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Does Red Background Color Enhance Short-term Memory or Blue?

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Abstract

Objective: Having in mind the fact that sports performance is done in environments with different colors, environment color, as one of the environmental constraints, can affect attention, acquisition, learning and also memory. Therefore, the aim of the present study was to investigate the effect of cold, warm, neutral and favorite colors on short-term memory.
Methods: In this quasi-experimental study, 24 male and female students of the Faculty of Physical Education, University of Tehran, with an age range of 22 ± 1.64 participated. Tachistoscope of RT-887 model, produced by Sina Institute of Behavioral Sciences, was used to measure sensory and short-term memory.
Results: The result of analysis of variance with repeated measures showed that cold background color resulted in better short-term memory recall than other colors ($P \geq 0.05$).
Conclusion: Based on the findings of this study, color, probably, can be considered as one of an environmental factor leading to short term memory improvement. Therefore, it is suggested that cold colors are used in cognitive learning for emphasizing on short term memory.

Introduction

One of the themes that has attracted the attention of the human beings since the past times is memory. Human beings have always tried to know and improve memory. Academic, professional, and especially athletic success seems to be directly related to memory (Dehghani D, 2005). In essence, memory is the product of information processing. When previously processed information affects current information, it can be assumed that these processes are due to memory (Schmidt RA, Lee TD, 2005).

Memory consists of three parts: short-term sensory store, short-term memory, and long-term memory. Sensory storage is a memory with unlimited capacity and very short duration, so researchers believe that auditory information and visual information stay in the short-term sensory store for 5 and 0.5 seconds respectively and are forgotten if left unattended. Short-term memory is a limited-capacity memory with a short storage time (30 seconds) that retains information about the environment in question for a short period of time - that information that attracts attention. If this information is not reviewed and practiced, it will be removed from memory after a short time and if transferred, it will be sent to long-term memory. Short-term memory therefore plays a vital role in learning and is essentially a bridge between short-term sensory store and long-term memory (H.

Edwards W, 2011). According to the theory of dynamic system perspective proposed by Nicolai Bernstein, the learning of motor skills, which is influenced by the transfer of information to long-term memory, is the result of interaction between the individual and the environment and task (Gallahue DL, Ozmun JC, 1998). The environment, which is one of the three parts of dynamic system perspective, has different components that can affect learning and execution; thus, one of the important goals of motor learning is to identify the optimal training environment for learning. (Raimondi GT, 2016).

Because the environment and tools used in sports have color, color is one of the most important environmental factors that can affect a person's performance. Environmental color is part of a powerful design that produces profound physiological and psychological reactions (Gaines KS, Curry ZD, 2011). In other words, colors can stimulate perceptual and emotional reactions in people and affect their behavior. (Kurt S).

One of the important characteristics of colors is their temperature. In terms of temperature, colors are in a continuum, which is divided into three main categories of warm, neutral and cold. Red, orange and yellow are the warmest colors, and green, blue and purple are the coldest colors (Dehghani D, 2005). Among the colors mentioned, Kobe (1966) evaluated evaluated color detection in the peripheral vision of the athletes and found that red and blue are more detected than white and green (Adilin Mohd Anuardi MN, Yamazaki AK, Eto K , 2018).

Warm colors, especially red, have an appearance that is more closely visible; thus, it attracts people's attention before others. Red is also irritating and may cause fights and escape. Although red places have warmth, energy, strife, and emotional effects on people, it can also be considered an exhausting and competitive color. Competitiveness, fight-seeking, pressure, and visual impact are all negative effects of red (Wright A, 2008), and exposure to warm colors increases arousal and decreases attention (Osueke KK, 2014, Cajochen C, Zeitzer JM, Czeisler CA, Dijk DJ, 2000).

On the other hand, cold colors, and on top of them blue, are soothing and calming and encourage thinking and reflection. Dark blue opens the mind and light blue helps calm the mind and focus (Wright A, 1998).

A number of studies have measured the effect of warm colors on cognitive learning, academic achievement, mood, and motor function; For example, Elliot, Meyer, and Müller (2007) measured the effect of red and blue on adult cognitive function and showed that red limits adult cognitive function (Elliot AJ, Maier M, A., Moller AC, Friedman, R, Meinhardt J, 2007). Meyer, Elliot, and Lichtenfeld (2008) also acknowledged that red distracts the mind and focuses on details rather than generalities (Maier MA, Elliot AJ, Lichtenfeld S, 2008). People who tend to wear red in competitions have higher testosterone levels than people who choose blue (Farrelly D, Slater R, Elliott HR, Walden HR, Wetherell MA, 2013) and wearing red with physiological responses. The body is connected. Also, the heart rate of people

who wear red has increased before, during and after the race compared to those who wear blue. Seeing a red stimulus also has a negative effect on motor performance and stimulates physical avoidance (Dreiskaemper D, Strauss B, Hagemann N, Büsch D, 2013).

Research on cold colors also suggests that exposure to cold colors at low wavelengths increases alertness and concentration (Cajochen C, Zeitzer JM, Czeisler CA, Dijk DJ, 2000). . Previous research in this field has shown that in the acquisition and retention phase of darts, groups that practiced with the blue background color had a better performance (Moradi H, Sohrabi M, Taheri H, 2015). Khajavi Ravari, Farrokhi, Abbasgholipour, Karshenas NajafAbadi and Soheilipour (2013) studied the effect of ambient color on the simple reaction time to sound among athletes. The results of this study showed that people recorded the best reaction time in cold background color. This study showed that being in a cool color environment can increase the speed of audio processing in the human information processing systems (KhajaviRavari E, Farokhi A, Abbasgholipour A, KarshenasNajafAbadi N, Sohilipour S, 2013).

Tahmasebi and Momeni (2014) also conducted a study to investigate the color on the perception of depth of female students during fatigue. The results showed that there was no difference between the depth perception of different groups, but phosphorous color significantly reduced fatigue in this group (Tahmasebi Boroujeni S, Momeni S, 2014). Regarding the effect of ambient color on memory, the results showed that color has a positive effect and a direct linear relationship with children's memory (Dehghani D, 2005); it was also found that dark blue stimulates long-term memory (Wright A, 1998). The study by Alkozei et al. (2016) showed that exposure to blue light leads to more functional reactions in the prefrontal cortex and has a positive effect on memory (Alkozei A et al.,2016). A study by Adilin, Yamazakia and Eto (2018), examining the effect of tablet background color on memory, showed that text on a page with a cold background remained in memory for a longer time (Adilin Mohd Anuardi). MN, Yamazaki AK, Eto K, 2018).

In terms of memory difference in girls and boys, studies of the scientists have shown that the hemispheres of the brain have different functions (Ganji H, 1397). For example, the left hemisphere is responsible for processing verbal information and the right hemisphere is responsible for processing spatial information. As they reach adulthood, these distinctions become more apparent and this distinction is more palpable in boys than in girls (Adilin Mohd Anuardi MN, Yamazaki AK, Eto K, 2018). The result of this distinction is that boys are more successful in processing spatial information and mathematics, especially in visual geometry, while women are stronger than men in verbal and memory tests (especially paying attention to details and in accuracy) (Ganji H, 1397).

Since the color of the environment, as one of the environmental constraints of the theory of dynamic systems has a great impact on learning and execution, choosing the right color of the environment for better learning and execution is

very important. A review of previous studies shows that there is no general agreement on the effect of background color on learning and memory. Some confirm the better effect of cold color on learning (Moradi H, Sohrabi M, Taheri H, 1394) and others confirm the positive effects of warm colors on learning (Al-Ayash A, Kane RT, Smith D, Green-Armitage P , 2016) and in some studies, the effect of ambient color was different according to the running skill (Jafari M, Badami R, 2018). There is also limited research in the field of the effect of background color on memory and their focus is on the effect of colors on long-term memory of individuals and no research has been found that has considered the effect of background color on short-term memory. Since short-term memory plays a key role in stimulus perception in moment decisions and subsequently affects a person's performance, in the present study, researchers seek to answer these questions: Can background colors (warm, cool, neutral and favorite) affect a person's short-term memory? And is there a difference between the short-term memory of girls and boys under different background colors?

Method

The research design is inter-group comparisons and the research method is quasi-experimental and applied in terms of purpose.

Participants

Participants included 24 students (12 girls and 12 boys) from the Faculty of Physical Education, University of Tehran, with an age range of 22 ± 1.64, who were randomly selected for cross-alignment into four groups (start test with warm color, start test with cool color, start test with neutral background color and start test with favorite background color). The number of samples was determined using G * power software version 1-3 with effect size of 0.5, statistical power of 0.8 and confidence interval of 95% by two-way analysis of variance.

Instruments

The instrument used to collect the research data was the TACHISTOSCOE RT-887 of the Sina Institute of Behavioral Sciences. A Tachistoscope is a device used to present a visual stimulus (text or image) at a specified and adjustable time. Tachistoscope is a good tool for experiments of memory, perception, motivation and personality. Tasks such as measuring the capacity of visual perception, selective memory, perception, et cetera are some of the deeds that can be examined using a tachistoscope, if properly planned.

Procedure

After obtaining informed consent, the candidate was told to register the subject details (name, surname, superior eye and favorite color); then a brief description of the test was told to him/her. The subject sat behind the tachistoscope and did the task. The task included looking at 12 images composed of Persian letters and memorizing them. These images included a 3 * 3 matrix of letters. The images were divided into four groups of three images with different backgrounds (cold color, warm color, neutral color, favorite color). The subject was told to sit in front of the

tachistoscope and, if ready, press the device key and look at the image for 9 seconds and write down the letters s/he had managed to memorize (Figure 1).

Figure 1. Memory Test Using a Tachistoscope.

According to Sprling experiment (1996), 3 * 3 matrices were considered as containing 39.5 bits of information for scoring (4.38 bits of information per letter) (Sprling G, 1996). When the subject wrote the letters correctly, s/he received the perfect grade; when s/he did the right thing in recognizing the sound but wrote the letter incorrectly (writing letter instead of letter), s/he was given 75% of the score, when s/he wrote two letters instead of each other, s/he got 50% of the score, and when s/he wrote a similar letter instead of the letter in the picture (letter instead of %25) of the score was put as the individual score. At the end of the test, the scores obtained in each group with the same background color were added together and averaged, and a total of four scores for short-term memory in different backgrounds for each person were considered as individual points.

Statistical Methods

Two-way analysis of variance was used to determine the effect of different background colors on short-term memory and to determine the differences between various groups. Analysis of variance with repeated measures was used to determine the effect of background color on memory and if it was significant, Bonferroni post hoc test was used to compare the two groups. Significance level was determined in all tests as $P \leq 0.05$ and data analysis was performed using SPSS software version 16 and also graphs were drawn using Excel version 2016. In this study, descriptive statistics (mean and standard deviation) was used for describing different groups, Shapiro-Wilk test was used to determine the natural distribution of data and Leven test was used to assess homogeneity of variance.

Results

Mean and standard deviation indices were used to describe the data. Table 1 shows the indicators for short-term memory by background color.

Table 1: Mean and Standard Deviation of Girls 'and Boys' Memory Scores by Different Background Colors.

Gender	Background Color	Average Memory Score	Standard Deviation
Girls	Red	31/75	4/25
	Blue	35/60	2/84
	White	34/29	3/87
	Favorite	33/22	3/63
Boys	Red	32/03	4/32
	Blue	35/65	2/77
	White	35/38	1/38
	Favorite	32/53	4/67

Since the results of Shapiro-Wilk test showed that the significance level of all variables was greater than 0.05, the normality of data distribution was confirmed and two-way analysis of variance was used to examine the differences between girls and boys in different background colors. Two-way analysis of variance showed (Table 2) that the interaction effect of background color and gender was not statistically ($F_{(3,88)}$ =0/24, P<0/86, η^2P=0/008) In addition, the main effect of gender was not significant ($F_{(1,88)}$ =0/05, P<0/86, η^2P=0/808) However, the results showed that the effect of background color on memory was significant ($F_{(3,88)}$ =5/45, P<0/05, η^2P=0/157).

Table 2: Results of Two-way Analysis of Variance to Determine the Difference between the Groups of Participants and the Background Color.

Resources	Total Squares	Freedom Level	Average Square	F	Sig	η^2P
Gender	0/778	1	0/778	2/059	0/808	0/001
Background Color	213/823	3	71/274	5/452	❋0/002	0/157
Gender × Background Color	9/779	3	3/260	0/249	0/862	0/008
Error	1150/341	88	13/072			

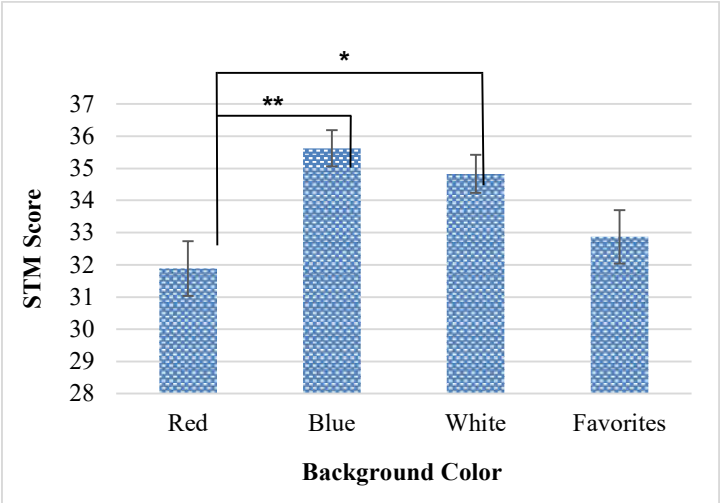
Due to the lack of significant differences between girls and boys, short-term memory function was performed in the next stage, including all samples. Accordingly, the results of analysis of variance test with repeated measures showed that background color has a significant effect on short-term memory ($F_{(2,461)}$ =6/768, P<0/05, η^2P=0/776).

As shown in Table 3, Bonferroni post hoc test showed that the short-term memory function of individuals in red background color was significantly weaker than blue background color (P = 0.009) and white background color (P = 0.036), but there was no significant difference with respect to the desired background color (P = 1.000). In addition, the short-term memory performance of participants in blue background color was not significant compared to white (P = 1.000) and the favorite color (P = 0.060) and there was not a significant difference in short-term memory performance in white background color with the favorite background color (P = 0.285) (Figure 1).

Table 3: Results of Bonferroni Post hoc Test to Determine the Difference between the Background Color Group in Short-term Memory (STM).

Factor (I)	Factor (J)	Mean Difference (J-I)	Standard Deviation	Significance level
Red	Blue	-3/738	1/044	** 0/009
	White	-2/946	1/044	* 0/036
	Favorite Color	-0/990	1/044	1/000
Blue	White	0/79	1/044	1/000
	Favorite Color	2/748	1/044	0/060
White	Favorite Color	1/956	1/044	0/285

* Mean difference at the level of 0.05, **mean difference at the level of 0.01.



Graph 1. Shows the short-term memory (STM) score of people in different background colors.

* Mean difference at the level of 0.05 ** mean difference at the level of 0.01.

Discussion and Conclusion

In the present study, the effect of background color on short-term memory of girls and boys in the Faculty of Physical Education, University of Tehran was investigated. The results showed that there was no significant difference between girls and boys in short-term memory and subjects had significantly better performance in cold (blue) background color but their performance decreased in warm (red) background color and their scores was significantly lower. These results are in line with the researches of Elliot, Maier and Moller (Elliot AJ, Maier M, A., Moller AC, Friedman, R, Meinhardt J, 2016), Maier, Elliot and Lichtenfeld (Maier MA, Elliot AJ, Lichtenfeld S, 2008). , Alkozei et al. (2016), Al-Ayash, Kane, Smith and Green-Armitage (Al-Ayash A, Kane RT, Smith D, Green-Armitage P, 2016) and Adilin, Yamazaki and Eto (Adilin Mohd Anuardi MN, Yamazaki AK, Eto K, 2018) but inconsistent with the researches of Hill and Barton (Hill RA, Barton RA, 2005) and Jafari and Badami (Jafari M, Badami R, 2018). In consistent studies, Elliot, Maier and Moller (2007) found in a study of 81 male and female students that red was associated with increased arousal and heart rate and decreased concentration, resulting in reduction of cognitive and motor functions in Individuals (Elliot AJ, Maier M, A., Moller AC, Friedman, R, Meinhardt J, 2016). In a study by Meyer, Priority, and Lichtenfeld (2008) on 20 high school girls and boys, it was found that red causes cognitive narrowing due to increased arousal, and that individuals experience redness when exposed to red., Receive fewer stimuli as input and as a result, individuals' performance is impaired (Maier MA, Elliot AJ, Lichtenfeld S, 2008). A study by Alkozei et al. (2016) on 35 women showed that because the frontal lobe is one of the areas involved in memory, exposure to blue light activates the anterior-lateral and posterior-lateral prefrontal cortex more and thus improves the performance of short-term memory and working memory of individuals (Alkozei A et al., 2016). Al-Ayash, Kane, Smith and Green-Armitage (2016) in a study of 24 undergraduate and graduate students between the ages of 20 and 38 found that blue made participants feel relaxed and thus improved their performance (Al-Ayash A, Kane RT, Smith D, Green-Armitage P, 2016). Adilin, Yamazaki and Eto (2018) who examined the effect of green, blue and white background color on the memory of 27 boys and 3 girls aged 18 to 24 years and 4 old men and 3 old women aged 65 years showed that the brain frequencies of the frontal lobe of individuals in the white background was less than blue and green background colors, which led to better memory performance in cold background colors (Adilin Mohd Anuardi MN, Yamazaki AK, Eto K, 2018). In the inconsistent studies, Hill and Barton (2005) in a study of martial artists in Taekwondo, boxing, wrestling, and freestyle wrestling at the 2004 Athens Olympics found that athletes who wore red in competition performed significantly better than those wearing blue (Hill RA, Barton RA, 2005). It seems that since in the inverted U-curve, large motor activities required more arousal, and given that red increases testosterone and arousal in men (Cajochen C, Zeitzer JM, Czeisler CA, Dijk DJ, 2000), red color increased arousal and thus led to

better performance of athletes with red clothing. In addition, in the study of Jafari and Badami (2017), which was performed on the static and dynamic balance of 40 gymnasts aged 8 to 10 years, it was showed that the color of the environment had no effect on people's performance (Jafari M, Badami R, 2018); it is worth mentioning that this difference can be due to a difference in age. The subjects in this study were immature children aged 8 to 10 years because in a study conducted by Hasani, Bahrami and Khalaji (2016) it was shown that adults in cold background color and minors in favorite background color performed better. (Hasani S, Bahrami A, Khalaji H, 1395).

According to the previous researches, the effect of background color on performance seems to be related to the inverted U-curve. In the researches in which the used task included cognitive activity (memory) or activities that were subtle (darts) due to the need for low arousal, cool colors due to their calming properties as well as the focus they create in people (Cajochen C, Zeitzer JM, Czeisler CA, Dijk DJ, 2000) cause better performance and it seems that the use of cool colors in environments that require low arousal can lead to better performance. In the field of physical and large tasks (boxing, wrestling, taekwondo) since higher arousal leads to better performance, warm colors due to characteristics such as increased arousal in people, increased heart rate, etc. improve people's performance.

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