradict current theories relating to this topic? CITE SOURCES.
- If your results match the background research and related studies, explain the similarities. If your results are not supported by the background research, explain the differences and propose reasons for why this may be.

III. Next paragraph: LIMITATIONS AND BIAS

- Discuss the limitations of your experimental design and ways that bias may have affected your results. This doesn't mean to say why the study is bad, but explain some of the obvious limitations and ways that bias specifically could have affected your results. Consider aspects of the experiment's design, uncontrolled variables, and human error.
- How can these limitations and bias be overcome? Propose solutions for improving the experimental design.

IV. Final paragraph(s): SUMMARIZE CONCLUSIONS AND PROPOSE FUTURE RESEARCH

- Briefly summarize your overall conclusions and discuss the implications and applications of your findings.
  - In your introduction, you stated why your study is important to society and how it would impact society. Restate the importance to society here. Do your findings support this? If so, why? If not, why not and what is the new importance to society based on your findings?
- Propose further research to extend the current findings. *Don't just say that you'd do it again with the limitations fixed – rather, come up with some unique, new ideas.* Based on your current findings, what would you be interested in researching next? Why?

PORTFOLIO ABSTRACT

PORTFOLIO: Neuroscience
TITLE: Colorful Patterns

ABSTRACT: Today, local governments provide schools with extremely sparse funding, even less than before the Great Recession (CBPP, 2017).Teachers are desperately trying to provide students with an adequate education using already scarce funding. Researchers, along with teachers must find new and cost effective ways to boost the performance of students in urban schools. It was hypothesized that students presented information on an opaque Yellow sheet of paper will perform better in pattern recognition tasks because yellow is primarily associated with joy, which will promote an approach motivation and will lead to more creative and attentive thinking. In a convenience sample study, 45 students were brought into a room in groups of three. The students were randomly assigned a color (Red, Yellow, Green, Blue or White) and were given five minutes to complete a five question pattern recognition test. The control group (White) had the highest results, with a mean of 46.57 and a standard deviation of 17.32. The other colors ranked the following, in order from best score to worst scores (Red/Yellow, Blue, Green). The P-value of this experiment was calculated to be .861614. The results failed to reject the null hypothesis, proving that there is no significant evidence to conclude that color has an impact on a student's pattern recognition. However, further research must be done regarding the impact of colors with symbolic relevance (Red, Black) on a student's temperament.
Keywords; Color, Pattern Recognition, Approach Motivation

Introduction

Boasting the largest militaries in the world and vast territorial control, the United States is nothing less than a superpower. However, the world's most influential country currently ranks 17th in educational performance and 24th in literacy among industrialized nations (Ranking America, n.d). It is undeniable that the United States needs to reform its educational system if it intends to uphold its position as a world superpower. Furthermore, amidst drastic changes impacting the Education department, the causes for America's lackluster performance in education primarily affecting urban areas are becoming increasingly apparent.

The lack of funding by government institution can be to blame for America's recent difficulties reaching a respectable ranking among their peers. According to the Center for

Budget and Policy Priorities, most states provide less support per student for elementary and secondary schools and in some cases, much less than before the Great Recession (CBPP, 2017). The lack of adequate funding for public schools will only perpetuate the violence and poverty that has

become permanently associated with urban environments. Funding for schools is only becoming more scarce, with recent reforms threatening to further reduce funding for public schools. Considering the state of the Education department in the United States, it's no wonder why the fabled reading crisis -which claims that Americans are becoming increasingly illiterate- is becoming more and more of a reality.

According to the National Center for Education Statistics (NCES, nd), an estimated 32 million adults in the USA suffer from severe illiteracy. Considering those statistics, if this paper was given to seven adults, one in those seven adults will have severe difficulties comprehending its contents (NCES, nd). The source of this problem is not hard to find. The federal and state government have made it overwhelmingly clear that funding for education is not a priority. This is where the work of teachers is most vital. Among desperately falling budgets, teachers along with researchers must find ways to increase student information retention and deter decreases in education performance.

One way to increase performance in schools is to modify the student's learning environment with the intent of promoting higher information retention in classrooms. If the environment is changed in a way that promotes attention and pattern recognition, there would be increases in performance across all subjects K-12. The question still remains, how can teachers modify learning environments when funding is so scarce? Many teachers in urban schools have to work with outdated textbooks in short supply, outdated computers and

inadequate science equipment (Hudley, 2013). One way to bypass the lack of funding is to use inexpensive methods to promote a better learning environment for students, such as changing the color of the marker used on the whiteboard. However, it is important to first look at how informations is interpreted in the brain on a molecular level.

Neurons, which are cells in the brain, communicate through a process called neurotransmission. This process involves the conversion of electricity, also known as an action potential, into a chemical signal, that is then dispersed into the synaptic space, eventually activating -or deactivating other neurons. Depolarization starts in the presynaptic cell membrane, where ion channels open up converting the neuron's negative internal charge into a positive internal charge. As a result, the action potential spreads across the soma, down the axon, and into the axon terminals. The axon is covered by a myelin sheath, which strengthens and speeds up the action potential while protecting the cell from electrical damage.

Once the action potential reaches the axon terminal, calcium ions rush into to the cell membrane, causing vesicles which contain the neurotransmitter to fuse with the cell. As a result of this, the neurotransmitters are 'pushed out' and disperse into the synaptic space, which is the space between two neurons. Once the dispersed neurotransmitters reach the dendrites of the postsynaptic neuron, the neurotransmitters activate the neuron. The neurotransmitters then go back to the presynaptic neuron through a process called Reuptake. The impact of this process can vary in the role of the signal (inhibitory or excitatory) and the specific neurotransmitter released into the synapse. In regards to memory and information retention, the neurotransmitter mainly involved in this experiment will be Glutamate, which produces an excitatory reaction. However, color really have a large enough impact to increase pattern recognition in students?

While all species have shown trends of pattern processing in nature, humans are capable of undertaking tasks realms beyond their animal peers. The human brain is capable of superior pattern processing (SPP), which is claimed to be responsible for human cultural/social

evolution as well as higher functions like creativity, imagination, language and thinking (Mattson, 2014). Studies have shown that images and sound can be manipulated by the brain and compared to different patterns which can, in turn, result in the creation of new pattern involving processes and different possibilities (Mattson, 2014). If one were able to link specific color to sound and images, then, through the use of those newly created patterns, the information retention of students can be heightened in specific areas.

The brain is capable of recognizing a pattern no matter how many changes it goes through. The normalization of changing patterns is called invariance (Ramachandran, 2002). This means that theoretically, a subject will be able to recognize a known pattern no matter how many times the experimenter changes it. However, more research needs to be done to determine the extent of invariance as well as color's influence on this brain mechanism. Studies have also shown that color plays a significant role in enhancing memory performance (Olurinola, 2015). In a study consisting of 30 graduate students from Olabisi Onabanjo University, the impact of color on the learning process was investigated in a posttest only design. A posttest only design is a simple study where participants are grouped, set aside for an intervention and then tested afterwards. The study concluded that the impact of color on number of words correctly remembered were statistically significant (Olurinola, 2015). Furthermore, color has the potential to increase the rate that stimuli is memorized and encoded, therefore increasing memory performance (Olurinola, 2015).

For centuries, philosophers and artists have debated the impact of color on the human consciousness. This area of study became known as color theory and one of the earliest publications of color theory came from Johann Wolfgang, who published Theory of Colours in 1810 (Popova, 2012). Wolfgang theorized that people associated different color and shades with different feelings; blue being associated with darkness and gloom, while yellow being

associated with joy and excitability (Wolfgang, 1810). This led many philosophers to theorize whether those associations people had with different colors were impactful enough to promote or deter learning. Philosophers have also realized that color uses both symbolic and cognitive means to affect learning, memory, and identification (Olurinola, 2015).

Furthermore, extensive research on color's impact on processing has not yet been done using psychology theories; specifically approach and avoidance motivations. In an approach motivation, the person sees the task as a responsibility while in an avoidance motivation, a person sees the task a responsibility (Olsen, 2014). In a two part study conducted at Carnegie Mellon University, a graduate student tested how color produced different cognitive learning motivations. In the first study, 60 participants were tested on their ability to remember a list of words and discern whether each word presented was a new word or came from the previous list. In the second study, 21 participants were tested on their ability to complete word stems using a list of words given to them. Color was the independent variable in both of these studies, saturation and lightness values were explained further in the reading. Although the graduate failed to show significant proof to support the claim, the study brought into question the symbolic importance of color on cognitive motivations. These motivations can influence a person's mental state, which will in turn impact how they react when faced with problems. In addition, these motivations can be altered using mood and emotions, since they are closely connected to behavior (Olsen, 2014). Taking this into account, theories of color, as well as the demography of the participants, will be vital for determining the impact of color on a student's pattern recognition. Students presented the test on yellow, opaque paper will perform better in pattern recognition tasks because yellow is primarily associated with joy, which will promote an approach motivation and will lead to more creative and attentive thinking. The null hypothesis states that color has no impact on a student's pattern recognition.

Methods and Materials

The experiment was a single blind study where participants were placed in groups of three and seated randomly, unless two participants with the same color-test were sitting adjacent to each other. Students were told that the order of the questions differed on each test and they were asked not to share answers, as in doing so would interfere with test results. If participants unintentionally shared answers, the test for the entire group was to be voided and another group of students would be selected. Upon entering the room, students were given a pattern recognition test (See Appendix A) consisting of five questions on standard 8" X 11.5" length sheet of paper. They had five minutes to complete the test -unanswered questions were counted as incorrect. Students were randomly assigned to a color (Red, Yellow, Orange, Green or White). White served as the control, while the different color papers served as the explanatory variables.

This study consisted of 45 students from my high school. The students were randomly selected. All students were also seated in room 412, alone at a table, with sufficient space to take the exam and a #2 pencil or pen given out by the experimenter. They were instructed not to have any recording/'smart' devices with them and informed that using the phone during the exam would void the results. Five minutes were set on a timer before students sat down to commence testing. Afterwards, the experimenter remained sat in a corner until the timer was up and collected the tests unless the test becomes voided during the five minutes. This process was conducted 15 times, no errors occurred with groups. In this experiment, color served as the independent variable while the student's score on the test was the dependent variable.

Results

After compiling the test results from the experiment, the tests were separated into 5 groups, designated by the test color. Students scored a cumulative average of 39.56% correct in the test- meaning that they answered around 2/5 questions correctly. For ease of access, responses from students were graded and organized using tables. In the table, a green highlight signifies a correct answer, while a red highlight marks an incorrect response. The students' individual answers are also shown in the columns. The tables showcasing all of the student answers are shown below;

Test Color- Red					
Answers	Question 1	Question 2	Question 3	Question 4	Question 5
//////////////////////	3	4	1	4	4
//////////////////////	1	1	1	2	4
//////////////////////	3	3	3	4	1
//////////////////////	4	2	1	1	1
//////////////////////	3	3	2	4	1
//////////////////////	3	2	1	4	4
//////////////////////	4	2	2	1	4
//////////////////////	3	2	4	2	1
//////////////////////	4	2	3	1	1
Total Correct (%)- 60, 20, 40, 20, 40, 80, 20, 60, 20					

Fig 1. Test Responses with Red Test

Test Color- Blue					
Answers	Question 1	Question 2	Question 3	Question 4	Question 5
//////////////////////	4	2	4	4	4
//////////////////////	1	2	3	4	4
//////////////////////	4	2	3	n/a	n/a
//////////////////////	1	3	3	4	4
//////////////////////	3	1	3	4	4
//////////////////////	4	3	2	1	n/a
//////////////////////	4	3	2	4	3
//////////////////////	3	3	4	1	3
//////////////////////	1	1	1	4	1
Total Correct (%)- 80, 60, 20, 40, 60, 0, 20, 40, 20					

Fig 2. Test Responses with Blue Test

Test Color- Yellow					
Answers	Question 1	Question 2	Question 3	Question 4	Question 5
//////////////////////	3	3	2	2	4

//////////////////////	3	1	3	1	3
//////////////////////	1	2	4	4	4
//////////////////////	4	3	3	4	n/a
//////////////////////	3	2	4	4	1
//////////////////////	4	3	2	3	4
//////////////////////	3	2	1	4	4
//////////////////////	1	3	3	2	1
//////////////////////	1	3	2	3	4
Total Correct (%)- 40, 20, 80, 20, 80, 20, 80, 0, 20					

Fig 3. Test Responses with Yellow Test

Test Color- Green					
Answers	Question 1	Question 2	Question 3	Question 4	Question 5
//////////////////////	1	3	2	4	3
//////////////////////	1	3	1	3	n/a
//////////////////////	2	3	2	1	4
//////////////////////	3	1	2	4	4
//////////////////////	3	2	3	4	4
//////////////////////	3	2	3	3	4
//////////////////////	n/a	1	n/a	3	n/a
//////////////////////	3	4	2	1	1
//////////////////////	3	3	2	3	4
Total Correct (%)- 20, 0, 20, 60, 80, 60, 0, 20, 40					

Fig 4. Test Responses with Green Test

Test Color- White(Control)					
Answers	Question 1	Question 2	Question 3	Question 4	Question 5
//////////////////////	1	3	3	4	4

//////////////////////	3	2	3	4	1
//////////////////////	1	2	3	4	4
//////////////////////	4	4	1	4	3
//////////////////////	4	2	3	4	4
//////////////////////	1	3	3	3	4
//////////////////////	1	2	3	1	4
//////////////////////	3	2	3	4	n/a
//////////////////////	4	2	3	4	4
Total Correct (%)- 40, 60, 60, 20, 60, 20, 40, 60, 60					

Fig 5. Test Responses with White Test

The Mean and Standard Deviation(Sx) of each group were calculated using the Total Correct values which can be found at the bottom of each table. The Interquartile Range(IQR) was also found in each group. The table displaying the Mean, Standard Deviation and Interquartile Range from each group is shown below;

Group	Sample Size	Mean	S_x	IQR
Red	9	40	22.36	40
Blue	9	37.78	25.39	40
Yellow	9	40	31.62	60
Green	9	33.33	28.28	50
White	9	46.67	17.32	30

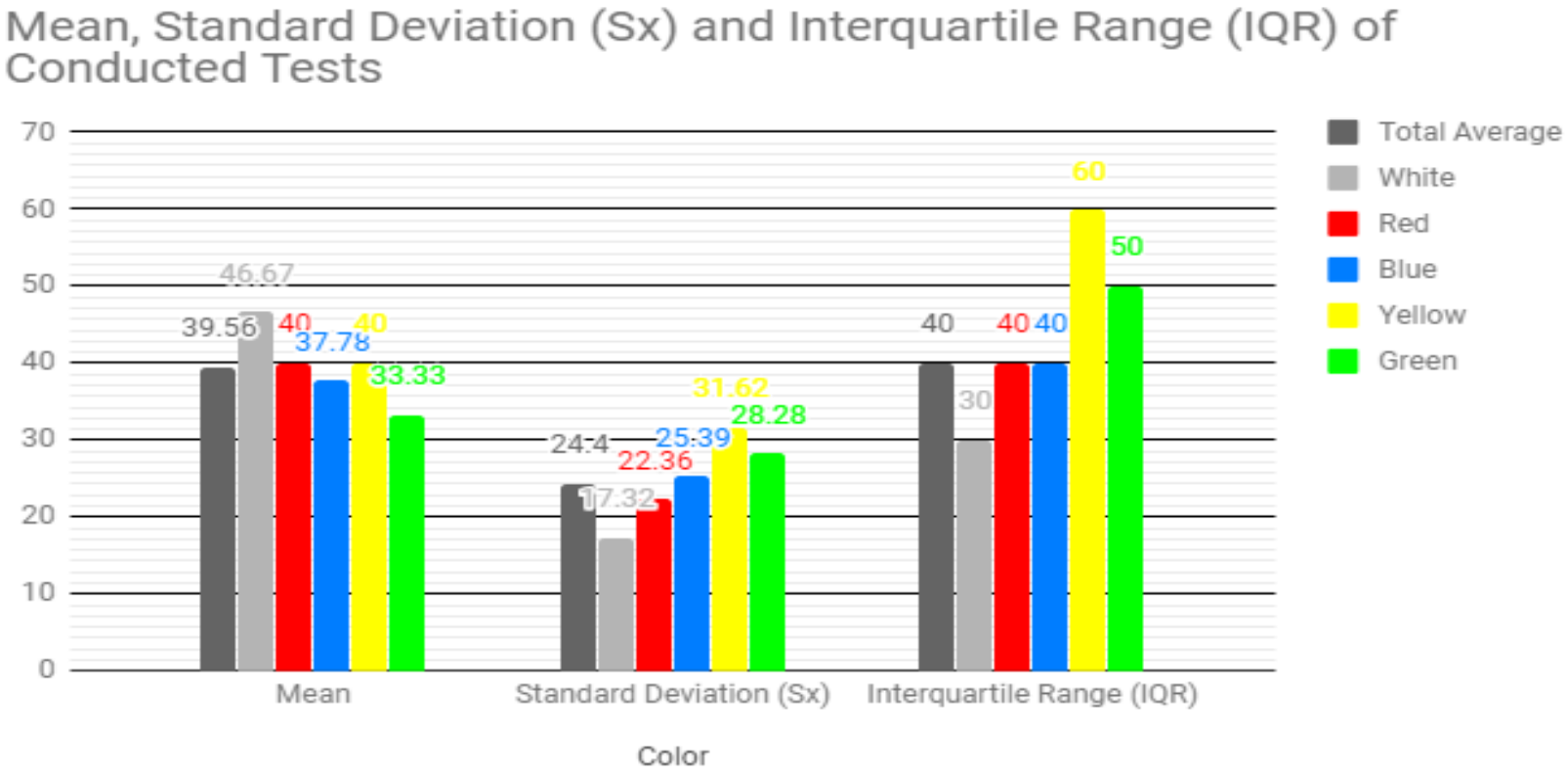


Fig 6. Table of Sample size, Mean, Standard Deviation, Interquartile Range of each group
Fig 7. Graph of Sample size, Mean, Standard Deviation, Interquartile Range of each group

The average pattern recognition scores of students varied greatly between colors. The students who were given a white test performed the best (mean= 46.57). Students who were given a Red test or a Yellow test ranked the highest among the experimental groups (Mean= 40), followed closely by the results from the Blue color test (Mean= 37.78) and lastly, the Green test results (Mean= 33.33) (see Figure 7).

Furthermore, students who were given a white pattern recognition test scored more consistently among their peers. The White color test had both the lowest Standard Deviation (17.32) and Interquartile Range (30) out of the groups(see Figure 6). This can also be seen in the result figures for each group. Whereas the results for different students would look scattered when looking at the experimental groups (See Figure 1-4), the White test results page has more consistency among answers the group answered right or wrong as a whole(See Figure 5).

Discussion

Students who were given the pattern recognition test on white paper scored the highest among the groups. Contrary to the initial hypothesis, students given a colored test performed worse among their peers. In addition, the scores obtained from those who were given a white colored test were more consistent, as shown in figure 5. The White test group had the lowest Standard Deviation (17.32) and Interquartile Range (30), which is reflected by their raw scores. The group scored the following(40, 60, 60, 20, 60, 20, 40, 60, 60), which when compared to the other groups, showed no outliers in the data.

Outliers can be seen in almost every experimental group. In the Green test group, participants 2, 5 and 7 were outliers. scoring far above or below the cumulative average (See Figure 4). This trend also resurfaces in the Yellow test group (participants 3,5,7 and 8), the Blue test group (participants 1 and 6) and the Red test group (participant 6) (See Figure 1-3). The appearance of these outliers can be attributed to the motivation of the students and the time of day (Students in the morning were more reluctant take the study seriously). On the other hand, students who took part in the study in the afternoon were overly excited to participate in the study in front of their friends. There is a possibility that these factors may have caused the students to score very high (80) or very low (0).

Since this experiment used more than 2 treatment groups, Anova and F- ratio was needed to analyze the results. F-ratio is a value that can be used to see the variance between multiple groups. Using the F-ratio (0.32192) and the degrees of freedom (df), (44), the P-value was calculated to be .861614. In order to reject the null hypothesis, the P-value needed to be less than 0.05. Since the calculated results did not meet the necessary P-value to become significant, the experiment failed to reject the null. This means that there isn't enough evidence

to go against the null hypothesis and that color has no impact on a student's pattern recognition score.

There is little evidence found in this study that connects the performance of pattern recognition in students to Johnan Wolfgang's Theory of Colours. While observing the participants, there was no deviance between the student's temperament, outward expression of emotion or concentration. However, there was a noticeable phenomenon among several students; those who were given the Red color test answered question 1- a question whose answer could be attained by simply counting the number of letters and then comparing that value to the answers- immediately and confidently, even if they showed difficulty completing the rest of the test. This could hint at the color Red improving the student's ability of identification using symbolic means, as described in 'Colour in Learning...' by Dr. Oluwakemi Olurinola.

One limitation of this experiment was the lack of participants and space. Because this experiment was conducted in a room with other students also conducting their own studies, there was not enough space to do trials with more students. This made it harder to take larger groups of students. Furthermore, since the students were taking part in a timed test, there was a finite number of trials that could be done per period. This, coupled with the inability to handle bigger groups made the total number of participants drastically drop from the intended 100 students (20 per group) to 45 students (9 per group). Furthermore, since other students were using the room to conduct their studies, there were factors like smell, sound and temperature that could not be controlled. To repeat this experiment with better results, the experiment should decrease the number of experimental groups while increasing the sample size. This will reduce the influence of skewers and allow for more focused trials.

Although this study did not have enough evidence to prove that color has an effect on student's pattern recognition, this subject area should still be researched. Considering how

students who were simply given a White test scored better than their peers, the ability of color to distract students should be researched as well its ability to make students more attentive. For future research, it would be interesting to see how different colors affect people's stress levels and their ability to identify common objects. In particular, a study using students who associate the color red with corrections and errors and students who do not have experience with that connotation. This would reveal if color can create a symbolic connection strong enough to stop people from operating normally.

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