EFFECT OF TEXT COLOR ON RECALL OF HIERARCHICALLY ORDERED INFORMATION

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Running Head: Effect Of Text Color On Recall

Effect Of Text Color On Recall Of Hierarchically Ordered Information

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A Thesis Presented For The Master Of Science Degree

Table Of Contents

Abstract

Information is everywhere, and recall is affected by many factors including color. Hierarchical information is a common way of representing information found in textbooks: organized from general to specific levels. In this study the effect of text color on recall of hierarchically organized information was tested by using increasing amounts of color on study information provided to 150 undergraduate psychology students in five different groups. It was hypothesized that recall would increase as the amount of color used on study material increased. In Experiment One a ceiling effect was discovered, and led to the development of Experiment Two. An ANOVA was used to test for significant differences in both experiments, but none were found by this study.

Effect Of Text Color On Recall Of Hierarchically Ordered Information

From the moment we wake in the morning until we go back to sleep at night we are constantly bombarded with information from a vast multitude of sources. Some examples include a clock that tells you it's time to get up, a sticky note reminding you to paint the house, and a newspaper that informs you to be careful of rabid squirrel attacks. With such a wide variety of information at our disposal it is not surprising that we make an attempt to organize all of it into a more comprehensible form (Soon & Tan, 2000).

Hierarchical Information

Hierarchical information organization is the most common and widespread way of organizing information because it closely resembles how we think (Soon & Tan, 2000). Hierarchical information is arranged such that topics at the highest level are the most general, and become more specific the further down you go within the hierarchy. For example, hierarchical information organization about amphibians would probably be in the following order: amphibians, frogs, tree frogs, poison dart tree frogs, and then African poison dart tree frogs.

Through use of an information hierarchy, inferences can be made between levels within the hierarchy, and can result in commonsense reasoning. Commonsense reasoning is a type of reasoning that plays an important role in most types of intelligent activities such as language understanding, planning, pattern recognition, and expert reasoning (Soon & Tan, 2000). Using the previous example, commonsense reasoning can be used to infer that poison dart tree frogs are both amphibians, and spend most of their time in trees. Depending on further branches within the hierarchy (Brazilian poison dart tree

frogs vs African poison dart tree frogs) another inference can be made; Not all poison dart tree frogs live in the same place (Soon & Tan, 2000).

The benefit of hierarchical information organization is that it aids comprehension of a given piece of information by detailing its place in comparison to other information about the same topic, and the relations between information (tree frog is a type of frog). As such, it's no wonder that this type of organization is often found not only in how we think, but also in research proposals like this one, encyclopedias, teacher lectures, text books, etc. However, while hierarchical information organization does improve comprehension whether or not it specifically helps retain information in memory is another matter.

Memory Factors

The determinants of what is remembered, and what is not could be briefly explained by saying "multi-factor" as the volume of literature on the subject would fill up several libraries. This is due to the fact memory variables are numerous, can have their own individual weighty influence, and interact with each other to create a combined effect. For example, a deficiency in a person's working memory may result in poor performance at a task regardless of how much attention he/she dedicates to it (Buehner, Krumm, Mangels, Ziegler, 2005).

Variables associated with the information to be remembered can include legibility, whether or not examples are given, logical organization, and the relationship between information elements. Information becomes more likely to be remembered the easier it is to understand. For example, the phrase "Distribute B among T within (# OF B X 4)M, and then roll B. Do 1 damage per (# ABOVE TARGET'S DEFENSE) or 6 rolled

to T." would be incomprehensible without a legend, and would be hard to memorize. However, the phrase "Distribute your intelligence dice among targets within 24 meters, and then roll them. You do one damage to a target for each number above a target's defense or six you roll." is easier to understand, and thus easier to remember (Pressley, Yokoi, Meter, Etten, Freebern, 1997).

Examples help memorization because they not only rehearse the main points of preceding information, but place the information in a relevant context (Pressley, et al, 1997). For example, the following text would be much harder to remember without an example;

> **Area Weapon Attack is how much damage Y does when attacking with an area weapon (grenade, napalm, rocket launcher, et al). Area weapons have 2 settings; unarmed, and armed to explode when (Y'S CHOICE). Y's Area Weapon Attack is: Roll C. Area Weapon Attack does 1 damage per (# ABOVE TARGET'S DEFENSE) or 6 rolled to everything within a (# OF C)MR area within (# OF E X 4)M.**
>
> **EX:** Shodan throws a grenade at five Tenzi and two Undead she encountered while setting up camp for the night. The following numbers are rolled from Shodan's 6 Perception Dice; 4, 5, 6, 2, 1 and 3. The Tenzi all have a defense of 2, and thus take 4 damage each. The Undead both have a defense of 4, and thus take 2 damage each (Carvin, 152).

The more logically organized information is the easier it will be to memorize as it not only makes rereading easier, but assists in the development of a mental hierarchy of the information (Pressley, et al, 1997). For example; A RPG (role-playing game) that

arbitrarily scatters information needed to create a character throughout the book will make it much harder to remember the process of character creation than one that has all the information in one place.

The more closely related information elements are the more they will reinforce the retention of each other (Pressley, et al, 1997). For example, information about Fantasy RPGs in a book about different kinds of RPGs would help in the memorization of further information about Fantasy RPGs. Meanwhile, the same information may not help, or might even hinder memorization of information about science-fiction RPGs.

Variables associated with the memorizer that affect memorization can include age, lifestyle, and metacognition. Age is influential in memory function as our memory peaks in our 20s, and then declines gradually for the rest of our lives at different rates depending on our lifestyles. Alcohol, bad nutrition, hormonal imbalances, inactivity, lack of food, lack of sleep, and stress are just some of the things that can adversely affect memory during a person's lifetime. Conversely, the opposite of those variables can slow, halt, or even reverse age related memory loss (Adderly & Crook, 1999).

Memory studies have tested numerous memory variables in isolation or in combination with others; more items make recall more difficult, delay between retention and recall, whether the memorizer is fresh or fatigued, etc. However, beyond these variables it has even been shown that how we think about the variables and the information to be memorized (metacognition) can have an effect on performance (Collins, Gheberman, Wellman, 1981).

In 1997 an extension of a metacognition study previously made by Collins, Gheberman, and Wellman in 1981 was conducted. The study replicated findings that

different age levels thought about future performance on tasks differently. Five year old children considered performance being primarily the result of effort. As such the five year old children would continue to predict success on future performance even with a failure rate of 9 out of 10 items since they believe they can increase recall through increasing their efforts (Demerval & Mullet, 1997).

Meanwhile, older children and adolescents would consider both factors (effort and number of items to recall) in their assessment by adding them together, but would weigh more heavily the most severe of the two factors. Further still, adults considered performance to be the result of a multiplicative interaction between effort and number of items, and thus would consider both variables as being equally important. (Demerval & Mullet, 1997). Unsurprisingly, in our efforts to organize, comprehend, and remember information we have come up with a variety of ways to make it easier.

Memory Aids

Memory aids come in a cornucopia of forms from "to do" lists to extensive notes gleaned from textbooks. For the most part, personally manufactured memory aids resemble our own idiosyncratic ways of thinking with ample use of abbreviations, shorthand, and summaries. The ability to create effective memory aids is especially important in academic environments, but effective note taking techniques are rare among student populations (Bretzing, Caterino, Kulhavy, 2001). Prior studies on note taking estimate that fewer than 30% of American and Nigerian students alone possess this ability (Simbo, 2001). This is a point of concern as note taking ability can have a large effect upon recall performance.

As such, studies were made in an effort to analyze the effectiveness of note taking techniques. A 2001 study by Dyer, Riley, and Yekovich analyzed three study skills (Note taking, summarizing, rereading) to determine their effectiveness. Written notes were defined as retaining only the most important statements in studied material, and summaries contained abbreviations of written material to aid recall. Rereading on the other hand only required reading the material again to get a better understanding of information (Dyer, Riley, Yekovich, 2001).

What they found was that note taking and rereading strategies improved recall, but the strategies were non-additive, and thus the same result could be garnered by doing one, or both. With summarizing, participants had to have a deeper understanding of information in order to reword it into abbreviated text, but rereading increased factual recall. While all of these strategies were found to be helpful in increasing recall the presence of the text was important for further learning, and referral to check information (Dyer, et al, 2001).

This is problematic when you consider how hard to read some textbooks are despite their hierarchical organization. Depending on the age and quality of a text it can be illogical, incoherent, disorganized, factually inaccurate, and can conflict with information presented in class. Some books are almost encyclopedic in their attempt to mention everything, and leave students painting their books yellow with highlighter. The readability of textbooks can even be mismatched to the students reading it, and contain many new terms unfamiliar to students. Even illustrations are often decorations rather than explanatory and do not clarify important concepts or make important points more

memorable. Worse than that are the books without any color or pictures that leave the poor reader adrift in a teeming sea of black and white words (Pressley, et al, 1997).

The obvious solution is to create better textbooks, but even with effective texts many students are overwhelmed by the amount of material covered in textbooks, and class. Poor exam performance is commonly caused by students having difficulty deciding what information is likely to be tested, and what can be safely ignored. Given the limitations of human memory, unknowingly cramming one's head full of information you don't need to know in lieu of information you do is a recipe for disaster. As such, effective study guides which highlight important concepts, but allow students to fill in their own information about the concepts (creating their own summaries) can greatly assist in the retention of needed information (Bird, 1983).

Effect Of Color On Memory Of Information

As previously mentioned memory is "multi factor," and influenced by many variables from individual (attention, metacognition, working memory) to the information being memorized (notes, summaries, textbooks). However, in all the reviewed literature about our efforts to organize, comprehend, and remember information, and construct memory aids to help us with those tasks the use of color on hierarchically organized information is conspicuously absent.

This is peculiar because color seems particularly viable as it increases information uniqueness, and memorability. Significant color priming has been shown when a color is bound to another stimulus like a picture. In studies where children were given a color memory task they chose previously seen colors more often during a test phase than

expected by chance on tasks after studying an original color (Hupbach, Mecklenbrauker, Wippich, 2001).

Of course, color responses at test phase are usually closer to distinct cognitive colors like red, orange, yellow, green, and blue. As such, a participant is more likely to choose the color that has the highest contextual match to a stimulus during test phase. An example of this would be choosing the contextually correct "grass green" during test phase when asked to draw someone's lawn in favor of choosing the correct "grape purple" that was shown during exposure phase (Seliger, 2002). Thus, a study phase containing "green grass" is more likely to be correctly recalled at test phase than "green car" because both color and context are more congruent (Bodrogi & Tarczali, 2001).

The relevance of color memory has been demonstrated in a wide variety of ways. One applicable use of color memory is its use in using abnormal color recall reaction times to discover color sight disabilities. Two such sight disabilities studied using color memory are protanomals and deuteranomals who are individuals that are not completely red or green color blind, but instead usually perceive red (protanomal) or green (deuteranomal) as dingy or gray. It was found that normal trichromats have significantly faster color recognition of an original color during test phase than those with anomalous color vision (Diaz, Camps, Carpinell, 2001).

Color is also used extensively to transfer brand equity between national and copycat product brands, and gain positive meaning to consumers. Examples of this can be found at your local grocery stores wherein red labeling is often used on store brand soda to mimic the more popular Coke products, or blue labeling to mimic Pepsi. By doing this they hope consumers will think of their sodas being just as good as the popular brands,

and also associate popular brand positive memories with their products as well (Tavassoli, 2001).

An alternate use of this phenomena would be a negatively viewed brand changing its colors as an effective means of re-branding, and regaining positive meaning for consumers. For example, Fictional Soda was packaged in a brown can right up until consumers began finding rat droppings mixed in with the soda. After the media frenzy, and subsequent drop in Fictional Soda sales the company changes to clear plastic bottles with blue "water splashes" to showcase it's "clean refreshing taste" (Tavassoli, 2001).

Colors are also used extensively to improve human performance in searching for colored targets in unformatted or dynamic displays, to organize information on maps, and quicken numerous other decisions based on visual information. An example would be a pilot responding to a red light on a console to fly to a safer altitude, finding where she needs to land by following green highways on a state map, and then quickly adjusting speed in response to a yellow "low fuel" light that has just come on (Berggrund, Bodrogi, Derefeldt, Swartling, 2004).

Additionally, color TV learning has been found to be more rapid and longer lasting than monochrome TV. This is due to color making it easier to separate information from any given whole being displayed, and thus increases memorization rate and recall of the information. For example, more details about a filmed marathon can be recalled when it's presented in color instead of monochrome (Berggrund, et al, 2004). However, despite all the studies addressing the usefulness of color, and its effect on memory there is not one study in the reviewed literature addressing how text color would effect the common way in which information is organized hierarchically.

Present Study

For this present study I wished to discover the effect of text color on the recall of hierarchically organized information. Color is currently used by many printed media as a means of drawing attention to specific information; book chapter titles, advertisements, pamphlets, etc. If it can be found that text color has a significant effect between groups of increased text color usage this may pave the way for greater use of color in hierarchically organized information, and thus create more "memory friendly" hierarchical organized information in printed media.

Due to the usefulness of color enhancing recall, it is my hypothesis that increasing text color on hierarchically organized information will also increase the recall of the information. As such, the independent variable is amount of text color used within an information hierarchy, and the dependent variable is number of correct recall answers of the information.

For this between groups study I tested 150 undergraduate psychology students at Austin Peay State University in Clarksville, TENNESSEE. Five different groups (N=30) studied hierarchically organized information. According to group, increasing amounts of color were used to present study material with Group 1 using the least amount of color, and Group 5 using the most color as shown in Table 1. After study, their recall of the information was tested, and the minimums, maximums, means, and standard deviations of correct answers for all five groups were gathered. Then an ANOVA was used to determine if there were significant group differences.

Experiment One

Method

Participants

The participants were 150 undergraduate psychology students at AUSTIN PEAY STATE UNIVERSITY in Clarksville, TENNESSEE seeking to participate in psychological studies for potential extra credit. This placed thirty participants in each of the five groups, and lead to the minimum suggested power for this study to detect real differences between the groups; 80% power (VanVoorhis & Morgan, 2001).

Due to the very brief nature of the individual memory tests associated with the research, and the need to commandeer a classroom LCD projector, the experimenter approached instructors to find participants. If OK'd by an instructor, the memory test was run sometime during his/her class period (at the beginning or end of a class), and the students could choose to either participate, or take a four minute break/leave early.

The experimenter maintained a sign in sheet to ensure that participants were tested only once. No attempt was made to connect the names with results, and the list was destroyed at the conclusion of the study.

Apparatus

A LCD projector connected to a computer was used to present the Microsoft PowerPoint 2003 memory tests at the front of the classroom.

Materials

Memory was tested using five different MS Power Point 2003 presentations, and questions about the study material was answered on Scantron bubble sheets. Each memory test was exactly the same except for slide 4 (study material), and slide 14 (group

membership). According to group, increasing amounts of color were used to present study material on slide 4 with Group 1 using the least amount of color, and Group 5 using the most color as shown in Table 1. This pattern is based on the order of the visible spectrum (ROYGBIV); Red, orange, yellow, green, blue, indigo, and violet. For the purpose of this study only black, red, orange, green, and blue was used due to their distinctiveness, and due to there only being five items within the study material. (Bodrogi & Tarczali, 2001).

Design

This was a between groups study with five non-randomly assigned groups each being presented a different memory test according to group number. The memory tests were only different in amount of color used as represented in Table 1, and group number. The independent variable is amount of color used on the study material, and the dependent variable is number of correct answers on the recall tests. There was only one session per participant in which the participant received one of the five presentations.

Ideally this study would have used nonsense syllables for study material, but it would have been hard to organize such information hierarchically, and even harder to memorize it since it does not reflect information commonly memorized in real life. Preexisting hierarchically organized information posed familiarity problems which could have artificially inflated recall performance. For example, performance on hierarchically organized information about lizards could be confounded by participants being biology majors, zoo employees, or owners of pet lizards.

It's been shown that recall and familiarity differ not only in definition, but also in brain function (Cycowicz, Friedman, and Snodgrass, 2001). Since this study's intention

was to test the effect of color coding hierarchically organized information on recall, and not familiarity, it was necessary to create unique study material with which no one will have prior familiarity. As such, the study material was a hierarchically organized collection of fictional facts loosely based on Zarrakan (a Role-Playing Game), but not actually contained within that work.

The recall tests themselves were five black text hierarchically organized multiple choice questions with one correct answer, and four close alternate answers. In form the recall tests mirrored the common design tests are usually given in; black text on white paper, hierarchical organization, and, if multiple choice, close alternate answers are given to the correct one. The recall tests' form also represented an additional attempt at eliminating familiarity effects within the study which may have appeared if the study information and matching question were in the same color (Suzuki, Takahashi, 1997). Correct answers on these tests formed a visually obvious "V" pattern on scantron bubble sheets in the following sequence; A, E, B, D, and C.

With these precautions taken the internal validity of the study should be high, and reliability proven with follow up studies. However, external validity may be compromised by not all real-world tests being in multiple choice format. In follow up studies it may be necessary to use essay, short answer, fill-in-the-blank, multiple choice or a combination of all of the above to further ensure external validity.

Procedure

Before initiating the study the experimenter obtained permission from instructors to run his/her experiment during class time. In addition the classroom/s the experiment was

run in had a working LCD projector, and a computer hooked to it that could run Microsoft PowerPoint 2003 presentations.

Prior to running the experiment the informed consent form was passed out to the participants, and then read out loud to them by the experimenter. In addition the informed consent form also acted as the participant's only debriefing since it told them everything except that color matters. In the interest of testing the hypothesis it was important to exclude that one piece of information from the explanation of the study so as to prevent people from paying unnaturally close attention to colored items. Such attention would have artificially inflated recall for the colored items, and the study would have only proven that attention effects memory rather than test the hypothesis.

Once a memory test began, the participants had 50 seconds to memorize study material, and then after a brief 50 second pause they were tested on the information with 10 seconds to answer each question. Following these questions was one question concerning eyesight problems (question 6 on slide 13), and instructions about what to bubble in for question 7 (group membership on slide 14).

Results

The number of questions each subject got correct out of 5 questions on the recall test are summarized as minimums, maximums, means, and standard deviations for all five groups in Figure 3. For the purpose of this study unanswered questions were counted as wrong answers, and descriptive statistics were calculated accordingly.

As shown in Figure 4, the results for the five groups are fairly similar, and when they are graphed all the group error bars overlap each other. Visually this suggests there is no significant difference between the groups, and an ANOVA (Table 2) also shows there is

no significant difference between any of them ($F(4,109) = 1.327$, $P > 0.05$). No further statistical analysis was required.

Discussion

With an ANOVA it was discovered there were no statistically significant differences between the groups ($F(4,109) = 1.327$, $P > 0.05$). However, the means are so close to 1 that the study material may be too hard for participants to test on, and thus a ceiling effect was created. Additionally, a rereading of the study material shows that it's hard to complete reading of the material within the 50 seconds allotted for memorization. This makes a "time effect" a likely possibility too.

The question about eyesight problems (question 6 on slide 13) also may have been too vague, and thus made any recorded answers for that question useless. Since the question occurs after the memory test it is possible to ask directly about colorblindness without confounding the study.

Because of these findings it was decided to re-work the study material, and conduct a second experiment. First a series of pre-tests were created, and some changes made to the testing format. It was hoped that these additional tests would reveal a set of study material that could be used to properly test this study's hypothesis.

Pre-Tests For Experiment Two

Method

Participants

As in Experiment One, 150 undergraduate psychology students at AUSTIN PEAY STATE UNIVERSITY in Clarksville, Tennessee seeking to participate in psychological studies for potential extra credit were used. This placed thirty participants

in each of the five groups, and should lead to the minimum suggested power for this study to detect real differences between the groups; 80% power (VanVoorhis & Morgan, 2001). Recruitment and record of participation were also the same as in Experiment One.

Apparatus

As in Experiment One, a LCD projector connected to a computer was used to present the MS PowerPoint 2003 memory tests at the front of the classroom.

Materials

New materials were developed to test participants using five different MS Power Point 2003 presentations, and questions about the study material was answered on Scantron bubble sheets. Each memory test is represented by Figures 5 through 14, and are matched to their groups sequentially (Figures 5 and 6 are group 1, Figures 7 and 8 are group 2…). All of the memory tests are in black and white.

Design

This was a between groups study with five non-randomly assigned groups each being presented a different memory test according to group number. The memory tests differ in both study material and questions as represented by Figures 5 through 14, and are matched to their groups sequentially Figures 5 and 6 are group 1, Figures 7 and 8 are group 2…). The independent variable is the study material and questions used, and the dependent variable is group membership. There was only one session per participant in which the participant received one of the five presentations.

Procedure

Before initiating the study the experimenter obtained permission from instructors to run his/her experiment during class time. In addition the classroom/s the experiment was

run in had a working LCD projector, and a computer hooked to it that could run Microsoft PowerPoint 2003 presentations.

Prior to running the experiment the informed consent form was passed out to the participants, and then read out loud to them by the experimenter. In addition the informed consent form also acted as the participant's only debriefing since it told them everything except that color matters. In the interest of testing the hypothesis it was important to exclude that one piece of information from the explanation of the study so as to prevent people from paying unnaturally close attention to colored items. Such attention would have artificially inflated recall for the colored items, and the study would have only proven that attention effects memory rather than test the hypothesis.

Once a memory test began, the participants had 20 seconds each to memorize 1 piece of study material, and then after a brief 10 second pause they were tested on the information with 20 seconds each to answer each question. Following these questions were instructions about what to bubble in for question 7 (group membership on slide 15).

Results

As shown in Figure 15, the results for the groups are fairly similar except for Group 3, and when they are graphed all the group error bars overlap at least one other group's with the exception of Group 3 (Figure 16). Visually this suggested there is little difference between most of the groups, but Group 3 might be significantly different from the others. The ANOVA (Table 3) confirmed there is a significant difference between the groups ($F(4,148) = 6.945$, $P < 0.05$), and the Scheffe Test (Figure 17) confirmed that difference lies with Group 3.

Discussion

The ANOVA (Table 3) confirmed there is a significant difference between the groups ($F(4,148) = 6.945$, $P < 0.05$), and the Scheffe Test (Figure 19) confirmed that difference lies with Group 3. However, the most important finding is that pretest one was still the most difficult in comparison to the other pretests even with the change to the new format, and increased memorization time. This illuminated the suspected ceiling effect in Experiment One, and validated Group 3 (Figures 9 and 10) as being a more appropriate choice for testing this study's hypothesis. Now that more appropriate study material was found this study proceeded with a second experiment to test this study's hypothesis.

Experiment Two

Method

Participants

As in Experiment One, 150 undergraduate psychology students at AUSTIN PEAY STATE UNIVERSITY in Clarksville, TENNESSEE seeking to participate in psychological studies for potential extra credit were used. This placed thirty participants in each of the five groups, and should lead to the minimum suggested power for this study to detect real differences between the groups; 80% power (VanVoorhis & Morgan, 2001). Recruitment and record of participation were also the same as in Experiment One.

Apparatus

As in Experiment One, a LCD projector connected to a computer was used to present the MS PowerPoint 2003 memory tests at the front of the classroom.

Materials

Memory was tested using five different MS Power Point 2003 presentations, and questions about the study material was answered on Scantron bubble sheets. Each memory test was composed of the study material and questions from Figures 9 and 10, and are exactly the same except for slide 14 (group membership). According to group, increasing amounts of color are used to present study material with Group 1 using the least amount of color, and Group 5 using the most color as shown in Table 1. This pattern is based on the order of the visible spectrum (ROYGBIV); Red, orange, yellow, green, blue, indigo, and violet. For the purpose of this study only black, red, orange, green, and blue will be used due to their distinctiveness, and due to there only being five items within the study material. (Bodrogi & Tarczali, 2001).

Design

This was a between groups study with five non-randomly assigned groups each being presented a different memory test according to group number. The memory tests differ in both study material and questions as represented by Figures 5 through 14, and are matched to their groups sequentially Figures 5 and 6 are group 1, Figures 7 and 8 are group 2…). The independent variable is the study material and questions used, and the dependent variable is group membership. There was only one session per participant in which the participant received one of the five presentations.

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dependent variable was number of correct answers on the recall tests. There was only one session per participant in which the participant received one of the five presentations.

The recall tests themselves are five black text hierarchically organized multiple choice questions with one correct answer, and four close alternate answers. In form the recall tests will mirror the common design tests are usually given in; black text on white paper, hierarchical organization, and, if multiple choice, close alternate answers are given to the correct one. The recall tests' form also represents an additional attempt at eliminating familiarity effects within the study which may appear if the study information and matching question were in the same color (Suzuki, Takahashi, 1997). Correct answers on these tests form a visually obvious "V" pattern on scantron bubble sheets in the following sequence; A, E, B, D, and C.

Procedure

Before initiating the study the experimenter obtained permission from instructors to run his/her experiment during class time. In addition the classroom/s the experiment was run in had a working LCD projector, and a computer hooked to it that could run Microsoft PowerPoint 2003 presentations.

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have artificially inflated recall for the colored items, and the study would have only proven that attention effects memory rather than test the hypothesis.

Once a memory test began, the participants had 20 seconds each to memorize 1 piece of study material, and then after a brief 10 second pause they were tested on the information with 20 seconds each to answer each question. Following these questions was one question concerning colorblindness (question 6 on slide 15), and instructions about what to bubble in for question 7 (group membership on slide 16).

Results

The number of questions each subject got correct out of 5 questions on the recall test are summarized as minimums, maximums, means, and standard deviations for all five groups in Figure 18. For the purpose of this study unanswered questions were counted as wrong answers, and descriptive statistics were calculated accordingly. Group 3 from the pretests was used as the base rate (group 1) during statistical analysis as their conditions match. If this study's hypothesis was correct a perfect graph of the group means should have recall of the study information increasing as text color usage increases. This would give Group 1 (black text only) the lowest mean recall rate, and Group 5 (all five different colors used) the highest mean recall rate.

As shown in Figure 18, the results for the five groups are fairly similar, and when they are graphed almost all the group error bars overlap each other (Figure 21). Visually this suggests there was no significant difference between the groups, and an ANOVA (Table 4) also shows there is no significant difference between any of them ($F(4, 155) = 1.162$, $P > 0.05$). No further statistical analysis was required.

Discussion

With an ANOVA it was discovered there was no significant difference between the groups ($F(4, 155) = 1.162$, $P > 0.05$). We can eliminate a ceiling effect since we used the group 3 study material (Figures 9 and 10) during the pretests for this experiment, and additionally used the results for group 3 as the base rate (group 1) for statistical analysis. Scores are higher on average with experiment two than they are with experiment one, but like experiment one the scores tend to be very close together. As such this study's hypothesis that increasing text color on hierarchically organized information will also increase the recall of the information has not been proven true.

This runs contrary to research supporting the usefulness of color enhancing recall. However, it may be that color plays such a small part in reading that it has little influence over the end memory result. Comparing the results of experiment one to experiment two clearly shows that the actual content of the information to be memorized has a significant effect while color of text seemingly has none at all. The scores in Experiment Two are higher than in Experiment One, but scores in both experiments follow a very similar pattern almost to the point that the error bar graphs can be overlaid. As previously mentioned, further experiments with a variety of testing formats outside of multiple choice may be required to fully explore my hypothesis.

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Tables And Figures

Study Material Item Color	Group				
	1	2	3	4	5
1	B	B	B	B	B
2	B	R	R	R	R
3	B	B	O	O	O
4	B	B	B	G	G
5	B	B	B	B	B

Table 1; Color usage on study material items according to group.

Analysis of Variance

Source	Sum-of-Squares	Mean-Square	l
GROUP	3.805	0.951	
Error	78.160	0.717	

Critical Point 2.46

(F (4,109) = 1.327, P > 0.05)

No significant difference = Accept Ho

No further statistical analysis required

Table 2; Experiment One ANOVA.

Analysis of Variance

Source	Sum-of-Squares	Mean-Square	I
GROUP	30.808	7.702	
Error	164.133	1.109	

Critical Point 2.43 = Significant Difference

Critical Point 2.43

$(F(4,148) = 6.945, P < 0.05)$

Significant difference = Reject Ho

Further statistical analysis required

Table 3; Pretests for Experiment Two ANOVA.

Analysis of Variance

Source	Sum-of-Squares	Mean-Square	1
GROUP	7.485	1.871	
Error	249.490	1.610	

Critical Point 2.43

(F (4, 155) = 1.162, P > 0.05)

No significant difference = Accept Ho

No further statistical analysis required

Table 4; Experiment Two ANOVA.

1. Most Planets in the Ebonari system have a plant to animal ratio of 3:5, but there are a few exceptions. Solari has a 2:5 ratio, Geptu has a 1:5 ratio, Cyphron has a 2:5 ratio, and Von Moth has a 5:5 ratio.
2. 50% of Cypron's animals are amphibians, and 70% of them live in Peaceful Trees. However, they can be found in numerous other locations; Peaceful Woods has 8%, Peaceful Meadow has 6%, Peaceful Jungle has 9%, and Peaceful Forest has 7% of the amphibian population.
3. Cyphron's amphibians vary greatly in form, but mostly fall into1 of 5 categories with uneven population percentiles; 25% Newts, 15% Salamanders, 35% Axolotls, 5% Toads, and 20% Frogs.
4. From the Kermity to the Green Squishersplat, Cyphron's frogs are some of the most colorful in the known galaxy, and are unusual in their preference for desert environments. In fact, 100% of Cyphron's frogs are in Cyphron's deserts; 12% in Mud Desert, 16% in Pebble Desert, 30% in Dry Desert, 22% in Dirt Desert, and 20% in Sand Desert.
5. Cyphron's deserts are fairly inhospitable, and contain miles upon miles of sandblasted terrain. As such, water is scarce, and amphibians often have to rely on eating insects for moisture. A desert dwelling amphibian's typical diet usually consists of 25% grasshoppers, 20% crickets, 15% worms, 30% spiders, and 10% beetles.

Figure 1; Experiment One study material.

1. Geptu's ratio of plants to animals is;

   A. 1:5 B. 4:5 C. 3:5

   D. 5:5 E. 2:5

2. 6% of Cyphron's amphibians are living in;

   A. Peaceful Woods B. Peaceful Jungle C. Peaceful Forest

   D. Peaceful Trees E. Peaceful Meadow

3. Most of Cyphron's amphibians are;

   A. Newts B. Axolotls C. Salamanders

   D. Toads E. Frogs

4. 12% Cyphron's frogs are found in;

   A. Mud Desert B. Pebble Desert C. Dirt Desert

   D. Dry Desert E. Sand Desert

5. Desert dwelling amphibians mostly eat;

   A. grasshoppers B. crickets C. spiders

   D. worms E. beetles

Figure 2; Experiment One test questions.

	GROUP1	GROUP2	GROUP3	GROUP4	GROUP5
N of	18	23	25	29	19
Min	1.000	1.000	1.000	1.000	1.000
Max	4.000	3.000	4.000	5.000	3.000
	2.222	1.783	1.920	2.172	1.789
Standar	0.808	0.736	0.812	1.071	0.631

Figure 3; Experiment One descriptive statistics.

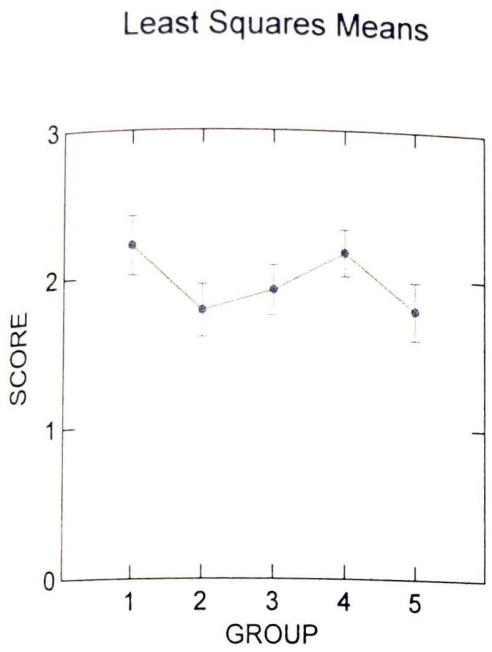

Figure 4; Experiment One error bars.

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5. Cyphron's deserts are fairly inhospitable, and contain miles upon miles of sandblasted terrain. As such, water is scarce, and amphibians often have to rely on eating insects for moisture. A desert dwelling amphibian's typical diet usually consists of 25% grasshoppers, 20% crickets, 15% worms, 30% spiders, and 10% beetles.

Figure 5; Pretests for Experiment Two group one study material.

1. Geptu's ratio of plants to animals is;

   A. 1:5 B. 4:5 C. 3:5

   D. 5:5 E. 2:5

2. 6% of Cyphron's amphibians are living in;

   A. Peaceful Woods B. Peaceful Jungle C. Peaceful Forest

   D. Peaceful Trees E. Peaceful Meadow

3. Most of Cyphron's amphibians are;

   A. Newts B. Axolotls C. Salamanders

   D. Toads E. Frogs

4. 12% Cyphron's frogs are found in;

   A. Mud Desert B. Pebble Desert C. Dirt Desert

   D. Dry Desert E. Sand Desert

5. Desert dwelling amphibians mostly eat;

   A. grasshoppers B. crickets C. spiders

   D. worms E. beetles

Figure 6; Pretests for Experiment Two group one test questions.

1. Travel in heavily armed vehicles has become the norm on Cyphron's largest continents due to long perilous journeys between cities. Vehicle usage for travel breaks down to Werishtal 60%, Vorcan 55%, Rax 70%, Dracon 90%, and Morgoth 85%.
2. All vehicles fall into one of five categories; Tanks, Artillery, Transports, Aircraft, and Turrets. A city's Commando vehicle pool typically consists of Tanks 30%, Artillery 20%, Transports 15%, Aircraft 25%, and Turrets 10%.
3. Tanks are often used as "meat shields" to guard more vulnerable units. Tank escorts are provided for Artillery 70%, Transports 90%, Aircraft 25%, Turrets 60%, and Commandos 50% of the time.
4. Transport vehicles provide an uncomfortable, but safe ride between destinations. All fall into one of five categories depending on the terrain they were designed to traverse; Submersible 15%, Airborne 25%, Legged 20%, Burrowing 10%, and Wheeled 30%.
5. Turrets often have to be flown or dragged into position by other vehicles. Few Turret models exist, but a recent poll found Commandos preferred the Rip-Line 10%, Cluster-Gun 25%, 8-Cannon 30%, Shockwave 20%, and Longbow 15%.

Figure 7; Pretests for Experiment Two group two study material.

1. Vehicles are used the least during travel on;

   A. Vorcan B. Dracon C. Werishtal

   D. Rax E. Morgoth

2. Typically 20% of a city's Commando vehicle pool are;

   A. Tanks B. Aircraft C. Transports

   D. Turrets E. Artillery

3. What unit has the least tank escort;

   A. Transports B. Aircraft C. Turrets

   D. Artillery E. Commandos

4. What is the most common Transport category;

   A. Airborne B. Legged C. Burrowing

   D. Wheeled E. Submersible

5. Which Turret model do Commandos prefer most;

   A. Cluster-Gun B. Shockwave C. 8-Cannon

   D. Rip-Line E. Longbow

Figure 8; Pretests for Experiment Two group two test questions.

1. Pet ownership on Cyphron has increased since the Arcane War. Rax has the least number of pets, Morgoth is about average, Dracon infrequently has pets, Werishtal has the second most pets, and Vorcan has the most pets of all.
2. Cypronite pets come in a variety of forms that reflect the interests of their owners. Insects represent the least owned pets, mammals are the average, reptiles are owned infrequently, birds are the second most owned pet, and amphibians are the most owned pets of all.
3. Cyphron large insects make great pets if you can tame them. The Thistle Bug is the least docile, the Snipe is about average, the Razor Tongue is infrequently tamable, the Dribbler is the second easiest pet to tame, and the Rock-Eater is the tamest of all.
4. The Thistle Bug can be quite entertaining watching it play with toys on its own. It likes the Beep-And-Squeak the least, plays with Pillow Fluff on average, infrequently notices the Whiffle-Splat, likes CaTennesseeip Balls second best, and likes the Chortle-Flurp best of all.
5. The Whiffle-Splat can be used with a variety of accessory attachments. The Feathered Bell is used the least, the Rubber Noodles are used on average, the Freaky Frog is used infrequently, the Flying Tunnel is the second most used, and the Paddle Ball is used the most.

Figure 9; Pretests for Experiment Two group three study material.

1. Which continent has the most pets ;

A. Vorcan	B. Dracon	C. Werishtal
D. Rax	E. Morgoth	

2. What kind of pet is owned infrequently;

A. Mammals	B. Insects	C. Amphibians
D. Birds	E. Reptiles	

3. What is the second easiest pet to tame;

A. Rock-Eater	B. Dribbler	C. Razor Tongue
D. Snipe	E. Thistle Bug	

4. What does the Thistle Bug like the least;

A. Whiffle-Splat	B. Chortle-Flurp	C. Pillow Fluff
D. Beep-And-Squeak	E. CaTennesseeip Balls	

5. What Whiffle-Splat accessory is used on average;

A. Freaky Frog	B. Feathered Bell	C. Rubber Noodles
D. Flying Tunnel	E. Paddle Ball	

Figure 10; Pretests for Experiment Two group three test questions.

1. Ever since the Arcane War, Cyphronites are obligated by law to arm themselves within city limits, but the number of required weapons differ between continents. Isbur requires 2, Bone Islands requires 4, Helos requires 5, Mur requires 1, and Vord requires 3.
2. Weapons fall into one of four categories, and reflect the personalities of their owners. Almost all Cyphronites carry projectile weapons, most carry melee weapons, infrequently carry thrown weapons, rarely carry area weapons, and very few go unarmed.
3. Melee weapons are rarely high-tech, but provide a simple means of self-defense. A recent poll found Cyphronites prefer swords 30%, daggers 15%, clubs 25%, axes 20%, and spears 10%.
4. Cyphronite swords all originate from one of five basic designs, and differ in the ratio of Dral to steel used in their construction. Falchions have a 5:5 ratio, Scimitars 3:5, Katana 2:5, Cutlasses 4:5, and Rapiers have a 1:5 ratio.
5. Cutlasses are a favorite among pirates, and how many they own depends on where they are from; In Isbur they own at least 1, in Bone Islands they may own more than 7, in Helos they may have 3 or 4, in Mur they own 2, and in Vord they own 5 or 6.

Figure 11; Pretests for Experiment Two group four study material.

1. Which continent requires the most armament;

   A. Helos B. Bone Islands C. Isbur

   D. Vord E. Mur

2. Cyphronites rarely carry;

   A. Thrown Weapons B. Nothing C. Projectile Weapons

   D. Melee Weapons E. Area Weapons

3. What melee weapon do Cyphronites prefer least;

   A. Clubs B. Spears C. Axes

   D. Swords E. Daggers

4. An equal ratio of Dral to Steel is used to build;

   A. Scimitars B. Katana C. Rapiers

   D. Falchions E. Cutlasses

5. Where do pirates own the most Cutlasses;

   A. Mur B. Isbur C. Bone Islands

   D. Vord E. Helos

Figure 12; Pretests for Experiment Two group four test questions.

1. All Cyphronites know at least a few abilities, and their frequency of use depends on where they live. In Rax they are used the second most, in Morgoth they are used the most, in Dracon they are used infrequently, in Werishtal they are used on average, and in Vorcan they are used the least.
2. Abilities fall into one of five categories, and polls of personal preference largely remained the same for the last 200 years. Cyphronites prefer Healing 30%, Enhancement 15%, Attack 25%, Defense 10%, and Creation 20%.
3. Attack abilities rarely require finesse, but can quickly change the outcome of combat. A recent poll found Cyphronites prefer Direct Damage 30%, Attribute Lowering 20%, Ability Negating 25%, Equipment Destroying 10%, and Mind Control 15%.
4. Equipment Destroying attack abilities are a favorite among those who seek to annoy more than harm their opponents. Shear is used on average, Shrink is used the least, Irradiate is used infrequently, Shatter is used the most, and Melt is used the second most.
5. Shatter is effective for destroying armor, and thus Cyphronites use Shatter on it's own the most. They infrequently combine it with Fireball, combine it with a Projectile Weapon the second most, combine it with Warp the least, and combine it with a Melee Weapon on average.

Figure 13; Pretests for Experiment Two group five study material.

1. Where are abilities used the most;

   A. Morgoth B. Rax C. Werishtal

   D. Dracon E. Vorcan

2. The abilities preferred the least are;

   A. Attack B. Enhancement C. Creation

   D. Healing E. Defense

3. 25% of Cyphronites prefer attack abilities involved in;

   A. Attribute Lowering B. Ability Negating C. Direct Damage

   D. Mind Control E. Equipment Destroying

4. What Equipment Destroying attack ability is used infrequently;

   A. Shatter B. Shrink C. Shear

   D. Irradiate E. Melt

5. On average what is Shatter combined with;

   A. Projectile Weapon B. Nothing C. Melee Weapon

   D. Fireball E. Warp

Figure 14; Pretests for Experiment Two group five test questions.

	GROUP1	GROUP2	GROUP3	GROUP4	GROUP5
N of	28	31	21	30	43
Mir	0.000	0.000	1.000	0.000	0.000
Max	3.000	4.000	5.000	5.000	4.000
	1.143	1.645	2.571	2.000	1.419
Standar	0.705	0.950	1.028	1.232	1.180

Figure 15; Pretests for Experiment Two Descriptive statistics.

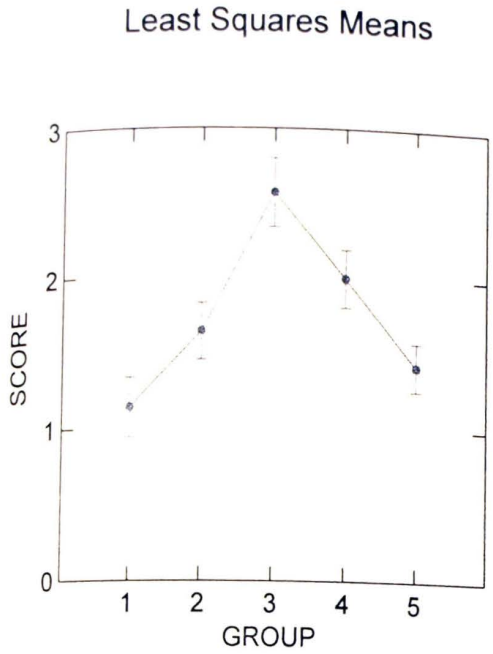

Figure 16; Pretests for Experiment Two Error bars.

Scheffe Test.

Matrix of pairwise comparison probabilities:

	1	2	3	4	5
1	1.000				
2	0.504	1.000			
3	0.000	0.051	1.000		
4	0.053	0.785	0.460	1.000	
5	0.884	0.933	0.003	0.255	1.000

Figure 17; Pretests for Experiment Two Scheffe Test.

	GROUP1	GROUP2	GROUP3	GROUP4	GROUP5
N of c	21	42	25	38	34
Minir	1.000	0.000	0.000	0.000	0.000
Maxir	5.000	5.000	5.000	5.000	5.000
M	2.571	1.905	2.160	2.263	2.000
Standard	1.028	1.322	1.179	1.446	1.181

Figure 18; Experiment Two descriptive statistics.

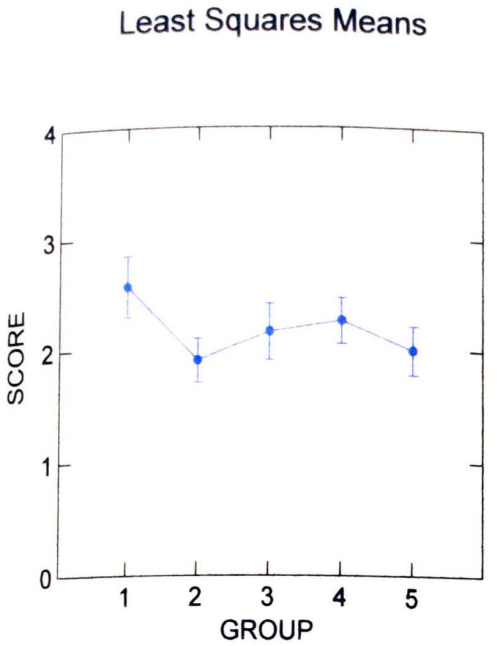

Figure 19; Experiment Two error bars.