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The Impact of Colour Perception on Cognitive Task Performance

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Abstract

Past research by Elliot and Maier (2007) has demonstrated that perception of a particular colour can actually affect performance on cognitive tasks. The present study sought to further investigate this possible relationship between colour and task performance using a similar concept and a modified design. Thirty-two participants were randomly assigned to complete a cognitive task by attempting a series of anagrams which had either easy or difficult solutions, and were printed in either red ink or green ink. The results showed that participants in the easy condition performed significantly better than those in the hard condition, as expected. However, the results also showed that there was no significant difference in performance between participants in the green ink condition and those in the red ink condition, which does not support previous findings. Possible limitations of the chosen experimental design and implications of potential future research in a variety of fields are also discussed.

Keyword: Colour, Performance, Anagram, Goal Orientation

The world is full of colour. It is present in everything from advertisements to works of art, or clothing brands to traffic signals. Colour perception is actually visual information, providing some sort of detail about the object or idea it is associated with. Colour adds characteristics to the world around us, and perception of the external world can affect thought processes. It might be possible that perception of colour can actually impact one's performance on a cognitive task.

Elliot and Maier (2007) have investigated the possible impact of colour on performance. After extensive research on the existing literature at the time, they developed a general model of colour and psychological functioning. These researchers wanted to outline both the theory and the application of the ways in which colour can affect the mind. They explained that all visible colours contain meaning which transmits specific information. Whether it is the ripeness of a

fruit, or the distance of a fire, humans are evolutionarily predisposed on a biological level to respond to information being presented through colour.

According to these researchers, the mere perception of a colour actually triggers an evaluative process which can produce two types of achievement style in an academic setting. These achievement styles refer to an individual's particular method of attempting to achieve a goal. The first type of achievement style was termed by Elliot and Maier as approach orientation. Students who adopt an approach orientation they are more inclined to try to succeed (2007). They focus on getting questions right, learning something new, seeking challenge, and doing their best, and generally they do well. Literally, they are moving toward success, by approaching their goal. The other type of motivated behavior was termed as an avoidance orientation. Students who adopt this orientation are generally trying not to fail. They address the task of learning with anxiety and awareness of their possible inferiority. They may withdraw effort or choose easy problems to protect themselves from failure. Literally they are trying to move away from failure by avoiding difficult goals. Elliot and Maier suggest that exposure to certain colours can trigger either type of goal orientation which in turn affects level of performance on tasks.

Why are different colours interpreted in different ways? Elliot and Maier suggest that colour meaning is often based on learned associations from past experience of repeated pairings of colour with a particular message, concept, or experience (2007). They focused their research on the colour red in achievement contexts. They point out that in American culture red is often associated with some form of danger, specifically the danger of failure. One possible source of this link between the colour red and failure is the academic use of red ink to mark mistakes and errors on a student's work. Furthermore, this association is likely based in more general cultural connection between red and danger, such as stop signs and warning signals. The influence of the colour red on psychological functioning occurs as an automatic process, which takes place without conscious intention or awareness. The mere perception of a colour, particularly red, can actually inhibit cognitive performance, even on a subliminal level.

Elliot and Maier conducted an experiment to test their hypothesis (2007). They had participants attempt various cognitive tasks such as anagrams, math problems, vocabulary analogies, and mazes. Prior to attempting the task, participants were exposed to a colour. The participant number was written in the corner of the test in red, black, or green ink. The red condition was predicted to lower performance, while black and green conditions were predicted to be unaffected. The tests were otherwise identical, with the same questions or problems, the same amount of time, and even the same experimenter conducting all sessions. They found that participants in the red ink group performed worse than those in the other conditions. They repeated the study with different colour manipulation, altering the ink colour of the test, the cover page, or even the entire test booklet. They consistently found that participants in the red ink condition performed significantly worse on a variety of cognitive tasks.

The current study aimed to further explore the results of Elliot and Maier by recreating the study using a slightly modified design. Participants were asked to attempt a single page twenty of anagrams. They page was printed in either red ink or green ink. The anagrams were either simple or difficult. Their level of performance was gauged by the number of words correctly unscrambled. It was predicted that individuals in the red ink condition would score lower than those in the green ink condition. It was predicted that individuals in the difficult condition would score lower than those in the simple condition. Lastly, it was predicted that individuals in the difficult condition would be more affected by colour than those in the simple condition, due to the influence of the triggered avoidance orientation (Elliot and Maier 2007)

Method

Participants

In total, thirty-two individuals (15 male, 17 female) who ranged in age from 16 to 67 years (M = 27.03 , SD = 12.71) were recruited to participate in this study. All participants were found by asking friends, family members, classmates, and co-workers of the researcher. All of these

individuals received no compensation in return for their participation. There were no restrictions on participation, meaning any volunteer was accepted. All participants provided written consent.

Materials and Procedure

Participants were invited to take part in a study about goal orientation and task performance. Colour was not mentioned to avoid influencing performance. After reading a letter of information and signing an informed consent form, participants were randomly assigned to one of four experimental conditions. They were each handed a test page from a pre-shuffled stack containing an equal number of all possible conditions. Each condition included eight participants.

The test was composed of a single page that began by requesting demographic data, asking participants to indicate their age and gender. The test page for all conditions contained exactly twenty anagrams, with each anagram being 5 letters long. The easy condition featured a list of anagrams which each had at least 3 possible solutions. The difficult condition featured a list of anagrams with only one possible solution. The single solution anagrams were selected from a list single-solution anagrams put together Gilhooly (1978). The pages were printed in either red ink or green ink, to examine the effects of a colour exposure manipulation. The instructions asked participants to attempt to unscramble as many of the 20 words as possible, and write their responses in the spaces provided. One example anagram was provided where the letters ‘K R N I D’ would correctly unscramble into the word ‘DRINK’.

Each participant was given exactly 5 minutes to attempt unscrambling as many of the anagrams as possible. The researcher timed them using a stopwatch function of an iPhone. Test pages were sometimes scored in front of the participant if they requested, otherwise they were scored at a later time. After completing the task and handing in the test page participants received a short debriefing letter regarding the nature of the study, as well as contact information and reference materials to find further information about the field of research.

Results

A 2 (Colour: red vs. green) x 2 (Difficulty: easy vs. hard) analysis of variance (ANOVA) was conducted to investigate the statistical relationship between ink colour and task difficulty with scored performance as the dependent variable. The results of the analysis are summarized in Figure 1, with the full table of results found in Appendix A. The results indicated that there was no main effect for colour, $F(1,28) = 3.51$, $p = .072$, $\eta p^2 = .111$. Task performance scores did not differ significantly between individuals who had the green test ($M = 12.81$, $SD = 4.29$) and those who had the red test ($M = 10.13$, $SD = 4.33$). The results indicated that there was a main effect for task difficulty, $F(1,28) = 5.74$, $p = .024$, $\eta p^2 = .170$. Task performance scores of individuals who had the easy test ($M = 13.19$, $SD = 4.92$) were significantly higher than those who had the hard test ($M = 9.75$, $SD = 3.26$). The results indicated that there was no significant interaction between colour and difficulty $F(1,28) = .154$, $p = .698$, $\eta p^2 = .005$.

Discussion

On a descriptive level the marginal means of colour conditions looked promising. Participants in the red ink condition scored on average 2.68 fewer correct responses than those in the green ink condition. This would suggest that exposure to the colour red leads to a lower level of performance. However, the statistical analysis showed no significance in these findings. Any perceived difference in the findings was due more to chance than to the manipulation of variables. The results of the analysis did not support the initial hypothesis, which suggests that during this study colour exposure did not have any significant impact on task performance. The results did actually support the prediction that participants who attempted the easy test would score significantly higher than those with the difficult test. The descriptive results also appeared to indicate that colour had a great effect on participants in the more difficult condition. However, the results did not support the prediction that participants in the difficult condition would be more affected by the colour manipulation. This does not necessarily refute any of the findings of past research, but is more likely due to possible limitations in the study, which are discussed below.

Figure 1. Number of correct responses to anagram test represented by marginal means of participants in each condition.

One possible limitation was the saliency of the colour manipulation. The particular shades of red and green chosen may not have been obvious enough to have an effect on performance. It was difficult to determine a level of brightness to use for the test, so the exact shade of red was chosen arbitrarily. The intention was to use a colour bright enough to be noticed, but not so bright that it would distract from the overall task, or inform participants about the nature of the study. It might be advisable to investigate colour saliency for future research using this type of design. Perhaps manipulating colour in more obvious method, such as printing the tests on red and green paper would be more effective. There is also the possibility of manipulating colour in a more subtle way. Perhaps the researcher running the study could be wearing a red or green shirt. In either case, it is worth exploring for future studies.

Another possible limitation was the condition and environment in which the study was conducted. Participants were recruited in a variety of ways, and so the test was conducted in many different locations under different conditions. Some participants wrote the test in a quiet classroom or in the library, while others wrote the test in a busy workplace environment. The differences in lighting, level of noise, and number of people around could all have skewed the results. The nature of this study requires focus and attention to detail. The ideal condition for such a study would be a neutral setting with no noise, good lighting, and little colour distractions in the surrounding area. It would be advisable to test all participants in a library study room with similar lighting, to avoid any confounding variables from external sources.

After completing the anagram test, most participants wanted to discuss the nature of the study, and many wanted to know their scores. This debriefing conversation always began by asking the participants to identify the colour of the test they had just attempted. This information was not systematically recorded, and so was not included in the results or analysis, but it seems worth mentioning. All participants in the red condition accurately indicated the colour of the test. Only some participants in the green condition could identify the colour of the test. Many

participants in the green condition believed the test had been black ink, or simply could not remember or had not noticed the colour at all. This suggests that, at least anecdotally, the red ink was more salient than the green ink. For future research, it would be advisable to include a follow-up survey as a manipulation check and a test of the colour saliency. It would also be worthwhile to ask participants about the nature of the study, to probe their awareness and ensure that no demand characteristics had affected their performance.

Research in the field of colour perception and cognitive performance is of interest to a variety of fields. Individuals in the education or other academic fields would benefit from knowledge that colour can affect performance. This could lead to a decline in the use of red marking pens, to prevent triggering avoidance orientation in students. There are also implications for the field of marketing and advertising.

The results of the present study may not have supported past research, but there is still plenty of room to explore the ideas of these researchers. If improved conditions and designs were utilized, the possibilities of future research are numerous. Any connection between colour and cognitive performance would be of interest to the field of education. Consider how students might perform if their goal orientation was taken into account, or their level of self-efficacy could be improved. The importance of colour is already assessed for use in marketing and advertising, and the connection between colour and psychological functioning can still prove to be significant in everyday life. Despite the findings of this study, the field of colour perception and cognitive task performance still holds many possibilities yet to be explored.

References

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Appendix A

Descriptive Statistics

Dependent Variable: Score

Colour	Difficulty	Mean	Std. Deviation	N
Green	Easy	14.25	5.120	8
	Hard	11.38	2.925	8
	Total	12.81	4.293	16
Red	Easy	12.12	4.794	8
	Hard	8.13	2.850	8
	Total	10.13	4.334	16
Total	Easy	13.19	4.916	16
	Hard	9.75	3.256	16
	Total	11.47	4.458	32

Tests of Between-Subjects Effects

Dependent Variable: Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	154.844[a]	3	51.615	3.134	.041	.251
Intercept	4209.031	1	4209.031	255.577	.000	.901
Colour	57.781	1	57.781	3.509	.072	.111
Difficulty	94.531	1	94.531	5.740	.024	.170
Colour * Difficulty	2.531	1	2.531	.154	.698	.005
Error	461.125	28	16.469			
Total	4825.000	32				
Corrected Total	615.969	31				