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The Effect of Visual Stimuli with Random Arrangement on Visual Reaction Time Among Female Students

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Stable visual stimulus
Changing visual stimulus
Stimulus color

Abstract

The present study was aimed at investigating the effect of presenting visual stimuli with random arrangement on visual reaction time. Fifty female students (with an average age of 11.23±2.14 years) with superior right hand and without visual impairment were selected by a purposive convenience sampling method. Their visual reaction was measured and recorded using a response time measuring device. In the end, variance analysis with repeated measures was employed to examine the difference in time of reaction to the visual stimuli. Testing the study hypotheses showed that there was no difference between the mean times of reaction to blue visual stimulus with stable status and average size and yellow stimulus with stable status and average size. There was a significant difference between the mean times of visual reaction in two methods of presenting blue and yellow stimuli with stable statuses and average size and the method of presenting the variable. The results indicated that there was a significant difference between time of reaction to the presented stimuli with random arrangement, and that changing the status of presenting the stimulus from a stable to changing led to an increase in visual reaction time ($p \leq 0.05$). Therefore, there was no significant relationship between a change in stimulus color and visual reaction time. The results of the present study indicated that the speed of reaction to visual stimuli with stable status is higher in than visual stimuli with changing status.

1. Introduction

We are living in a world in which we are in contact with different stimuli. In order to react to a stimulus, it should first be received by the receptors and transferred to the central nervous system through the peripheral nervous system, so that appropriate response can be selected and initiated. After the appropriate response is initiated, it is transferred to the effector through the peripheral nervous system, so that the initiated response can be executed there (1, 2). Human eye is a complex system to receive light stimuli. In the structure of the eye, there is a three-part section system responsible for eyesight: The first part deals with shape perception, the second with color perception, and the third with motion, location, and spatial organization (3). It is one of the most important factors to skillfully carry out decisions on what to do and what not to do. In special situations, this decision should be made faster and with a higher reliability. Factors such as environmental information processing and coding play a role in this decision making. Environmental information processing happens in some stages including stimulus identification, response selection, and response initiation. Stimulus identification is basically a sensory stage in which the information received from the environment is analyzed through different sources such as visual, auditory, tactile, motor, and olfactory receptors. In this stage, motion patterns are identified. Response selection stage includes making decisions about the type of motion. Response initiation stage is responsible for organizing the required motion. Also, these decisions sometimes include response to visual stimuli which can appear in different shapes, colors, contexts, and intensities. In order to react to a stimulus, it should first be received by the receptors and transferred to the central nervous system through the peripheral nervous system, so that appropriate response can be selected and initiated. After the response is initiated, it is transferred to the effector through the peripheral nervous system to be executed there (1, 4). What is expected in reaction to visual stimuli is visual reaction time which includes reaction time and motion time. Reaction time is the interval between presentation of an unexpected stimulus and response initiation, and motion time is the interval between response initiation (motion) and its end (5, 6). In fact, reaction time is the interval between presentation of an unexpected stimulus and the end of motion (response). Reaction time refers to the certain response at a maximum speed to a presented stimulus, and the individual does not need to recognize the stimulus and response. Reaction time and motion time are considered as important factors in sports success, which means maximum reaction and decision-making time, and shortness of these two factors leads to shortness of the time of reaction to visual stimuli, which means maximum reaction and decision-making speed (7, 8). Using reaction time as a measure for intelligence dates back to Francis Galton (1883) and James McKeen Cattell (1980) Galton and Cattell both believed that there is a relationship between mental ability and sensory discrimination (9). Due to high significance of reaction time in sport and life, numerous studies have focused on this issue, and different factors that affect reaction time have been examined. These factors include age, gender, number of stimuli, sports exercises, intensity of stimulus, type of stimulus, motivation, intelligence, brain injury, superior hand, focal vision and peripheral vision (environmental color), personality type, stimulants, learning disorders, hunger, and environmental heat and humidity (7, 10-12). In fact, factors affecting reaction time influence response time. In a study aimed at measuring performance using colorful balls, Morris (2004) concluded that changing background color and stimulus color affected reaction time (13). Hall-Zazueta (2011) carried out a study in order to examine the effect of stimulus color on reaction time, and observed a significant difference (10). In their study, Gordjin et al (2005) pointed out that blue light makes retinal ganglions sensitive in both humans and animals, and that processing blue stimuli is faster than yellow ones (14). Cobb (1969) assessed color recognition in the eyesight of athletes in different athletic fields, and the results showed that color resolution had a significant effect on visual reaction time (15). Moreover, Morris (2004) studied children of 7 and 8 years old and stated that the children responded to their favorite color faster and more precisely. Signal detection theory states that environmental conditions can be a factor that increases or decreases the speed of recognizing a stimulus, and according to this theory, the environment's color can also be a factor in decreasing errors in recognizing signals (13). Ziaee et al (2007) reported a significant reverse relationship between reaction time and intelligence (16).

In a study entitled, "the relationship between intelligence and reaction time", Aiken (1985) found a significant relationship between these two variables (17). Eysenck et al (1998) reported a significant relationship between reaction time and intelligence (18). Roberts et al (1998) also showed a significant relationship between intelligence and reaction time (19). Salehi et al (2010) observed a positive significant relationship between presenting random stimuli and stimulus-response compatibility (shortness of reaction and motion time and in the total shortness of response time) (20). Daneshfar et al (2006) carried out a study in order to examine the effect of before symptoms on reaction time, and concluded that before symptoms had an effect on reaction time such that they reduced reaction time (21). Delbari et al (2009) carried out a study to measure reaction time and motion time (response time) and concluded that computer games had a significant effect on reaction time and motion time (response time) and reduced them and thus response time would be shorter (22). According to different studies focusing on reaction time, which is the most important component of response time, in the face of visual stimuli, the present study was carried out in order to examine the effect of presenting visual stimuli with random arrangement on visual reaction time in order to figure out whether changing color from blue to yellow and status from stable to changing while presenting the stimuli randomly and with unpredictable arrangement and also presenting the stimulus 10 times in changing intervals affected visual reaction time or not, or whether there was a difference between different visual stimuli or not, and in case of difference, what types of stimuli differed with each other.

2. Material & Method

2.1 Subjects

The present study was semi-experimental, and The present study was semi-experimental, and with regard to purpose, it was an applied research in which the effect of presenting visual stimuli of average size and with random arrangement (each stimulus repeated 10 times and the average response time was obtained from the 10 repetitions) on visual reaction time was measured. The statistical population included all of the 6th-grade female students of Pars Abad town with a mean age of 11.23±2.14 years and superior right hand, and without visual impairment. From among them, 50 students were selected as the study sample by a purposive convenience sampling method. Before the study, the participants were examined by an ophthalmologist to make sure they did not have visual impairment, as a result, the study participants had equal conditions. Afterwards, in order to carry out the study, the test execution environment was controlled regarding disturbing factors such as noise, light, and so on, and before the visual stimuli were randomly presented, the participants were provided with short verbal explanations on how to respond to the visual stimuli by moving the computer mouse, and the time allotted to finish the task.

2.2 Measuring tool

In order to evaluate and measure the collected data, a visual reaction time measuring software was employed. The software was made by the researcher, which is a part of dynamic biofeedback device. This software can show reaction time and response time both dynamically and non-dynamically. In the present study, response time was examined non-dynamically. In so doing, the participants were asked to start the test once they saw the rectangular blue box and respond to the presented visual stimuli in intervals and with different repetitions of a maximum of 10 times. In this software, diversity of options of size, background color, and target image enables the researcher to do a lot of researches by designing different types of tests. Therefore, this software can be utilized to design a test and statistically analyze the collected data. To confirm the validity and reliability of the software and the biofeedback device, 6 types of comparative reaction time and response time tests were administered on 35 male university students (age: 23.9±2.4 years) using computers and the biofeedback device, and the results indicated the validity and reliability of the device and the software. The measuring instrument of the present study consists of control unit, monitor, stimulus presentation, and reaction application unit. The reliability of this instrument was 88.5 in measuring motion time and 0.88 in measuring reaction time, and its validity was 0.78 (7).

2.3 Procedures

First, necessary permissions were obtained from the Department of Education of Pars Abad, and after making necessary coordination, the researcher referred to the girls' primary schools and provided the teachers, the students' parents, and trainers with clear explanations about the aims of the study. The consent form was completed by the participants' parents. Participation in the study was completely voluntary. At last, 50 female students were selected by a purposive convenience sampling method. Afterward, the test execution environment was controlled regarding noise, light, and other disturbing factors. Then, the selected participants randomly received blue stimulus with stable status, blue stimulus with changing status and yellow stimulus with stable status, and they were tested without giving them any feedback. The administration and scoring method was as this: After the participant announced to be ready, she sat on a chair at a computer desk in a calm room, and once she concentrated enough for 1 minute, she would randomly respond to one of the 3 stimuli that she was not aware of their color and appearance time, and this response was given 10 times, and the mean time of response in those 10 attempts was calculated and recorded separately for each participant. This procedure was carried out for all of the 3 stimuli and the mean of the responses for each stimulus appeared in changing times and without letting the participants know the appearance time was calculated. Therefore, all of the 50 participants responded to the 3 types of presented stimuli with random arrangement, and the mean time of response that was obtained from 10 repetitions of each presentation of the stimuli to each participant was recorded.

2.4 Statistical method

Descriptive statistics was used in order to examine the mean and standard deviation, and inferential statistics was utilized to examine the difference between the participants' response time. Mauchly's sphericity test was used to test the sphericity of the data, and Huynh-Feldt statistic was used when the data were not spherical. Finally, ANOVA with repeated measures was employed to examine the difference in time of reaction to the visual stimuli. After the difference was approved ($p<0.05$), Bonferroni post hoc test was run to identify stimuli that are different at the time of visually responding to them.

3. Results

After the required data were collected, descriptive statistics including mean and standard deviation was examined (See Table 1).

Table 1. Mean and standard deviation of the time of response to visual stimuli with random arrangement.

Conditions of presenting the stimulus	Mean	SD	N
Blue visual stimulus with stable status	0.553	0.159	50
Blue visual stimulus with changing status	1.295	0.515	50
Yellow visual stimulus with stable status	0.496	0.141	50

According to Table 1, the shortest response time was related to the yellow visual stimulus with stable status and the longest to the blue visual stimulus with changing status.

After the descriptive statistics were examined, inferential statistics were used to examine the study's hypothesis more. First, the sphericity of the data was tested, and in case of lack of data sphericity (sig=0.001) and Mauchly of equal to 0.339, Huynh-Feldt statistic was used. Afterward, variance analysis with repeated measures was used for the study's data (See Table 2).

Table 2. The results of ANOVA with repeated measures of the time of response to visual stimuli with random arrangement.

Variation source index	SS	Df	SM	F	Sig.	Pes
Factor	19.854	1.218	16.304	111.108	0.001	0.694
Error	8.756	59.668	0.147	-	-	-

SS = Sum of squares, SM = Square of means.

The results presented in Table 2 show that presenting visual stimuli in a random way had a significant effect on visual reaction (sig=0.001), and that there was a significant difference between the visual stimuli.

Bonferroni post hoc test was run to identify the difference in the time of response to different visual stimuli (See Table 3).

Table 3. The results of Bonferroni post hoc test.

Conditions of presenting the stimulus	Blue visual stimulus with changing status and average size		Yellow visual stimulus with stable status and average size	
Blue visual stimulus with stable status and average size	I-J sig	0.741* 0.001	I-J sig	-0.058 0.090
Blue visual stimulus with changing status and average size			I-J sig	0.799* 0.001

The results presented in Table 3 show that there was no difference between the mean times of response to the blue visual stimulus with stable status and average size and yellow stimulus with stable status and average size. They also showed that there was a significant difference between the mean times of visual response to two methods of presenting the blue stimulus and yellow stimulus with stable status and average size and the mean time of response to the blue visual stimulus with changing status and average size. Also, they indicated that there was a significant difference between the mean times of response to the stimuli presented with a random arrangement, and changing the presenting status from stable to changing led to an increase in visual response time ($p \leq 0.05$). Therefore, there was no significant relationship between the color of stimulus and visual response time.

4. Discussion

Determining reaction time and motion time (generally response time) is an important criterion in specifying the neuromuscular status among different individuals. Successful performance in different motions or in sports skills requires not only efficient and proper conduction of motor behavior but also a high level of perception ability. In each activity that requires fast and accurate reaction, enhancing prediction skills and response time can help improve motor control. Decrease in response time can result from improvement in information processing speed or in transmission speed of nerve signals in the body. It can even result from a combination of some factors that cause alertness in human. Examples of activities and motions that need fast response include response to visual stimuli that are affected by factors like intensity of the stimulus, resolution of the stimulus, type of stimulus, age, and gender (6). The present study was also an attempt to examine the effect of visual stimuli that were presented randomly on reaction time. The results indicated that among the three different methods of presenting the stimuli, the shortest time belonged to the yellow visual stimulus with stable status and average size, and the longest to the blue stimulus with changing status and average size. The results of ANOVA with repeated measures and Bonferroni post hoc test showed that there was no difference between the mean times of response to the yellow stimulus with stable presentation status and average size and the blue stimulus with stable status and average size, but in changing presentation status, there was a difference between them. The results also showed that changing the color of the stimulus from blue to yellow lead to a decrease in time, but this effect was very marginal and not significant. With regard to the effect of color on visual reaction time, the results of the current study are in agreement those of the studies carried out by (7, 10, 11). Regarding the effect of color type on reaction time and thus visual response time; however, the findings of the current study are not in line with those of the studies conducted by (10, 13, 15). The results of those studies showed that the time of response to blue stimulus was shorter than yellow stimulus while the findings of the present study indicated that the yellow stimulus was processed faster than the blue one. That yellow stimulus is processed faster than blue stimulus may be because yellow has a longer wavelength than blue, and individuals are willing to react to yellow more and faster. It can also be attributed to the higher resolution of yellow (brighter) compared to blue. However, willingness toward color type and different reactions to different types of color may differ in boys and girls (opposite genders), and boys might be more willing toward yellow and react to it faster than blue and vice versa; therefore, furthers studies need to be conducted in this regard.

Numerous studies have focused on processing of information by measuring the individuals' response time, and the results have been contradictory, which is in turn due to various factors that affect reaction time. Some studies have also reported the effect of color difference of stimuli on visual reaction time (6, 11, 12). Moreover, in 1971, Eugene Schurrle carried out studies of color therapy in a clinic in Sweden. The results of his study showed that yellow is motivating while blue is relaxing. Taking a look at the results of all these studies shows that colors with long wavelength cause more motivation than those with short wavelength. The results of the present study showed that the times of response to the yellow stimulus was to some extent shorter than the blue stimulus. They also indicated that when a stimulus was presented in an unpredictable way, the visual reaction time increased remarkably, which is in complete agreement with the results of the study carried out by Salehi et al (2010) with regard to presenting a stimulus in an unpredictable way and its effect on visual reaction time (20). Frank Gebert (1977) studied color therapy and concluded that yellow is a stronger stimulus than blue, which was also shown in the present study, and it was indicated that the shortest average time of visual reaction was related to the yellow stimulus. This finding is in line with those of the studies carried out by Delignières and Brisswalter (1995), Zazueta (2011), and O'Donell and Colombo (2008) regarding the effect of color on visual reaction time (7, 10, 11), but regarding the effect of color type on reaction time and thus visual response time, the findings of the current study are not in line with those of the studies conducted by Morris (2004) and Cobb (1969) who showed that the time of response to blue stimuli was shorter (13, 15). In this regard, Gordjin et al (2005) stated that blue light makes retinal ganglions sensitive in both humans and animals. Retinal ganglion cells are sensitive to short wavelengths like blue, and these changes are because of this color. They attributed the higher 30% of alertness in blue environments to the indirect processing of blue light in such areas. Because athletes showed shorter reaction time by being present in blue environment compared to other environments, it can be concluded that they had a better performance due to their higher level of alertness (14).

The results of the present study showed that a blue stimulus is processed a little faster than a blue one; however, comparing different statuses of presenting visual stimulus showed the longest response time as a result of presenting visual stimulus with a random arrangement regardless of its color. Overall, the results showed that presenting visual stimuli in a random way had a significant effect on visual response time, and changing the status of the stimulus from stable to changing led to an increase in visual response time. They also indicated that the time of response to the yellow visual stimulus was a little shorter than the blue one. However, there was not a significant relationship between changing color from blue to yellow and visual response time. It is recommended that the average time of visual response be compared among teenage boys and girls in a condition in which the stimuli are presented in a random way. Moreover, time of reaction to auditory stimuli should be examined in both genders.

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