

Effects of Font Color on Memory:

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PSYCH 121: Laboratory in Cognitive Psychology

University of California, Los Angeles

March, 22, 2023

Abstract

This study explores how font color affected memory function. The three font color conditions employed in the within-subjects experimental design were black, red-black, and green-black. In a free recall test, participants (N=30) were asked to recall as many terms as they could after being shown a list of 12 words. The notion that a change in font color improves recall was not supported by the results. Gender and font color did, however, interact significantly, with women recalling more words than men under the color-changing settings. This study adds to the body of knowledge about how color affects memory and emphasizes the need for more research into how gender affects memory function.

Keywords: memory, recall, color, color psychology, font

Effects of Font Color on Memory

Extensive research has been conducted on the effects of color and memory to show that there is a significant interaction such that color, or more specifically a change in color, enhances memory. With that being said, one major limitation to this body of research is how font color may be used in this way to enhance the memory of an individual. For this reason, our study aims to determine impacts of font color on memory; specifically, how a change in font color impacts memory.

Previous studies have shown the significance of color change on enhancing memory. Here, researchers found that changing the background color when presenting words to participants, was enough to induce a significant context effect thus increasing the total number of items recalled (Isarida & Isarida, 2007). In trials conducted with a common background color (no change in background color between words), the background color context effect was eliminated. Researchers attributed this overall effect to habituation; participants' attention was redirected by the color change (Isarida & Isarida, 2007).

Furthermore, Donthu et al. (1993) noted a similar habituation/change effect when researching the impact of color on outdoor advertisement recall. Researchers found that respondents were more likely to recall black and white outdoor advertisements than colorful outdoor advertisements (Donthu et al., 1993). Advertisement agencies tend to market products with bold colors that “attract” the consumers’ attention. However, overusing this tactic causes consumers to lose attention, or habituate, to the presence of colorful advertisements. Therefore, advertisements that contrast with the colorful norm improve a person’s overall ability to recall an advertisement

Research conducted on font characteristics, including color, did not properly assess color. Beyon and Cox-Boyd (2018) gave participants a health-affiliated reading and then tested via a recall test. In this study, no statistically significant results for any font characteristic were found. Most surprisingly to researchers was the lack of effect on font color and memory (Beyon & Cox-Boyd, 2018). This lack of interaction between color and memory was attributed to how color was manipulated in this study. Instead of using color to direct attention through some sort of contrast, this study presented the font color uniformly. For example, in the red font condition, the participants received a passage written uniformly in red font. Despite testing font color and memory, the materials used for the color manipulations did not correspond to what we know regarding the need for a change or contrast of color to evoke a significant effect on memory.

The aim of the current study is to fill the holes in research and establish the relationship between font color and memory. As mentioned earlier, there is a significant effect between color and memory such that a change in color enhances memory. However, not much research has been conducted on this effect with the use of font color. This study aims to determine if a change in font color enhances memory. Given past evidence, we predict that trials which contain a color change between words will influence memory. Additionally, we expected to observe a significant difference between the uniform black font condition and the green-black and red-black conditions such that participants would recall more words from the green-black and red-black conditions. Also, we expected to observe better recall performance in the red-black condition than in the green-black condition as measured by the number of words recalled.

Methods

Participants

The sample size consists of 30 subjects aged from 18 to 34 who are UCLA affiliated students and faculty. Before starting, participants receive a detailed research description and give informed consent as we respect the privacy rights of our participants. Additionally, This study satisfies the ethics IRB Review qualifications. Next participants are screened for color blindness and other visual impairments that may affect the participants color perception and overall performance in this study. Specifically, we will ask if they have a color-blind diagnosis. If the participant is diagnosed as color-blind before, the study immediately ends. The recruitment strategy involved the opportunity sampling method, where researchers contacted friends, acquaintances and colleagues and requested participation in the study. After completing the study, participants were requested to share the study with their networks. In addition to this recruitment strategy, blind convenience sampling via UCLA psychology GroupMe chat was conducted. There was no compensation provided for participating.

Instruments

In this within-subjects experimental research design, the independent variable is font color with three levels: black, red-black, green-black. The dependent variable is memory, which is tested using a free recall test. Participants will be shown 12 words, then tested on the number of words they can recall via a free recall test. If more words are recalled on average in one condition when compared to another, a significant effect on memory can be deduced.

A number of controls were put in place in order to ensure the validity of the results. To control for order effects, the order of the words within each condition are randomized. Additionally, the order of the conditions is randomized as well. All words are simple nouns and

will be presented to each participant for three seconds. Each condition has a different list to ensure no words are repeated between the conditions. After all words in the condition are shown, participants will be given a free recall test where they will have one minute to recall all words from the previous condition. Further controls include the font size, type, and rgb code. The font size used was 64 px and the font type used was the default font provided by Qualtrics. Words written in the red font had rgb code rgb(219, 53, 58); words written in the green font had rgb code rgb(65, 191, 46); words written in the black font had rgb code rgb(74, 77, 79) (see Figure 3, for a visual of the material). In all conditions, the background color was white: rgb(255, 255, 255). By using a controlled experimental design and considering various factors that can affect the results, the study aims to test the effects of font color on memory performance in a rigorous and systematic way.

Red-black and green-black conditions are used to create a color change. In these conditions half of the words are black, a total of six words, and the other half correspond to the color of the condition. For instance, when in the red condition, participants will be shown six words in a black font and six words in a red font; the order of the color presentation is randomized. This same procedure occurs for the green-black condition.

Procedure

Participants will be given a Qualtrics link to a project. Each participant will be tested in all conditions: black, red-black, green-black. After participants give consent and are screened for the visual impairments stated above, participants will be presented with words one by one on the screen for three seconds each. There are 12 words for each of the conditions. After being shown all words of the condition, participants will move onto the recall test. The recall screen has a text box that will allow the participants to type in as many words as they remember separated by

commas from the most recent list in one minute (see Figure 4, for text box visual). This procedure is repeated for each condition.

Results

Participants' ages ranged from 18 to 34 years. 95.5% of the participants were aged from 18 to 24, and 4.5% identified as 25 to 34 years old. 54.5% of participants identified as female, 40.9% identified as male, and 4.5% identified as preferring to self-describe. Furthermore, 54.5% of the participants identified as Asian, 36.4% identified as White or Caucasian, and 9.1% identified as Other. The majority of participants were UCLA affiliated (Students/Faculty) with 81.8% of the participants identified as Students, 13.6% of the participants identified as faculty, and 4.5% identified as non affiliated (See Table 1, for participant demographics). 59.1% of the participants completed the study in under 8 minutes, with the average time to complete the survey being 6.32 minutes.

We began analyzing our data by removing participant's results who had failed to complete all conditions of the survey. We then sorted and counted the number of words that were correctly recalled and identified from each recall test. We had three recall conditions: black, red-black, and green-black, and we sorted them accordingly. Additionally, in the red-black and green-black conditions, we sorted the number of words recalled in the red or green font and in the black font.

According to our hypothesis, we expected to observe a significant difference between the uniform black font condition and the green-black and red-black conditions such that participants would recall more words from the green-black and red-black condition. Also, we expected to observe better recall performance in the red-black condition than in the green-black condition as measured by the number of words recalled. To calculate the significance of our results, we

performed a one-way analysis of variance. The one-way ANOVA was done with font color as the variable of interest having three levels (black vs. red-black vs. green-black) and the number of words recalled acting as a proxy to measure memory as the dependent variable. As observed in Table 2, we found no statistically significant effect of font color on recall for any condition, $F(2,33) = 0.52, p = 0.601$.

Further, we analyzed the red-black and green-black conditions separately to determine if there was a significant difference between the color of the font and the number of words recalled. We first looked at the red-black condition and split the words according to the color they were presented to the participants, i.e. split by black font and red font. Then, we conducted a one-way analysis of variance to determine if there were significant differences. As seen in Table 4, there was no statistically significant difference between the number of words recalled in the red font when compared with the number of words recalled in the black font, $F(1,8) = 0.24, p = 0.636$. For the green-black condition, we analyzed the data following the same method as the red-black condition. Again, we did not find any statistically significant difference between the number of words recalled in the green font when compared to the number of words recalled in the black font, $F(1, 10) = 1.25, p = 0.290$ (See Table 5). Lastly, we analyzed the number of words recalled in the red font compared to that of words in the green font following the same method depicted above. Similar to previous findings, we found no significant difference in the number of words recalled between the red font and the green font, $F(1,10) = 2.33, p = 0.157$ (See Table 6).

Interestingly, when comparing results according to gender, we found a significant difference. Initially we were not interested in studying gender, however, when conducting the background research for our study, we were made aware of various gender-based differences in color perception. Because of this, we agreed it might be interesting to examine our results with

the additional variable. To do this, we split our data by male and female and removed the person who preferred to self-describe. Next, we split the conditions and calculated the number of correctly recalled words per condition, just as in the previous data analysis. Using a 2x2 factorial analysis of variance, it was found that there was a significant interaction between gender and font color in terms of the number of words recalled, $F(14, 48) = 2.17$, $p = 0.024$ (See Table 7). Further exploration of this relationship will be explored in the discussion section.

Discussion

Our study included three conditions: black, red-black, and green-black. We developed the conditions in this way to assess 1) whether a specific font color and 2) whether a change in font color would enhance recall of the word. We predicted that we would find a significant result in the color change conditions of red-black and green-black such that these conditions would enhance the number of words recalled when compared to the black condition. Additionally, we predicted that the number of words recalled in the red-black condition despite the font color would be significantly higher than in the green-black condition. Further, we predicted that significantly greater words in red font would be recalled than in green font. After analysis, no significant interaction was observed in any condition, thus, our data do not support our hypotheses. An interesting note, however, was the observation of a significant interaction between gender and font color with the number of words recalled such that females significantly recalled more words than males in the color-changing conditions.

Previous research has shown that color change significantly increases recall. In one study, researchers found that changing background color when presenting words to participants induces a significant context effect, thus increasing the total number of words recalled (Isarida & Isarida, 2007). Similarly, when understanding the significance of color in the recall of outdoor

advertisements, it was found that color contrast or a change in color significantly enhances consumers' ability to recall (Donthu et al., 1993). Despite the implications of this past research, the results of our study indicated that the use of font color did not significantly enhance the recall of words, with the exception of gender-based interaction. In this case, marketing strategists would need to search for ways to capture males' attention and appeal to them so the slogans would stay in their memory. Furthermore, the major difference between this study and the previous studies is the placement of the color. To reiterate, our study specifically focused on the font color of a single word, whereas other studies that noted significant results used color as a backdrop for content. Although the color change was present in our study, the inconsistencies in findings between our results and the results of previous works could be due to the color change occurring in the content or words rather than the backdrop of the content. This would mean that there are specific conditions that would make the color more memorable than others and would need to be explored further before adopting them to the real world. Therefore, instead of focusing on the font color in learning materials or commercial phrases, more effective manners of presenting information to enhance recall can be explored.

The sample size and college affiliation of the study's population limit the validity of the study. To begin, the study's population consisted of only UCLA students and staff, which limits the external validity of the results. Even though it was a within-subjects experiment, there is still emphasis on the total amount of words recalled for each condition in addition to the difference in the amount of words recalled. Therefore, this population may contain characteristics that are uniquely associated with highly educated populations, including literacy and the ability to retain and recall substantial amounts of information through test performance, which could have affected the outcome of the recall. Next, our small sample size ($N = 22$) could have impacted our

results, thus impacting the study's statistical validity. In this case, using a larger sample size may elicit a more convincing and statistically significant response. Using G*power we calculate that a sufficient sample size needed is 252 participants.

Despite attempts to control for all confounding variables, one major potential confounding factor that we could not control for is the testing environment. Because the study was not administered in a laboratory, participants were able to choose their test environment, which can include the presence of distracting stimuli and helpful resources. This is important because our recall test relied heavily on the expectation that participants would pay full attention to the words shown to them and would not engage in other activities. However, if distracting stimuli or useful resources were present in the test environment, this could have altered the participant's attention and innate effort, resulting in an inaccurate outcome. Additionally, since the study only employs basic one-to-two-syllable nouns as its stimuli, it does not accurately reflect more intricate stimuli present in real world situations like visuals or sentences.

Despite the lack of evidence supporting a statistically significant effect of font color on recall when the population is viewed as a whole, there are many possible areas to explore regarding the color-changing font condition. Our research found unexpected results that women recalled significantly more words from the color-change conditions than men; on average, women recalled two words more than men in both the red-black condition and the green-black condition. Therefore, future research could explore why these gender-based differences occur. One possible explanation could lie in perceptual and cognitive differences between the way men and women experience the appearance of color. Jain et al. (2010) showed that females correctly identified more colors in less total time when compared to males. Additionally, females gave more correct responses when distinguishing red and green categories.

Further, future studies can assess more font colors in the study aside from black, green, and red to observe different results related to colors. Research has shown that certain colors are correlated with positive and negative sentiments. Commonly, people associate green and yellow as positive mood colors, and red and black are associated with negative mood colors. Therefore, depending on the various colors, future studies could assess the impact of color on an individual's mood during the test to explore potential implications for memory and recall. If it were to be done, then we expect participants to have more emotional fluctuations and would remember the stimuli presented in aforementioned colors more than “neutral” colors such as white and blue. Possible research directions would also include pairing word or phrase stimuli with a visual cue and determining the participants’ recall. Since there are more possible paths of association in the brain, this study would relate to neuroscience and could possibly utilize brain imaging techniques to determine the physical reasoning behind the results.

References

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Table 1. Participant Demographics

Demographics	n	% of Total
Gender		
Female	12	54.50%
Male	9	40.90%
Prefer to self-describe	1	4.50%
Age		
18-24	21	95.50%
25-34	1	4.50%
Affiliation with UCLA		
Student	18	81.80%
Faculty	3	13.60%
Not affiliated	1	4.50%
Race		
Asian	12	54.50%
White or Caucasian	8	36.40%
Other	2	9.10%

Table 2. Statistical analysis of variance (ANOVA) comparing all conditions

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.167	2	2.583	0.517	0.601	3.285
Within Groups	164.833	33	4.995			
Total	170	35				

Table 3. Statistical distribution of the number of words recalled in each condition including the sum, average, and variance

Groups	Number of words per condition	Sum	Average	Variance
Black Condition	12	141	11.75	8.023
Red Condition	12	134	11.167	1.424
Green Condition	12	145	12.083	5.538

Table 4. Statistical analysis of variance (ANOVA) comparing the number of words in black font and the number of words in red font in the red-black condition

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.399	1	0.399	0.242	0.636	5.318
Within Groups	13.200	8	1.650			
Total	13.599	9				

Table 5. Statistical analysis of variance (ANOVA) comparing the number of words in black font and the number of words in green font in the green-black condition

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	6.750	1	6.75	1.246	0.290	4.965
Within Groups	54.167	10	5.417			
Total	60.917	11				

Table 6. Statistical analysis of variance (ANOVA) comparing the number of words in black font and the number of words in green font in the green-black condition

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	8.333	1	8.333	2.336	0.157	4.965
Within Groups	35.667	10	3.567			
Total	44	11				

Table 7. 2x2 factorial statistical analysis of variance (ANOVA) demonstrating the interaction of gender and color on the number of words recalled

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Gender	33.056	7	4.722	2.194	0.051	2.207
Colors	2.111	2	1.056	0.490	0.615	3.190
Interaction	65.444	14	4.675	2.171	0.024	1.903
Within	103.333	48	2.153			
Total	203.9444444	71				

Figure 1. Average number of words recalled per participant in each condition: black condition = 6.41, red-black condition = 6.09, green-black condition = 6.59

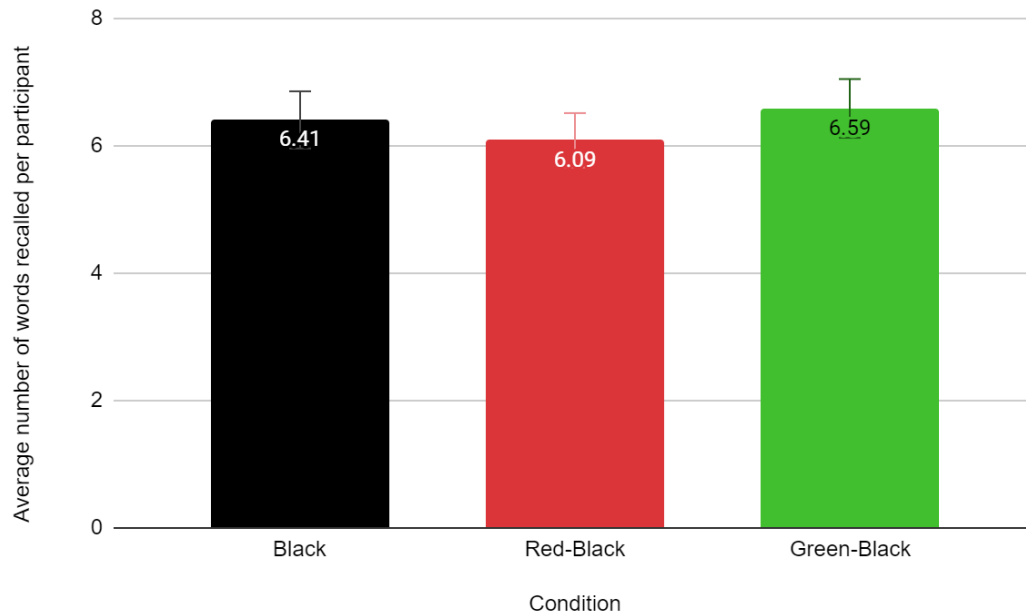


Figure 2. Average number of words recalled per participant in the red-black and green-black condition split by font color: red font = 3.05, black font (red-black condition) = 3.05, green font = 3.5, black font (green-black condition) = 3.09

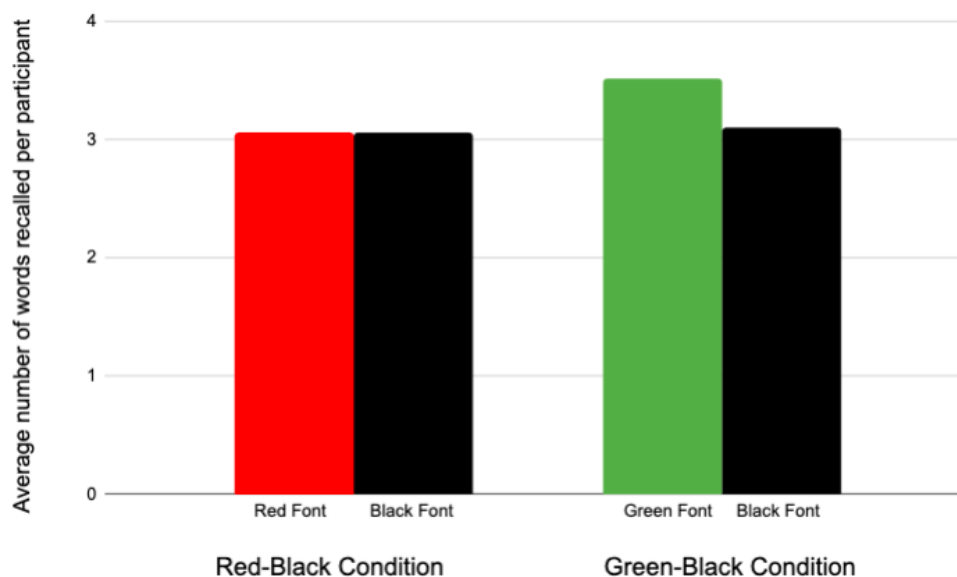


Figure 3. Example of words were shown to participants in each condition



Figure 4. Example of recall test given to participants

Please type all the words you remember and separate the words with a comma.