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RESEARCH ARTICLE

Effect of background color perception on attention span and short-term memory in normal students

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ABSTRACT

Background: Color is a central component of primate vision and perception of color is crucial to scene identification, recognition, and visual memory. **Aim and Objectives:** The present study was undertaken to find out relationship between color perception and memory. **Materials and Methods:** Memory tests such as visual digit span test, paired association test, and picture recall test were conducted on 90 subjects divided in two study Groups – I (red) and II (blue) and one control group (white) exposed to different color backgrounds to evaluate the recalling capacity to digits, paired words, and pictures. Results were expressed as mean ± standard deviation. ANOVA and unpaired "*t*-test" were applied to compare the results between study and control groups. $P < 0.05$ was considered statistically significant. **Results:** In visual digital span test, Group I (14.36 ± 2.34) showed significant increase in attention compare to Group II (11.77 ± 2.13) and control (12.43 ± 2.27). In paired association test, Group I (16.08 ± 2.46), Group II (16.33 ± 2.77), and control (16.5 ± 2.24) $P > 0.05$ showed no significant difference. In picture recall test, no significant difference was seen between control (9.7 ± 2.91) and study groups; Group I (10.43 ± 3.22) and Group II (9.63 ± 2.94) ($P > 0.05$). **Conclusion:** We conclude that red background color perception has a positive influence on attention span and short-term memory as compared to white or blue color.

KEY WORDS: Color; Memory; Visual Digit Span Test; Paired Association Test; Picture Recall Test

INTRODUCTION

Color is an important part of human perception. It is a central component of primate vision. Perception of color is crucial to scene identification, recognition, and to visual memory.[1] The way how colors affect psychological processing has not been fully explained. Relatively little theoretical work has been done regarding the influence of color on psychological functioning by researchers that are more descriptive in nature rather than aiming to explain color experience in terms of a developed theory.[2,3]

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Red and blue have been shown to have different associations within the cognitive domain. Red is often associated with dangers and mistake and has been linked to the highest level of hazard and also the highest level of compliance. In contrast, blue is often associated with openness, peace, and tranquillity.[4] A word association test confirmed that people indeed generate these different associations to red versus blue color in the cognitive task domain.[5]

Aims and Objectives

This study was aimed to further document the relationship between color perception and psychological functioning

in terms of its influence on attention span and short-term memory. This was achieved by experimentally examining the effects of color on memory performance.

MATERIALS AND METHODS

The study was carried out in a reputed medical college on 90 healthy MBBS students in the age group of 17 to 22 years who volunteered for the study and were randomly selected. The ethical committee was informed about the nature of the study and a permission to conduct the study was obtained. The nature of the study was explained to the subjects and written informed consent was obtained before the procedure.

The subjects were divided in three groups, two study groups, and one control group. Each group comprised 30 subjects. The two study groups consisted of 30 students exposed to black letters and figures on red background (Group I) and another 30 students exposed to black letters and figures on blue background (Group II). The control group comprised of 30 students exposed to black letters and figures on a white background. GPower software (version 3.1.9) was used to determine the sample size.

Subjects suffering from visual impairment, color blindness, and neurological deficits such as amnesia, dyslexia, and those taking medications which could affect memory and intellectual functions were excluded from the study. Before the study, subjects were clinically examined and were not found to be having any significant abnormalities.

Before the day of study, subjects were suggested to have 6–8 h of sleep, have light breakfast, avoid caffeine, and wear comfortable clothing of black and white color preferably to maintain environmental uniformity in term of colors. All tests were performed in black and white color painted room which was quiet and properly illuminated. The subjects were properly instructed about the test procedures and trials were given for optimum performance. These tests were conducted on a 15 inch laptop screen and all subjects were exposed to colors using the background screen color of the laptop.

For visual digit span test, digits from 1 to 9 (Calibri bold font, 300 font size) were grouped in six series and were randomly shown on laptop screen. In any series, each digit was shown for 1 s. Starting series of digits had minimum four random numbers and last series of digits had nine random numbers. In the first series, four random numbers were shown to the subjects and subjects were asked to recall it in the same manner (forward recall). If the subject successfully recalled, the second series consisting of five random numbers were shown to them. Thus, the cycle was repeated until the subject failed to recall any of the series shown to them. Last successful recall by the subject was used to give the score. For example, if the subject failed at third series consisting of six random numbers, it meant that the subject had given successful recall at second series consisting of five random numbers, thereby a score of five was given to the subject. Final score was calculated by adding the score of initial tests to repeated test.

In paired association test, we presented a list of 14 paired words (Calibri font type, 120 font size). Paired words were used, for example, big-small, black-white, and so on. Furthermore, 14 paired words were divided into seven easy paired words and seven difficult paired words. Each paired words presented on laptop screen were shown for 3 s. After showing the first presentation list, first word of the pair was uttered by the examiner and subject was asked to recall second word of the pair within 5 s (e.g., for "big" word uttered by examiner, the correct recall word by the subject would be "small"). After completion of first presentation recall, a 10 s gap was given before showing the second list of presentation consisting of the same list of 14 paired words arranged in different sequential manner. For each easy and difficult association, a score of 1 and 2, respectively, was awarded. Total score was divided by two to get the final score and maximum score was 21.

For picture (free) recall test, pictures of 20 objects were shown on laptop screen for 1 min (i.e., total two slides were shown; each slide containing black and white picture of 10 objects; and each slide was presented for 30 s). After that, we engaged the subjects for 20 min in other activity (i.e., conducted intellectual test). After 20 min, the subjects were asked to write down the list of 20 objects seen previously in his/her preferable language within 4 min. Each correct answer was given a score of 1. Maximum score for this test was 20.

The data entry was done in MS-EXCEL and the analysis was done by SPSS-IS software. The descriptive statistics were used, that is, mean and standard deviation for describing the parameters. ANOVA and unpaired "*t*-test" were used as a statistical test of significance to compare the results of the tests between the three groups. $P < 0.05$ was considered statistically significant.

RESULTS

On comparison between the three groups, we found that *P* value ($P < 0.001$) was significant for visual digit span test [Table 1]. Group I (14.36 ± 2.34) showed significant increase in attention compared to Group II (11.77 ± 2.13) and control (12.43 ± 2.27). In case of paired association test, we did not find any definite relationship between color and new learning ability ($P > 0.05$) [Table 1], that is, Group I (16.08 ± 2.46), Group II (16.33 ± 2.77), and control (16.5 ± 2.24). Similarly, for picture (Free) recall test, no significant difference ($P > 0.05$) was seen between control (9.7 ± 2.91) and study groups, that is, Group I (10.43 ± 3.22) and Group II (9.63 ± 2.94) [Table 1].

Table 1: Comparison of visual digit span test, paired association test, and picture (Free) recall test between Group I, Group II, and control

Test	Descriptive statistics	Group I (Red background)	Group II (Blue background)	Control (White Background)
Visual digit span test	Mean±SD	14.37±2.34	11.77±2.13	12.43±2.27
Paired association test	Mean±SD	16.08±2.46	16.33±2.77	16.5±2.24
Picture (Free) recall test	Mean±SD	10.43±3.22	9.63±2.94	9.7±2.91

SD: Standard deviation

DISCUSSION

Red and blue colors can induce different motivations in individuals. Red is associated with danger and mistakes, induces an avoidance motivation, and makes people become vigilant.[4] As a result, exposure to red (versus blue) narrows the scope of attention, enhancing among others performance on detailed-oriented tasks.[5] On the other hand, blue is associated with openness and induces an approach motivation. Consequently, exposure to blue broadens the scope of attention, causing people to behave in an explorative way. Thus, red and blue tune the scope of attention differentially, with blue and red leading to attention broadening and narrowing, respectively.[6]

The patient's basic level of attention can be readily assessed using the digit repetition test. The immediate recall of digits is a process that does not require any long-term storage of information but does require initial registration, short-term holding, and verbal repetition.[7] As it requires, short-term memory humans are able to retain information about color within short-term memory with a high degree of accuracy over relatively long periods of time.[8]

In our study, we found that there was a significant increase in attention in Group I (red) as compared to Group II (blue) and control (white) group. Our findings are consistent with studies done by Maier *et al*. (2008) which showed that participants exposed to red focused on the detailed local feature (triangle) of a target figure (a square composed of symmetrically arranged triangles) and ignored the broad global form (square) implying that focus narrowing by red color increase attention.[9]

Paired associate learning is commonly used in standard memory batteries and is another highly sensitive measure of new-learning ability. Adequate performance requires the integrity of the total memory system involving recognition and registration of the initial sensory input, retention and storage of the information, and recall or retrieval of the stored information. An interruption in any of these stages impairs clinically relevant new-learning ability.[7]

In our study, we did not find any definite relationship between color and new learning ability. Group I (Red), Group II (Blue), and Control groups did not show any difference. Although we tried to use neutral words for paired association, there were so many words with might be related to other colors. Some previous studies indicate that color related word can produce the same processes and outcomes as actual color stimuli.[5,10] Therefore, there is a possibility of interference with processing of background color meaning unconsciously which might affect the results.

Recent memory is the ability to learn new material and to retrieve that material after an interval of minutes, hours, or days.[7] In our study, subjects recalled 20 pictures after a 20 min gap. We found that there was no significant difference in performance of control and study groups, that is, Group I (red) and Group II (blue). This is probably due to the fact that we used neutral images in color meaning as far as possible. But still there is major possibility of large group of our test subject relating the neutral images to other color. Previous studies have shown that a particular image could be correctly recalled with its natural scenario as compared to grey scale. Furthermore, color memory is not perfect and when human subjects view a color and try to match it from memory after a period of time has elapsed, there are often slight, but measurable, differences between the original and memory-matched color in terms of hue, saturation, and brightness.[11,12] The time gap of 20 min before final recall in our test procedure might have possibly affected the results.

CONCLUSION

Our study shows that there is a significant correlation between background color and memory and learning abilities. We found that short-term memory (attention) improved by red color as compared to the black-white and blue color. However, we did not find a significant correlation between color and new learning ability and recent memory. This may be because of various confounding factors which may have played a role in the final results. There is a scope for further research in this area using appropriate modifications in study design. Finally, we can say that proper and appropriate use of background color would be better than singular use of black and white color material for enhancing memory and intellectual performance especially in case of students.

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