Critical Flicker Fusion Frequency and Visual Reaction Time in Six Different Colors in Students with Different Grade of the Perceived Stress

Arun Kumar Mohan[1], Gopi Kumar Shivaramaiah[2], Neelam Dwivedi[3], Kanessagini Kanageswaran[4], Angelo Soukovelos[4]

[1]Assistant Professor, [2]Associate Professor, Physiology, [3]Professor, Department of ICMPD, Xavier University School of Medicine, Aruba, [4]MD Student, Xavier University School of Medicine, Aruba

Introduction

Perceived stress is the thoughts or feelings one has about their level of experienced stress. The onset of fatigue and perceived stress could be detrimental to the cognitive functioning and ability. Visual reaction time indicates the sensory motor coordination and critical flicker fusion frequency indicates detrimental to the cognitive functioning and ability. In this study the levels of perceived stress and their effect on visual reaction time and critical fusion frequency is measured.

Methods: A total of 75 apparently healthy students in the age group of 18-40 years students were included in the study. The perceived stress scores were measured using the questionnaire and participants were divided into mild (group I) and moderate stress group (group II). The visual reaction time recording was done using different color like red, green, blue, yellow, purple and aqua. Critical flicker fusion frequency was also measured.

Results: The average visual reaction time for red, green and blue was less when compared to purple, yellow and aqua. The mean reaction time for red color in mild stress group I (392 ± 44 msec) was more when compared to group II (379 ± 40 msec). similar findings were found in all other colors except purple were mean reaction time same in both the group. There was no difference in the CFFF between the groups.

Conclusion: It found that sensory coordination in the mild stress group was diminished when compared to participants in moderate stress group. There are no changes in cognitive ability (CFFF) between the groups.

Keywords: *Color visual reaction time, Critical flicker fusion frequency, Moderate stress.*

Introduction

Stress is an inevitable part of the progressive growth of an individual. Students are exposed to various activities in their schedules which are sometimes perceived as stressors. Their involvement of activities like mobile usage, gaming, use of digital media for their studies and entertainment could add on to the stress. Continuous multimedia usage leads to long lasting functional stimulation leading to fatigue. The onset of fatigue and perceived stress could be detrimental to the cognitive functioning and ability. **Perceived stress** is the thoughts or

feelings one has about their level of experienced stress.

Perception of colors depends on the electrical activity in the retina and the integrity of optic nerve. The color perception time varies for different colors. According to the trichromatic theory of color vision the three types of cones: red, green and blue forms the primary colors of the vision[1]. Stimulation of red and green cones forms yellow, stimulation of blue and green forms aqua and stimulation of red and blue forms magenta color.

Visual reaction time is time taken for the time interval between the stimulus presentation and motor response given by an individual. It is an indirect indicator of sensory motor coordination of an individual and thus it also indicates the activity of the central nervous system[2]. The time interval also indicates how quickly person a person can identify the spot of light, decision making and also cognitive ability to perform appropriate motor activity.

Critical fusion flicker frequency is the parameter is which is considered as a parameter to measure the cognitive ability of an individual[3]. It is equated to the studies similar to evoked potentials measuring the effect of stimulus on cognition[4]. When the flickering light with increasing frequency is subjected to an individual, it measures the frequency of the light at which an individual can no more as a see flicker of light. It is measured in hertz.

In this study the levels of perceived stress and their effect on visual reaction time and critical fusion frequency is measured.

Materials and Methods

The study was done in Xavier University School Medicine, Aruba during September 2021 to January 2022. The Institutional scientific and ethical committee clearance was obtained. A total of 75 apparently healthy students in the age group of 18-40 years students were included in the study. The participants with history of color blindness, smoking, alcohol or any cardiovascular disease were excluded from the study.

Any student with history of medications which could impair cognitive performance were also excluded from the study. Participation in the test was voluntary and informed written consent was taken from every participant.

Demographic data, such as age, gender, body mass index, body fat percentage, vitals were collected from the students.

Perceived stress scale (PSS) testing

Standardized questionnaires were used in the study namely PSS -10 to measure the stress levels among the participants. The questionnaire consists of 10 items to be answered in the 5- point Likert scale[5]. Participants were asked to answer the questions fairly and quickly. Individual scores on the PSS range from 0-40 with higher scores indicating higher perceived stress. Based on the PSS scores the participants were grouped into group I - mild stress (0-13), group II – moderate stress (14-26) and group III – (high perceived stress 27-40).

Critical flicker fusion frequency (CFFF) testing

The CFFF testing was done by using a standard electronic module and protocols[3]**.** The CFFF device consists of red light flickering at frequencies

ranging from 1 Hz to 100 Hz. The examination was conducted in a dimly lit room with the subject sitting 80 cm away from the module. The red light was presented against a white background, and the frequency of the flicker was gradually increased from 10 Hz until the subject reported that the presented light was perceived no more flickering or as "steady" single light. Two such reading was taken and best one was chosen as CFFF for analysis.

Visual reaction time (VRT) testing

VRT testing was done using a standard electronic module and protocol. The VRT device consists of source of light or stimulus presenter and the software in the computer. The person responds to the stimulus by clicking the mouse using dominant hand as soon as he sees visual stimulus. The VRT was measured in milliseconds (msec). The recording was done using different color like red, green, blue, yellow, purple and aqua. Any reaction time less than 150 or more 650 milliseconds was ignored asked to repeat. Three reading was taken for each color and average of the three readings were taken for analysis.

Statistical Analysis

All the data were fed into the computer and analyzed by using the Statistical Package for Social Science (SPSS) software, version 25.0 (IBM, Armonk, NY, USA). The continuous variables like age, BMI, body fat percentage, Vitals, PSS, CFFF, and VRT of different colors were presented as mean and standard deviations. Student's t-tests were conducted for comparing CFFF, VRT between different mild and moderate stress groups (PSS group I and group II). The statistical analysis was performed at a 0.05 level of significance.

Results

Description of Demographic parameters

Total participants were 50 with the average age of 25.2 ± 8.3 years. The baseline parameters like Body mass index (BMI), pulse, blood pressure is mentioned in the table 1. The mean PSS in the participants was 16.3 ± 7.3 in all the participants. The mean CFFF in the participants were 26.8 ± 5.3 Hz.

Table 1: The descriptive parameters of the study population

Parameters	Mean ± SD
Age (years)	25.1 ± 8.3
Body mass index in (kg/m2)	24.7 ± 5.3
Body fat (%)	20.9 ± 7.0
Pulse (beats per minute)	87 ± 20
Systolic blood pressure (mm Hg)	125.6 ± 22.8
Diastolic blood pressure (mm Hg)	80.8 ± 14.7
Body temperature (in oC)	36.3 ± 1.3

Comparison of mean VRT with primary and secondary colors

Visual reaction time for 6 different colors. The mean visual reaction time increases for different color in this order: red < green < blue < purple < yellow < aqua. Red, green, blue is considered as the primary colors and purple, yellow and aqua are considered as the secondary colors. The mean VRT for the primary and secondary colors was 385 ± 37 msec and 398 ± 37 msec respectively with a statistically significant difference (p= 0.002).

PSS scores and groups

The participants were grouped into group I - mild stress (0-13) and group II – moderate stress (14-26). The total; number of participants in group I and group II were 19 and 31 respectively. The mean PSS scores in group I was 7.75 ± 3.47 and group II was 19.56 ± 3.43, with a statistically significant difference (p= 0.000). The baseline characteristics of group I and Group II is mentioned in the table 1. The baseline characteristics of the participants are matching, there is no statistical difference between group I and group II.

Table 2: The descriptive parameters of the study population

Parameters	Group I	Group II	
Age (years)	25.8 ± 5.31	24.75 ± 5.98	0.667
Body mass index in (kg/m^2)	24.87 ± 4.11	24.55 ± 3.96	0.874
Body fat (%)	19.85 ± 7.36	21.38 ± 6.13	0.311
Pulse (bpm)	88 ± 15	86 ± 15	0.930
Systolic blood pressure (mm Hg)	124.4 ± 14.59	126.25 ± 13.60	0.715
Diastolic blood pressure (mm Hg)	79.62 ± 13.02	80.87 ± 6.37	0.698
Body temperature	36.3 ± 0.25	36.2 ± 0.54	0.693

Comparison of CFFF in groups

The mean CFFF in group I was 26.37 ± 4.71, and group II was 26.95 ± 3.03 with a p value of 0.417.

Comparison of Color reaction time in group I and group II

The mean reaction time in the group I and group II were compared using t test. There is increase in the reaction time in group I when compared to group II in all the colors except purple (Table 3). The reaction time for primary color and secondary colors were lower for the group II when compared to group I.

Table 3: Comparison of Visual reaction time for different colors between group I and Group II.

Parameters	Group I VRT (msec)	Group II VRT (msec)	p value
Red	392 ± 44	379 ± 40	0.315
Green	391 ± 35	380 ± 32	0.237
Blue	391 ± 49	387 ± 32	0.723
Purple	399 ± 40	400 ± 33	0.908
Orange	401 ± 40	393 ± 39	0.630
Aqua	405 ±43	397 ± 32	0.486

Discussion

The perceived stress scale (PSS) is a 10-item self-report measure designed to assess "the degree to which situations in one's life are appraised as stressful"[6]. The mean PSS is suggestive that the participants in the study is in the moderate stress. This moderate stress is termed as 'eustress' because this amount of stress in inevitable or essential for survival. Most of the participants are students and they are spending significant amount of time in the academics, acquired new knowledge and skills which could contribute to the moderate stress/ eustress.

The visual reaction time for different colors of light like red, green, blue which are considered as primary colors and purple, orange, yellow is considered as secondary colors. The reaction time is lower for primary colors when compared to the secondary colors. And these differences can be explained in according to corpuscular theory which explains that light with higher wavelength carries less energy. In visible spectrum red light has highest wavelength and carry the lowest amount of energy. And the combination of colors, since combination of different wavelengths, they stimulate two different types of cones and hence takes more time to produce the response. In consistent with our findings, a study by Amini et al 2019, it is reported that there was difference in the simple visual reaction time for the four different colors like red, green, yellow and blue light[7].

The participants reacted quickly to the primary colors when compared to the secondary colors. This could be because the signal processing time in the S-cone system is slightly longer than the other cone systems. Hence further stimulation of the system needed to lead to the delayed perception of blue and purple hues and hence increased reaction time. And moreover, since there is already fatigue due to digital eye syndrome due to mobile usage, there could be further delay in the transmission of

impulses and thus processing of the colours[8].

Group I was with mild stress, the stress not enough to cope up with the everyday activities in life whereas Group II participants had eustress. Participants with mild stress reacted slower when compared to the moderate stress. This slowing is suggestive that their ability to respond to the stimuli was sluggish. In moderate stress, the participants to respond to the given scenario more quickly and appropriately. The cognitive reactivity is better whenever eustress. These findings are similar to the study Bak et al 2022, where the participants with stress reacted better for a task accuracy and behavior task. Further, it is described that the abilities of performing tasks under a positive stress condition (eustress) can be more enhanced than that under extreme conditions (negative stress called distress). This explicitly means that the members of the eustress group work faster and more efficiently[10,11].

CFFF measures the cognitive ability of the individual and it is one of the indicators of visual perception and decision-making capabilities. It also indicates the integrity and functioning of visual system from retina to cortex. The CFFF is considered to be a better indicator of psychomotor performance, attention and concentration. Its measurement does not depend on level of education or language[9]. Curran et al 2000, have explained in their study that CFFF has been used in the early detection of the Alzheimer's disease. The short-term memory loss in Alzheimer's subjects is enhanced with the 10 Hz flicker[12]. There was no significant difference in the CFFF among the two groups, which is suggestive of the fact the cognitive task is not much affected between the mild stress and eustress subjects.

Conclusion and Acknowledgement

It is concluded that the stress levels among the participants moderate. These moderate stresses are required to cope up with the daily activity and survival. The moderate stress individuals react better when compared to mild stress. There is no difference in the CFFF between the moderate to severe stress.

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