Color Perception: Assessing The Effects of Red on Cognitive-Task Performance

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Abstract

People have cognitive associations with certain colors. These associations can impact information processing in areas such as cognitive-task performance. The purpose of this study is to test the effects of color on cognitive-task performance. Cognitive-task performance was measured among participants ($N = 120$) who attempted to solve a list of 30 single-solution anagrams with five letters in five minutes in either green, red, or black ink. There was also a self-esteem scale and a survey about test anxiety. Results indicated that the participants who solved green anagrams solved significantly more than the other two conditions. These results do not support the hypothesis and suggest that green caused a higher performance on the anagram test. Also, self-esteem and test anxiety showed to have no correlation with the number of anagrams solved. The results might imply that the use of green ink may lead to greater cognitive-task performance.

Individuals tend to perceive color in different ways depending on the situation and the task given (Elliot, 2015; Elliot, Maier, Friedman, & Meinhardt, 2007; Elliot & Niesta, 2008; Kaya & Epps, 2004). In general, people associate colors with emotions. However, one emotion can be associated with several different colors, and one color can also be associated with several different emotions (Linton, 1999; Saito, 1996). In addition, people typically associate red with more than one emotion. It is a dominant, bold color that has a stimulating effect which possesses both positive such as strength, passion, and love, along with negative emotions such as, aggression, error, and failure. In addition, the color green also has positive and negative perceptions such as refreshment, nature, and success along with tiredness and guilt (Davey, 1998; Mahnke, 1996; Saito, 1996). A research question worthy of exploration is if the color red produces or results in a negative impact on cognitive task performance, or if the color green results in a positive impact on cognitive task performance when each condition is compared to a control group of black anagrams. Previous research has established that college students associate the color green with mostly positive emotions relating to comfort, nature, and success whereas they associate the color red with both positive emotions relating to love and romance along with negative emotions associated with the devil, blood, and error (Kaya & Epps, 2004). The current research will examine these issues in relation to cognitive task performance. In addition, there is also interest in determining if a relationship exists between self-esteem and cognitive-task performance.

An individual's perception of color can vary depending on the that situation the individual encounters. In an original study the effects of the colors blue and red were tested, and it was established that performance on detail-oriented tasks was higher for the color red while

creative tasks were performed better with the association of the color blue; red was also shown to be associated with avoidant motivation whereas blue was used for approach motivation in anagram-solving tasks (Mehta & Zhu, 2009). In the Elliot and Niesta (2008) study, the color red was associated with high appeal or attractiveness when testing men's appeal to women. The photos of women were placed on a red background, and then the photos were compared with green backgrounds. The research demonstrated that participants perceived higher attractiveness when compared with the red backgrounds. In the studies that tested the perception of the color red, the color was perceived differently in accordance with the task that was given; when the task involved cognitive performance, the red was perceived with avoidant motivation whereas it was perceived as love and attraction when males were tested on how they perceived attraction towards women.

The color red, when perceived in classroom-like settings that test cognitive performance tasks, generally impacts performance in a negative way. Several studies were conducted where the participants were asked to solve Chinese idioms and were randomly assigned either a red or blue color condition, and the results showed that participants with the blue condition performed more accurately than participants with the red condition (Shi, Zhang, & Jiang, 2015). Similarly, a study was conducted and tested the effects of seeing red or gray prior to taking an IQ test where a colored rectangle (red or gray) was put on the cover page of the test (Maier, Elliot, & Lichtenfeld, 2008). The results indicated that participants with the red condition answered fewer items correctly than those with the gray condition. The common theme in these studies, along with others, was that the color red impacted performance on cognitive tasks negatively (Bertrams, Baumeister, Englert, & Furley, 2015; Xia, Song, Wang, Tan, & Mo, 2016).

There is a minuscule amount of research that has tested the impact of the color green on cognitive task performances. The Elliot et al. (2007) study showed that participants who had a green condition performed better than participants with a red condition, however, the condition itself was subtle. Participants were given an anagram-solving task where the anagrams were selected from a published list of 205 five letter anagrams with single solutions (Gilhooly, 1978). The researchers wrote the participant's number on the corner of the test using red, green, or black ink. The participants who had the green condition performed best. However, previous research lacks a constant exposure to the color condition to fully evaluate the effects of the conditions validity for the color conditions, which is why there is a need for this study.

Another potential factor in cognitive task performance is self-esteem. Established research has shown that people who have low self-esteem score lower on simple letter-copying tasks than people who have high self-esteem (Terry & Kearnes, 1993). This study provides evidence for a correlation between self-esteem and cognitive task performance. In addition, a study was conducted to determine how self-esteem impacts easy and difficult anagram solving tasks. The study showed that people with high self-esteem in the easy condition solved more anagrams than in the difficult condition (Tang, Liu, & Vermillion, 1987). There is a need for this study because my participants will have the same test difficulty, and the correlation between self-esteem and anagram performance will be shown with more clarity.

The current study assessed the effects of constant exposure to the colors red or green during an anagram test compared to the color black control group along with the impact of self-esteem on cognitive task performance. Previous research, such as the Elliot et al. (2007) study established that exposure to the colors red or green prior to a cognitive task will result in participants in the green condition outperforming the participants in the red condition; however,

this study will establish the relationship between color perception and performance throughout the entire cognitive task. After the task, participants will complete the self-esteem evaluation to determine the correlation between test performance and self-esteem, and then a test anxiety survey that I created will be administered; therefore, it was also of interest to determine the relationship between self-esteem and perception of test anxiety to cognitive task performance results. The hypothesis predicted that individuals who solved anagrams that are in red ink would solve fewer anagrams than individuals with the green or black ink anagrams. I also hypothesized that people with high self-esteem would outperform people with low self-esteem on the anagram test. If supported, these hypotheses will help educators use color appropriately and efficiently in academic settings.

Method

Participants

Recruitment of participants occurred through the convenience sampling process throughout a selection of various psychology courses. Participants received no form of compensation for their participation. Participants ($N = 120$) were primarily female (73%) and male (26%) with one participate who responded as "Other" to the question (1%). The average age of participants was 20 ($SD = 2.80$) years old, and the academic year breakdown was 38% Freshmen, 20% Sophomore, 31% Junior, 7% Senior, 2% Senior+, and 2% Graduate. One participant had a red-orange and blue-green color blindness and one participant had a blue-green and yellow-orange color blindness. Also, 25% of the participants reported a need for glasses, two of the participants reported being far-sighted, and two participants reported having dyslexia.

Materials and Procedure

Demographic survey. Participants reported basic demographic information including sex, age, academic year, and if they had a color blindness or visual impairment.

Anagram test. Participants were given an anagram-solving test with a color condition—a test with anagrams in red ink, a test with anagrams in green ink, or a test with the control condition consisting of anagrams in black ink. Participants were given five minutes to solve a list of 30 anagrams that ranged in difficulty and were selected from Gilhooly's (1978) list of 205 five-letter word anagrams having single-solutions. The Gilhooly's (1978) list of anagrams has been validated in previous research.

Self-esteem test. Participants indicated their perception of self-esteem by rating their agreement with the 10 statements on the Rosenberg Self-Esteem Scale (1965) similar to the following samples: "I feel that I have a number of good qualities" and "I take a positive attitude toward myself" and were rated on a scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Construct validity was established for the Rosenberg Self-Esteem Scale's through correlations with self-evaluations of self-esteem, along with many other measures of personality, psychological and physical health, and academic outcomes (Bagley, Bolitho, & Bertrand, 1997; Robins, Hendin, & Trzesniewski, 2003). The test-retest reliability showed that similar test results occurred when participants completed the Rosenberg Self-Esteem Scale a second time (Baumeister, Campbell, Krueger, & Vohs, 2003).

Test anxiety survey. Participants next answered a six-item survey I created that pertained to test anxiety. The survey is self-made and was rated on a scale from 1 (*strongly disagree*) to 4 (*strongly agree*). The survey consisted of the following six statements: "I generally feel anxious when given a test," "I felt anxious throughout the anagram test," "I felt

rushed throughout the anagram test," "I felt confident about the anagram test when I first observed it," "I felt confident about my ability to solve the anagrams throughout the anagram test," and "I felt confident about the anagrams I solved after the anagram test."

Results

The purpose of the main analysis was to test my hypothesis that individuals who solved anagrams that are in red ink would solve fewer anagrams than individuals with the green or black ink anagrams. I also hypothesized that people with high self-esteem will solve more anagrams on the anagram test. A one-way ANOVA with the total number of anagrams solved as the dependent variable and the color condition as the independent variable tested if there were significant differences between people with who solved green, red, and black anagrams. The ANOVA confirmed that significant differences existed between those who solved green anagrams, red anagrams, and black anagrams, $F(2, 117) = 3.94$, $p = .022$. An independent samples t test demonstrated that means were significantly lower, $t(59) = 2.95$, $p = .017$, in the red anagram condition ($M = 7.98$, $SD = 3.55$) than the green anagram condition ($M = 10.93$, $SD = 6.74$). Also, the means were significantly higher, $t(78) = 2.00$, $p = .048$, in the green condition than the black anagram condition ($M = 8.35$, $SD = 4.53$). However, the difference between red and black anagram conditions, $t(78) = 0.41$, $p = .68$, was not significant. These results do not provide support for the hypothesis that individuals who solved red anagrams would solve less anagrams than the other two conditions.

I also hypothesized that people with high self-esteem will solve more on the anagram test. The total mean score for self-esteem was 19.93 ($SD = 5.53$), and the total mean for the total number of anagrams solved was 9.07 ($SD = 5.23$). A Pearson's correlation tested the relation between the measures. The results showed a nonsignificant, small correlation in the negative

direction ($r = -.11$, $p = .23$). The nonsignificant relation between the variables do not provide support the hypothesis that the people with self-esteem will solve more anagrams on the anagram test.

Discussion

In this study, color perception impacted cognitive-task performance. The hypothesis predicted that participants who had the red condition would solve fewer anagrams than the green and black conditions. That hypothesis was not supported by the results in this study. There was a significant difference between the means of red and green anagrams solved, and there was a significant difference between the means of green and black anagrams solved; however, there was no significant difference between the means of red and black anagrams. This suggests that people solved more anagrams due to the green condition rather than solving less due to the red condition. Also, the other hypothesis predicted that participants who had high self-esteem would outperform those who had low self-esteem. The hypothesis was not supported in this study as there was no significant correlation between self-esteem and total anagrams solved.

The results of this study do not replicate past studies on color perception impacting cognitive task solving (Bertrams et al., 2015; Elliot et al., 2007; Maier et al., 2008; Mehta & Zhu, 2009; Shi et al., 2015; Witzel & Gegenfurtner, 2016; Xia et al., 2016). However, they extend the previous work as participants in this study were exposed to the color condition throughout the entire study as the anagrams were colored. In most of the previously established research, the color red was responsible for the poor performance on cognitive-tasks where green was a factor not typically tested. My research has proposed the idea that the color green may actually be a factor for success in cognitive-task performance; however, these results will have to be replicated to support my results. A possible explanation for the performance of the participants with the

green condition is that those individuals perceived the color green to be a promoter of success throughout the duration of the test, and the perception translated to a higher performance. These results could be applied to real world classroom settings. Educators could implement the color green in lectures and learning activities to promote success in the classroom. In addition, this research could serve as a new baseline in current color perception research as there is very little empirical research for the cognitive impact of the color green on cognitive tasks.

A limitation of this study is that participants were selected through convenience sampling making this study solely represented by college students in which women predominantly made up the sample. Another limitation is the external validity of the study because people rarely solve anagrams in daily life, but most people almost never solve anagrams presented in one color font. This might infer that future research studies should replicate the findings using different cognitive tasks such as word searching or a different, more common cognitive task. Future research could address the first issue by expanding on the population and adding a sample that is equivalent in the amount of genders and ages selected.

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