

The Effect of Color on Text Memory in

Relation to Learning Style

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Abstract

Evidence has shown that pictures, and more importantly color pictures play a large role in recall (Spence, Wong, Rusan, & Rastegar, 2006). The present research compared memory for textual information when that information was presented alone (text only), supplemented with a black and white picture, or supplemented with a color image My research found that when color images are combined with textual information was an increase in recall over the same images in black and white. The secondary goal of my research was to see if there is a relation between the subjects' learning style (visual or verbal) and recall. I found that verbal learners had an increase

in recall for the text only information and that visual learners had an increase in recall for text information supplemented with color images.

The Effect of Color on Text Memory in Relation to Learning Style

When learning new and remembering old information, two major ways of communicating this information to students is through textual information and visual aids (pictures). Much research has shown that combining the two formats has had a positive effect on students learning. In Mayers and Gallini's (1990), study found that when textual information for the steps for creating mechanical devices, such as a pumps is combined with a picture showing the steps of how the pump works, there is a drastic increase in recall of how create a pump. Prior research has focused primarily on the effects of pictures in black and white on memory. The proposed research is based on the addition of color picture over one in black and white. By adding color images this should cause an increased effect on memory, making the picture worth a million words.

A related factor to be explored in this research is learning style. Those who have better strengths in visual learning may benefit more from the picture. This may allow participants to recall more information when given a text plus a complementing image than when given the text alone. In Kirby and Moore's (1988) study, they found that visual learners approach a task with mostly visual strategies and verbal learners use verbal strategies. This concept will be further explained in this research because it showed that those who are better visual learners are able to gather more information from the pictures complementing the text than those who are verbal learners.

Likewise, those who are verbal learners may benefit more from the text than those who are not verbal learners.

Text Comprehension

One of the first key components in learning and memory is the ability to comprehend information presented in text. In Verhoeven and Perfetti's (2008) research stated that in order to comprehend text a person must be able to identify words, and then people must process the words, turning them into a linguistic representation. In order to fully comprehend the text at hand the researchers state that must also rely on prior knowledge not just the text they have just read. Verhoeven and Perfetti state this is due to the fact that text is not completely explicit and some parts are missing and need to be filled in. Verhoeven and Perfetti's research goes along with the information found by Matlin's (2005), study who states that individuals have a somewhat large working memory span. Matlin also states that those with large memory spans have better comprehension because of participants extra working memory they can remember more important cues to recall for later. This was important to the current research because this could be one possible explanation to why some participants will be able to encode and recall more information about the text than others.

Another key point that Matlin's (2005) review of the research shows is that the majority of comprehension of a sentence comes from the last few words. This is due to the close proximity of the word to the end of the sentence. This close proximity allows for these words to be rehearsed in working memory. One such study by Leong, Tse, and Loh (2008) studied the effects of text comprehension, stating that text comprehension would be primarily influenced by verbal working memory. A verbal working memory task requires a participant to read and hold in memory complex information and then answer questions regarding what you read thus tapping into text comprehension. Leong, Tse, and Loh tested third, fourth and fifth grade Chinese children by administering a text comprehension task, and a memory span test. The researcher's memory span test consisted of thirteen sets of information to read. The sets of information consisted of two, three, four, or five sentences. Subjects were asked to listen and answer short questions about what they read as well as recall what the last word of each sentence was. Leong, Tse, and Loh's results show that those children with better verbal working memory performed much better in text comprehension.

Another key concept to the idea of text comprehension is perspective that the reader adopts. This makes certain information that is in the text more or less appropriate (Kaainen & Hyona, 2008). Kaainen and Hyona's study looked at the benefits of participants having prior knowledge of the perspective of the how the story is to be read may increase recall. They had participants read three house walkthrough stories. The researchers house walkthrough stories was a short one page story putting the participant in the perspective of someone viewing a house that is for sale. Half the participants were told to look at the story from a burglar's perspective and decide which house they would rob. The other half were told to look at it from an interior designer's perspective and decide which the nicest house to live in was. The house walkthrough each contained 14 phases relevant to each perspective. Afterwards, participants were administered a speed memory test which had participants remember as much as they could about their perspective in 90 seconds. Not surprisingly Kaainen and Hyona found that target phrases in the relevant condition were recalled better than those outside their condition. Their results show

that having prior knowledge or the perspective of the reader aids in the comprehension, thus allowing for an increase in overall recall. The results of Kaainen and Hyona supports that prior research showing that in order to gain valid results the text and picture combination will have to be one that is not very recent allowing for none of the participants to have knowledge of the topic. This will put the participants all on an even scale, not causing a biased effect. The current study chose topics that prevent participants from having expert knowledge.

Picture memory

Those individuals who are indeed visual learners should benefit from pictures and in regards to the current research, color images. Color may act to enhance the recognition of objects and is beneficial in the encoding process allowing for an increase in memory of the image (Ratner & McCarthy 1992). One study done by Spence, Wong, Rusan, and Rastegar (2006), studied the effects of color memory on natural scenes and how it is enhanced by this stimulus. The researchers presented 120 participants with 120 natural scene images in either color or in matched gray-scale monochrome (black and white). Later Spence et. al. presented participants with the same 120 images and an addition 120 new images and asked participants to identify if the images presented were new or old. Spence et. al. found that color images over gray-scale monochrome images improved recognition by five percent. These results show the important effects that color has on the recognition and encoding phase. The results of Spence et. al are similar to a study done by Gegenfurther and Rieger (2000). Gegenfurther and Rieger used the same concept of the prior study and found that color has a drastic increase on the coding of color images over black and white images. These results of Gegenfurther and Rieger and Spence et. al go along with Borges, Stepnowsky, and Hunt's (1977) study that found that there was a significant improvement with recall with color images then with black and white images in college students.

Other research on color was done by Nijboer, Kanai, Hann, and Smagt, (2008), who studied the effects of color on picture recognition and perception. They chose images from four different categories: coasts, forests, deserts and one man made scene of cities. Images in this study were presented in color, inverted color (which is where the researchers changed the color of an object to one that would not fit), or black and white. During the first phase participants were shown 96 images divided equally among the three conditions. Then during the test phase, which started after a three minute delay, participants were shown 96 new and 96 old images and asked if the images were present in the study phase. Nijboer et al. found that with natural scenes participants were better able to remember color images over black and white and inverted color. As for man made scenes there was no significant difference between color, black and white, and inverted color.

The research findings of Nijboer, Kanai, Hann, and Smagt (2008), found that color images are recalled better, this goes against with what was found in Anglin and Levie's (1985) study, which looked at the role of vividness in the recognition of pictures from memory. Anglin and Levie had participants view forty-eight slides containing color pictures, black and white pictures, line pictures and words. Then after an eight week delay participants were administered a memory recognition test which consisted of 12 old slides from before and 12 new slides, participants were asked to distinguish the old from the new images. Anglin and Levie's results show that black and

white images were more accurately recalled than words, but there was no difference between color and black and white.

Anglin and Levie's (1985) results go along with Paivio, Rogers, and Smythe's (1986) study that found that there is no difference between solid color pictures and basic black and white drawings. The main problem is that in Anglin and Levie's study was that they had an eight week delay for participants. Participants may only be guessing if they had seen the image, not that black and white is better recalled. Anglin and Levie's research contradicts the hypothesis that was given in the present research, because it only looks at half the equation. The current research looked to see if there is a significant benefit of having color images in combination with text.

Picture and Text Combinations

As shown earlier in the research by Ratner & McCarthy, (1992) and Leong, Tse, and Loh, (2008) there are many positive benefits of pictures and strong text comprehension. Recent studies have taken this a step further and combine the two. One study done by Garry, Strange, Bernstein, and Kinzett (2007) studied whether photographs can cause false memories of what really happened in the newspaper stories. Garry et al.'s study asked participants to play the role of a newspaper editor and correct three past newspaper articles, one of benefits of red wine, one on a hurricane, and one on O! Magazine. The researchers removed the pictures and asked the participants to place a box where they thought was a good place for a picture. Garry et al. research was concerned with the hurricane article, the other two were only included as filler stories. The researchers deployed a 48 hour delay before they administered session two. Garry et al. then administered during session two a memory test to participants to see whether they thought sentences presented on the test were mentioned in the previously read articles. Their 30 question test consisted of nine old (ones that were directly from the articles), nine new (ones that are on topics unrelated), and twelve lure sentences. Lure sentences were sentences that were in the previous articles but the main points were changed. One example of the main point being changed was "Beer contains vitamin B6, which research suggests that may be effective in fighting some kinds of tumors"; here the researchers change the main word wine into beer. Garry et al.'s goal was for the participant to remember the sentence in its entirety and after identifying it they then had to decide how sure they were. The researchers main concern was with the hurricane article and how the results would differ on whether the participants got the before or after photo. They found that participants were more likely to claim that there was serious injury mentioned in the article when they received the after photo showing the destruction left behind. This shows the importance and influence of pictures in combination with corresponding text. Pictures also have benefits on text comprehension when they are used in school lectures. In Seaman's (1998) study found through informal observations that using both text and pictures on slides improves students learning process. The research observations show that information on slides should be short and only relay one topic on a slide. Seaman also found that pictures should be used wherever possible, this allows for information that is being presented in text to be backed up and encoded better. Seaman's findings go along with Robinson's (2002) study that pictures can represent and make text more memorable, and that pictures are of utmost importance to allow students to learn in today's classrooms.

Research done by Verdi and Kulhavy (2002), looked at the effects of textual information in combination with images of maps. The researchers found that this combination of text and map allows for students to make cross connections of information, allowing for more information to be gained. Second, Verdi and Kulhavy found that prior knowledge gives the learner an edge as to what to look at and to devote their attention to. Third, the researchers found that features of the map information such as color can have an added effect to learning. Lastly, Verdi and Kulhavy found the process of task demands in their present research. This translates to depending on the purpose of the information there are different strategies that are used by students to remember the necessary information.

The results of Verdi and Kulhavy (2002) fit with the study done by Glenberg and Langston (1992) that looked at the effects that pictures have on conveying and reiterating important information. Glenberg and Langston placed images in step-by-step textual models. Participants were then given thirty-two four step procedures and in some cases a picture was inserted to correspond to the text. An example of this would be a four step process for writing a rough draft for a paper. Following each procedure participants were asked to complete six speeded yes or no tests to see how well information was retained. In the speeded tests that involved a correct response the participants were asked if any of the steps could be switched. After six of these tests were completed they administered a comprehension test. They found significant differences between picture versus no picture combination. Participants were more accurate in stating back what the order of the steps was, and in what cases the steps could be switched. This goes along with the results of the prior studies by Garry, Strange, Berstein, and Kinzett (2007) that the presence of a picture facilitated improved memory.

Along the same lines as the research above by Glenberg and Langston (1992), Carney and Levin's (2002) research looked at the function of pictures in combination with text. Their research tested five key types of pictures that are used in texts: decorative, (which only provide decoration to the page), representational, (which copy all or part of the text), organizational, (which provide a step-by-step illustration to what the text is trying to explain), interpretational, (which help clarify difficult text), and transformational, (which to help boost the reader's comprehension). Carney and Levin's results show that all but decorative images provide some sort of benefit for the reader. Second, the researchers found that the most effective type of image was transformational. Carney and Levin's finding go along with Schnotz (2002) research that found when a text article is incorporated with an images there is an increase in recall over when a picture is absent. This is due to the fact that pictures in the mind are formed into multiple mental representations such as surface structure, mental models and a genre style. This allows for the images to boost whatever it is being incorporated, in this case text. The boost of recall when images are present is due to the fact that information for images and text is processed and encoded in two separate cognitive systems (Clark and Pavio, 1991). Clark and Pavio state that verbal information, such as words are processed and encoded in the verbal system where as visual information is processed and encoded in the imagery and verbal system. This allows picture memory to be dual encoded allowing for it to increase recall over that of the corresponding text that it connected to.

Another study that compared pictures and text together was done by Mayer and Gallini (1990) to compare textual information with pictures on producing mechanical devices like pumps and brakes. Participants were asked to read passages about pumps. There were four conditions: one was only with text, one with text and pictures of the major parts, one with text and pictures of the

steps of how to build a pump, and lastly one with text and pictures with parts and steps. Afterwards participants were asked to take a recall test having them write down as much as they could remember about pumps as if writing for an encyclopedia for beginners in the subject. The second part was a problem-solving test containing five questions. For example: Why do brakes get hot? Mayer and Gallini found explanative pictures significantly improved creative problem solving and explanative textual recall. Mayer and Gallini drew three interesting conclusions. First, the text must be appropriate to the instruction goal, Mayer and Gallini mean between narrative and descriptive text. The second is the test must fit what you had the participants read. Lastly the picture must fit with the institution goal of the text. These findings by, Mayer and Gallini helped the current research by giving a clear indication of the way the text and picture combinations should be set up to maximize the effect that they will have on the participants. A similar study done by Hegarty and Just (1993) found similar results. Hegarty and Just presented subjects with pictures of pumps, text about pumps, or pictures and text about pumps. They found that those who had no mechanical ability of the task to assemble a pump were able to learn when they received the combination of the picture and text. When participants had this combination they outperformed those with a high mechanical ability. Hegarty and Just suggest these finding is because the participants use the picture as an external memory aid. This allows participants to store more information about the workings of the mechanism and allows for the information to be mapped out spatially.

Visual versus Verbal Learners

What is the distinction between verbal and visual learners? Capuano, Gaeta, Micaelli and Sangineto's (2004) study gives a good indication of what these are. Those who use and prefer visual aids and do best when they are presented with pictures, diagrams, or movies are classified as visual learners. Those who use written text and spoken information to comprehend information would be classified as verbal learners. The verbalizer-visualizer questionnaire by Richardson (1977) is an assessment for determining ones strengths in visual or verbal skills. This fifteen question assessment was designed to identify individuals who are verbal versus visual learners.

Research on this topic was conducted when Kirby, Moore, and Schofield (1988), who studied the factors of learning style. They asked participants to complete the Richardson VVQ (1977), as well as two mental ability assessments from the Factor-Referenced Cognitive Tests. These tests consisted of an advanced vocabulary test to measure verbal ability and a card-rotation test to measure spatial ability. The card rotations test consisted of participants stating whether an object was rotated within the same plane or not. Kirby, Moore, Schofield's results cast a considerable amount of doubt on the validity of the VVQ as a measure of learning preference. This doubt stems from the fact that some of the questions in the VVQ on visual learners had an additional factor of dream vividness where others did not. The other issue is that they found that participants often had both visual and verbal skills. This is because the original VVQ was set up so that participants with high visual strengths would score high on the test, and participants with high verbal strengths would score low. This goes against what the test was intended to look at, which led them to do a second study.

The second part of Kirby, Moore, and Schofield's (1988) study was to create a new questionnaire that would allow for the existence of separate verbal and visual learning preference factors. Their new questionnaire consisted of 36 questions, 12 for verbal, 12 for visual

preference, and 12 for dream vividness. Dream vividness was included in the Richard VVQ (1977), and was included now to look at imagery in participants who are visual learners. Kirby, Moore, and Schofield's modified questionnaire proved valid but they wanted to make sure that it truly tapped into learning style.

The third part of Kirby, Moore, and Schofield's (1988) study looked at how participants who were visual or verbal learners according to their new questionnaire would stand up to other assessments. They gave participants a spatial abilities task, which had them perform simple and complex transformation on human figures. The researchers then gave a verbal ability task from the Austrian Council of Educational Research. This had participant's answers questions about vocabulary, verbal reasoning and verbal analogies. Kirby, Moore, and Schofield found that participants who fit their description of verbal learner had high scores on the verbal abilities task. Likewise, participants who fit their description of visual learners had high scores on the visual abilities task. These results showed that their modified design proved to be both valid and reliable (verbal alpha level .70; visual alpha level .59).

Another key study on the differences between visual and verbal learners was done by Mayer and Massa (2003), who looked at the differences between the two different learning styles. In their research, Mayer and Massa identified cognitive spatial ability, cognitive style (thinking in meaning of words or images), and learning preference as factors that differ between verbal and visual learners. They tested 95 college students using 14 different measures. The first three were for general cognitive ability (e.g. verbal and mathematical ability; SAT), measures four through six were for spatial ability (e.g. Card Rotations Task), seven through ten consisted of visual verbal assessments (e.g. VVQ), and eleven to fourteen were for learning styles (e.g. Learning Scenario Questionnaire). Mayer and Massa found that participants either scored high on the visual task and poor on the verbal, or high on the verbal and poor on the visual. Mayer and Massa's results showed that cognitive spatial ability, cognitive styles and learning preference are important in determining learning style. The researchers recommend that a more in depth study be looked at these factors in the learning environment.

The findings of the above research Mayer and Massa (2003) and Kirby, Moore, and Schofield (1988) benefit the proposed research. First, Kirby, Moore and Schofield provide a better visual/verbal questionnaire; it has more depth than prior questionnaires by adding additional questions to the original 15 and qualifying those already included. They also make a clear indication on the questions of dream vividness, unlike the prior VVQ (Richardson, 1977), in which some questions tested visual and dream vividness. Just as in Mayer and Massa's (2003) research, link cognitive components such as text comprehension to learning style which will help the current research tap into participant's learning style effectively.

The purpose of this current research was to examine differences in memory for text information when the text was presented alone, supplemented with black and white images, or supplemented with color images. The secondary hypothesis of the research was that the learning style of participants would make a difference on their use of either the pictures or the text.

Method

Participants

The participants were undergraduate students from the Richard Stockton College of New Jersey. This target population for this research was key because this is a time when

learning and memory are most important for students. The average age of participants was 19.32 years ($SD = 1.44$). A total of 56 participants (11 male, 45 female) were tested; I had to drop 4 participants because they did not fall into either learning style category, resulting in a final sample size of 52.

Materials

Visual-Verbal Questionnaire (VVQ; Kirby, Moore, & Schofield, (1988). This questionnaire was used to assess the participants' learning style, whether it was visual or verbal. The VVQ consists of 36 questions (12 verbal, 12 visual, 12 dream vividness). The results were tallied for each category and the category with the highest total was the preference of the participant. This assessment has shown to be reliable because of the research conducted by Kirby et. al. See Appendix A for a complete copy of the assessment.

Text Comprehension Task (Sooy 2008a). This task consisted of two articles. The articles contained four pictures in color and four in black and white. At the end of the article there were two questions to make sure that participants were not experts in the category or had prior knowledge of the topic. One of the articles is a hurricane article from Garry, Stange, Bernstein, and Skinzett's (2007) study. See Appendix B for a complete copy of this article. The other article is a global warming article from Time Magazine, Schmid, (2008). See appendix C for a complete copy of the article.

Memory Assessment (Sooy 2008b). This assessment was used to determine the over recall of information presented in the two articles. Questions were related to information provided only in text, in text with a supplementary black and white picture, and in text with a supplementary color picture. The Memory Assessment consisted of ten questions for each article, as well as four distracter questions for each article to make sure that participants were unable to figure out the true nature of the assessment. Scoring for the assessment were based on the total number of correct number of responses out of the total number possible for each question type. A pilot study was conducted showing the test as reliable and valid. See appendix D for a complete copy.

Procedure

In order to participate in this study, participants were required to fill out and sign a consent form indicating that they are willing to complete the two part study. At this point any general questions about the consent form and the participant's rights were answered. There were three different versions of the two news articles to prevent bias from the easier questions. This also allowed for participants to be tested in groups. Next participants completed a general demographics questionnaire to obtain basic information about each individual.

Participants then completed the reading comprehension task. Complete counterbalancing was used to randomize the order in which subjects read the articles. In order to eliminate any participants who had any expert prior knowledge about these topics there were two general knowledge questions about each article. Participants who did very well on these were removed. After reading the two articles, participants were thanked and asked to come back after 48 hours to complete the second half of the study.

After the 48-hour delay, participants completed the Memory Assessment. Once completed participants were then asked to flip over their test and wait for the others to complete the task. After everyone completed the memory assessment, participants were asked to complete the last page which contained the Visual-Verbal questionnaire. Following completion, the assessments were collected and a feedback form was handed out to explain the true nature of the

study and explain why any deception was needed. This was followed by a question and answer period to explain anything unclear to the participants. Then participants were thanked for their time and allowed to leave.

Results

Scoring

Coding for the memory assessment was determined by totaling the correct answers. Each participant had a total of eight possible questions in each condition (color, black and white, and text). In the analysis of the data participants received a score for each condition based on the number of items answered correctly.

Coding for the learning style assessment was done by awarding participants one positive point for each verbal response and one negative point for each visual response. The assessment contained 10 questions for visual, 10 for verbal, and 10 for dream vividness responses. The purpose of dream vividness was to act as a filler and was not used in the assessment of learning style. The participants' learning styles were calculated by adding up their points. If they had a positive score they were categorized as verbal and if they had a negative score they were categorized as visual.

Analysis

I was interested in determining if the type of image (black and white versus color) seen in context with the news articles makes a difference in the accuracy of recall for the corresponding text depending on the type of learning style of participants. First, I looked at the mean memory scores of each article condition (color, black and white, and text alone) and found that there were significant differences which will be discussed below. The mean of the color condition was higher ($M = 5.95$) than that of the black and white condition ($M = 4.40$) or the text condition ($M = 4.67$). To see a complete list of all the means and standard deviations see Table 1.

I conducted a 3x2 factorial ANOVA to examine differences in memory performance. The first independent variable was condition and it contained three levels: color, black and white, and text (within groups). The other independent variable was learning style which was a between groups variable containing two levels, visual and verbal. To determine if there was an overall difference in the three conditions (color, black and white, and text) I looked at the main effect. The main effect for condition was significant, $F(2, 86) = 20.59, p < .001, h^2_p = .32$. This means that there was a difference between the three conditions in performance on the memory assessment. The partial eta squared shows that there was a large effect size indicating that the three groups differed considerably in performance. To see a visual representation of the main effect between conditions see Figure 1. To follow up the significant main effect, post hocs were conducted to see exactly where the difference was. I found that there was a significant difference between color and text, $t(44) = 4.93, p < .001$. This suggests that participants overall recalled more information to answer the color questions over the information for text only questions. I also found that there was a significant difference between color and black and white, $t(44) = 8.85, p < .001$. These suggest that participants overall recalled more information to answer color questions over black and white. I found that there was no significant difference between black and white and text conditions, $t(44) = -1.01, p = .319$. This means that participants overall recalled equal information for both text and black and white. Next I looked at the main effect for the second independent variable of learning style and I found that there was not a significant effect $F(1,43) = .165, p = .686, h^2_p = .004$. This suggests that participants who were verbal versus

visual did not differ significantly on overall performance on the memory assessment. Lastly, I looked to see if there was an interaction between the two independent variables in which I found a significant result, $F(2,86) = 3.876, p = .024, h^2_p = .083$. This indicates that there was a significant difference on the scores of the three conditions color, black and white, and text depending on what learning style the participant fell into. The partial eta squared shows that there was a medium effect size. These results show that those participants who are verbal learners scored much higher on the text only condition than participants who were visual learners. The results also indicate that visual learners scored much higher on the visual condition than those who were verbal learners. See Figure 2 to see the interaction effect between the two independent variables.

Discussion

The current research predicted that having a color image over a black and white image or no image at all would produce an increase in recall of information which was supported. In addition, the research predicted that the learning style (visual or verbal) of the participant would also provide a benefit to recall which was also found to be true. The research found significant results for condition, (color, black and white, text only), meaning that participants did better in the color condition than the other two conditions. My research findings go along with Spence et al.'s (2006) study which found that participants are able to recall color images 5% better than black and white images. Another study done by Nijboer, Kanai, Hann, and Smagt (2008), found that color images as a whole were recalled more accurately than black and white or simple words. Their findings go along with my research because I found that after the 48 hour delay, participants overall were able to answer more questions correctly that were tied to color than any other condition. My findings do however go against Nijboer et. al,'s (2008) because they found that man-made objects were not recalled better even if they were in color. I found that my images were remembered more when they were seen in the color condition.

My current research in contrast goes against the findings of Anglin and Levie's (1985) study. They found that color and black and white images were remembered at a similar level, showing no significant difference. My research found that color was recalled at a much higher level than black and white. My research also showed that black and white images and text were recalled at an equal level. These findings go against those of Mayer and Gallini (1990), who found that having pictures in black and white with text produced an improvement over text alone.

The results in the current study found that the learning styles of participants had an impact on their recall of the article content. These findings go along with Capuano et al.'s (2005) study that stated that those who are visual learners did better on visual tasks. This is evident I Capuano et al. because those who took the test with the pictures and were visual learners had a higher recall of that information than verbal learners did. Capuano et al. also found that verbal learners did better on verbal tasks. The current research found similar results; those who were verbal learners did better on recall in the text only condition than visual learners did because they used their verbal skills and did not pay much attention to the pictures.

My findings are important; they show that when using memory color images give a boost over black and white and text alone. This could have major impact on the educational field. When presenting information I would suggest that the use of color images in Power points would help students recall more information for tests and make it easier to study. I also noticed that

those who were verbal learners relied on the text greatly because they were able to answer more text questions right than visual learners. This means that though color images are important for memory that having text incorporated with color pictures would be the best combination, allowing for both types of students to get the most information out of the class.

With all the success of the study I did however find some limitations with the current study. There were only a few male participants, I would wonder what the results would show if there was a more even split between genders.

I do, however, recommend the more extensive research be done in this field. The difference in memory of visual and verbal information is key to the educational field. The current research did show some promising results but this is only the beginning. One area of research that could be studied further is when do participants get the benefits of color images. This would be looking to see if the same benefit existed when the color images are inverted. Inverted color means that for example a stop sign that should be red is instead blue.

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Appendix A

Verbalizer-Visualizer Questionnaire (VVQ)

Please read the following statements and put a check next to any that apply to you.

- I enjoy learning new words.
- I seldom daydream.
- I read rather slowly.
- I prefer to read instructions about how to do something rather than have someone show me.
- I dislike word games like crossword puzzles.
- I can easily think of synonyms for words.
- I dislike looking words up in dictionaries.
- I have a hard time remembering the words to songs.
- My dreams are rather indistinct and hazy.
- I don't believe that anyone can think in terms of mental pictures.
- I like maps or diagrams in books.
- I find illustrations or diagrams help me when I'm reading.
- My dreams are extremely vivid.
- I have a hard time making a "mental picture" of a place that I've only been to a few times.
- I seldom use diagrams to explain things.
- I like newspaper articles that have graphs.
- I enjoy doing work that requires the use of words.
- I have better than average fluency in using words.
- When I read books with maps in them, I refer to the maps a lot.

___ The old saying "A picture is worth a thousand words" is certainly true for me.

___ I have always disliked jigsaw puzzles.

___ I find maps helpful in finding my way around a new city.

___ My dreams are sometimes so vivid I feel as though I actually experience the scene.

___ My powers of imagination are higher than average.

___ I seldom dream.

___ I seldom fantasize.

___ I seldom use diagrams to explain things.

___ I enjoy daydreaming.

___ I often dream about things I'd like to be.

___ I spend little time attempting to increase my vocabulary.

___ I can hardly ever remember my dreams.

Appendix B

Report Says Arctic Temperatures at Record Highs

(WASHINGTON) — Autumn temperatures in the Arctic are at record levels, the Arctic Ocean is getting warmer and less salty as sea ice melts, and reindeer herds appear to be increasing while the polar bear population is decreasing, researchers reported Thursday. "Obviously, the planet is interconnected, so what happens in the Arctic does matter" to the rest of the world, Jackie Richter-Menge of the Cold Regions Research and Engineering Laboratory in Hanover, N.H., said in releasing the third annual Arctic Report Card. The report, compiled by 46 scientists from 10 countries, looks at a variety of conditions in the Arctic. The shocking report generated by these scientists shows that each year huge chunks of ice fall off the arctic ice shelf.

The region has long been expected to be among the first areas to show impacts from global warming, which the Intergovernmental Panel on Climate Change says is largely a result of human activities adding carbon dioxide and other gases to the atmosphere.

"Changes in the Arctic show a domino effect from multiple causes more clearly than in other regions," said James Overland, an oceanographer at the National Oceanic and Atmospheric Administration's Pacific Marine Environmental Laboratory in Seattle. "It's a sensitive system and often reflects changes in relatively fast and dramatic ways."

For example, autumn air temperatures in the Arctic are at a record 9 degrees Fahrenheit (5 Celsius) above normal.

The report noted that 2007 was the warmest year on record in the Arctic, leading to a record loss of sea ice. This year's sea ice melt was second only to 2007.

Rising temperatures help melt the ice, this in turn allows more solar heating of the ocean. That warming of the air and ocean affects land and marine life, and reduces the amount of winter sea ice that lasts into the following summer. The study also noted a warming trend on Arctic land and an increase in greenness as shrubs move north into areas that were formerly permafrost. Another issue is that many mountain tops that were covered in ice now are bare.

While the warming continues, the rate of warming in this century is less than in the 1990s due to natural variability, the researchers said. In addition to global warming there are natural cycles of warming and cooling, and a warm cycle in the 1990s added to the temperature rise. Now with a cooler cycle in some areas the rise in temperatures has slowed, but Overland said he expects that it will speed up again when the next natural warming cycle comes around. Asked if an increase in radiation from the sun was having an effect on the Earth's climate, Jason Box of the Byrd Polar Research Center in Columbus, Ohio, said while it's important, increased solar output only accounts for about 17 percent of global warming. "You can't use solar output to say that greenhouse gases are not a major factor," Overland added.

Other findings from the report include: The Arctic Ocean continued to warm and freshen due to ice melt. This was accompanied by an "unprecedented" rate of sea level rise of nearly 0.1 inch per year. Warming has continued around Greenland in 2007 resulting in a record amount of ice melt. The Greenland ice sheet lost 24 cubic miles of ice, making it the largest single contributor to global sea level rise.

Goose populations are increasing as they expand their range within the Arctic. Data on marine mammals is limited but they seem to have mixed trends. They are adapted to life in a region that is at least seasonally ice-covered. There is concern about the small numbers of polar bears in some regions, the status of many walrus groups is unknown, some whales are increasing and others declining. This according to the National Oceanic and Atmospheric Administration is because many species are land and sea based.

"This is a very complicated ecosystem and we are still working diligently to sort out its mysteries," said Richter-Menge.

CD NEWS NETWORK

Category 5 Hurricane Kenna slams into Mexico TEPIC, Mexico (October 25, 2002)

The most powerful hurricane in decades crashed into Mexico's Pacific coast on Friday, destroying houses and ripping roads in fishing towns while burying hotel swimming pools under seawater in the resort of Puerto Vallarta.

Officials evacuated more than 20,000 people from coastal areas before Hurricane Kenna hit land about 40 miles (65 kilometers) northwest of Tepic with winds of 140 mph (225 kph).

Waves thundered over the coastal boulevard of Puerto Vallarta, 60 miles (100 kilometers) to the southwest, and swept over hotel swimming pools. Power was out to much of the city. The brunt of the hurricane hit Nayarit state, where Gov. Antonio Echeverria met aides by the light of a battery-powered fluorescent lamp to monitor the crisis. Power was knocked out in parts of the state capital of Tepic, a city of 250,000 people, and officials cut the rest due to danger from downed power lines.

"We are worried because never before in the history of the state have we had a phenomenon of this magnitude," Echeverria said, flinching as a metal window guard banged against the glass.

In Puerto Vallarta, Mayor Pedro Ruiz said at least 42 people were treated for injuries and 2,000 others had been evacuated to shelters – which ranged from humble schools to the meeting rooms of luxury hotels. Trees and power lines littered the streets of Tepic leaving many businesses destroyed. Some falling branches smashed into cars. Most of the homes in San Blas were destroyed or badly damaged and fishing boats were toppled at their docks.

Power was knocked out to a wide region and roads were slashed. Estimates of the storm surge were somewhere between 10 to 15 feet above normal.

About 3,000 evacuees, most from San Blas, gathered at a Tepic high school whose classrooms were crowded with children sleeping on blankets. "You can replace things, but not life," said Alicia Ortiz, 46, who brought her two sons to the shelter. Her husband stayed behind in San Blas to protect the ice factory where he works. Nayarit Civil Defense Director Jose Heriberto Betancourt said 20,000 people were evacuated from coastal areas of his state. Neighboring Jalisco and Sinaloa states reported thousands more evacuated there.

Red Cross officials said the coastal highway from Tepic to Mazatlan -- a key section on the road from Mexico City to the Arizona border -- was washed out, blocking ambulances.

Some drivers were trapped by trees on the highway from Tepic to San Blas. Local television reports said hundreds of houses in San Blas had been damaged or destroyed.

The U.S. National Hurricane Center in Miami said the hurricane hit land near the fishing and tourist town of Tepic. Sustained winds -- which had reached 160 mph (260 kph) on Thursday -- dropped to 140 mph (225 kph) before the storm hit the coast, then slipped further to 80 mph (130 kph) as the storm raced into north-central Mexico in the direction of Texas at 24 mph (39 kph).

A spokeswoman for the city emergency department said at least 15 hotels, 22 restaurants, 48 clothing shops, 12 houses and seven shopping-office complexes had been damaged. On Saturday, troops, residents and business owners cleared chunks of wood, scraps of twisted metal and tons and tons of sand from the streets and parking lots. Backhoes and dump trucks rumbled through seafront streets usually crowded with suntanned residents. Hazel Burns, a 26-year-old student from Southampton, England, said she and friends had tried to leave the resort early Friday, but their bus was forced back by a fallen tree blocking the road. Back in town, they took a taxi through flooded streets, past floating cars and fleeing seaside residents.

"I don't think I've ever been so scared in my entire life. All the cars were floating around. We didn't know what direction to go in," she said. "The taxi driver was excited and kept saying, 'Hey, look at this!' I didn't want to look. I was just saying to myself, 'Just keep going, keep going!'"

General Questions for articles

1. Prior to reading this article, how much knowledge did you have on hurricane Kenna?

1	2	3	4
None	little	somewhat	a lot

2. Have you ever heard about this particular hurricane?

Yes	no
-----	----

3. What would you rate as your prior knowledge on the topic of global warming?

1	2	3	4
none	little	somewhat	much

4. During your college career how much instruction have you had on global warming?

1	2	3	4
none	little	somewhat	much

Appendix D

Text and memory Questionnaire

Please answer the following questions to the best of your ability based on the two articles that you read in the previous session. You want to base your responses on the content you remember from the articles and not on other facts you may know.

1. Which of the following matches what you read in the hurricane article?
 - a. **winds reached as high as 160mph (260kph) during the hurricane.**
 - b. over 250 people were killed during the destruction of the hurricane.
 - c. this was one of the most devastating natural disasters in Texas history.

2. According to the Global warming article what animal is decreasing in population?
 - a. orcas
 - b. reindeer
 - c. seagulls
 - d. **polar bears**

3. True/False The hurricane article discussed the following: Due to the sudden appearance of tornados it is very hard to predict exactly when they will appear or for how long?

- a. true
- b. false**

4. Where did hurricane Kenna first make landfall?

- a. Tepic**
- b. Houston
- c. Miami

5. True/False. The global warming article reported the following: The Artic temperature for autumn was six degrees higher than average?

- a. true
- b. false**

6. With continued polar cap melting there seems to be a decrease in the following animals except?

- a. polar bear
- b. goose**
- c. walruses

7. Which of the following happened to San Blas during the hurricane?

- a. streets were flooded and roads were destroyed.
- b. fishing boats were toppled and smashed onto docks.
- c. earthquake damage as a result of close proximity to the san Andréa's fault.
- d. both a and b**

8. True/False. In the global warming article, due to the dessert climate of Arizona, there was a drastic increase in the temperature?

- a. true
- b. false**

9. The report from the 46 scientists on global warming found what to be true?

- a. that hurricanes will continue to grow in strength for many years to come.
- b. that green house gasses are a direct cause of the deaths of many polar bears in the region.
- c. that each year huge chunks of ice continue to fall off of the artic shelf.**

10. In the hurricane article they mention the height of the storm surge. What was it?

- a. 0-4 feet
- b. 10-15 feet**
- c. 9-12 feet
- d. 5-8 feet

11. True/False. Because of the damage done following the hurricane, the city streets looked more like a garbage dump.

- a. **true**
- b. false

12. What percent of global warming did Jason Box say accounted for green house gases?

- a. 5%
- b. 25%
- c. 40%
- d. **10%**

13. Was the following mentioned in the articles? “Red Cross officials said that the coastal highway from Tepic to Mazatlan was washed out”

- a. **yes**
- b. no

14. True/False. The amount of green plants in Canada are decreasing drastically due to high temperatures?

- a. true
- b. **false**

15. Officials of Puerto Vallarta reported which of the following?

- a. the massive damage of the fires left up to 1,000 homeless
- b. **that 2000 people were evacuated and sent to shelters.**
- c. due to the seismic activity reports of many of the cities highways are destroyed.

16. Which of the following is a reason for the ice melting according to the article?

- a. rising temperatures with no sign of a cooling period.
- b. the increase in the radiation from the sun's rays.
- c. large amounts of oil pollution in our oceans.
- d. the increase in garbage dumps.
- e. **both A and B.**

17. Due to the strength of the storm which of the following caused the most damage in Tepic.

- a. high winds during the strong nor'easter.
- b. **the powerful winds from the hurricane**
- c. the sudden appearance of the tornado that ripped apart the small town.

18. Which of the following is true about mountains?

- a. due to their high altitude the peaks are often covered with ice.
- b. **many mountains today are bare, when in past years they weren't.**
- c. several animal species have begun to migrate to their home climate.

19. What category was the hurricane that hit the coast on Friday in 2002?

- a. category 2

- b. category 4
- c. category 3
- d. category 5**

20. True/False. Because of the frigid weather in the arctic shelf many ships will get frozen in the ice requiring a rescue ship to free them.

- a. true
- b. false**

21. True/False. There has been a drastic increase in carbon dioxide from the increase in car on today's roads?

- a. true
- b. false**

22. In Puerto Vallarta, how many people were treated for injuries during the hurricane?

- a. 71
- b. 49
- c. 58
- d. 42**

23. True/False. Once great valleys of ice now are rivers with vegetation?

- a. true**
- b. false

24. Rescue for those trapped by the hurricane was very difficult because of _____?

- a. high water levels, submerging city streets with water.**
- b. walls of flipped over cars.
- c. rioting due to the mass panic of the citizens.

25. By what amount do the ocean levels rise due to the rise of sea temperature?

- a. 0.3 inches
- b. 0.5 inches
- c. 0.1 inches**
- d. 0.2 inches

26. All of the following Except were damaged from the hurricane?

- a. soccer stadiums
- b. businesses**
- c. national monuments

27. The trouble with protecting these arctic species is because _____?

- a. there are both sea and land species with different needs.**
- b. whaling has caused a threat to this ecosystem.
- c. not enough research has been done to avoid extinction of these animals.

28. True/ False. On average there has been a steady increase in water temperature since the 1940's?

- a. true
- b. false**

29. True/False. According to Mexican officials this was one of the most devastating hurricanes that hit their coast in decades?

- a. true**
- b. false

Table 1

Descriptive Statistics

Learning Style	Color	Black and White	Text
Visual	$M = 6.13 (SD = .915)$	$M = 4.41 (SD = 1.15)$	$M = 4.37 (SD = .979)$
Verbal	$M = 5.62 (SD = 1.20)$	$M = 4.37 (SD = 1.20)$	$M = 5.18 (SD = 1.42)$

Overall $M = 5.95$ ($SD = 1.04$) $M = 4.40$ ($SD = 1.15$) $M = 4.67$ ($SD = 1.20$)

Figure 1

Mean scores on color condition memory assessment

Mean Scores (visual/verbal)

0

1

2

3

4

5

6

7

Color

Black and White

Text

Condition

Visual

Verbal

Overall

Figure 2

Interaction Effect Between Variables

Interaction effect between variables

