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Modified Computer Work Related Mental Stressor Based On Stroop Color Test

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ABSTRACT : Mental stress can be defined as a normal physical response to any mental stimulus or environmental condition. However, it is uncomfortable experience that accompanied by biochemical, physiological and behavioral changes. Jobs and tasks complexity rises recently in a rapidly way, mental stress associated with these jobs should be studied with its influence on human activity and performance. One of the most frequently used laboratory mental stressors is Stroop color test, which is considered as a psychological experiment. The proposed system was based on a modified version of Stroop color stressor with gaze point detection, the stressor is designed with six colors' choices and voice correction protocol to stimulate the required mental stress in three different levels of difficulty. Subjects' mean heart rate is measured to validate the change of heart rate corresponding to difficulty level of mental stress, this validation is to ensure the correct evaluation of the subject's performance. Consequently, identifying the mental stress state.
Keywords: Gaze location, Mean Heart Rate, Mental Stress, Stroop color**.**

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I. INTRODUCTION

The Mental stress is caused due to the response of brain and body to any demand such as work, school, life changes and any traumatic events [1], this response is done by imbalance of parasympathetic and sympathetic levels in human Autonomous Nervous system (ANS) [2], which results in increased and decreased activity of parasympathetic (PNS) and sympathetic nervous system (SNS)[3]. Mental stress can be classified as two types, acute mental stress response that happened in short time due to instant or short mental stressor. However, prolonged or chronic stress response can affect human's physiological functions, such as: immune system, metabolism, and can leads to death[4-6].

In the past, Jobs were based mainly on physical activities. Consequently, physical stress was the only response. However, nowadays and in the future, jobs turns to be computer related work with no physical activities based on pure mental work, computer related work complexity raised in an exponential trend from easy tasks to complex and hard ones[7], especially in last years, causing giant mental stress. Consequently, this leads to mental illness and diseases, and the human starts to lose joy and focus and starts gradually to lose the ability of doing this job[8].J. Stroop invented Stroop color test in 1935[9], and J. Stroop did this test by using colored cards. However, now it becomes a computer related test, this test based on identification of colors in trials, each trial has a certain time duration that adapted as mental stress required[10]. Changing the trial time duration leads us to be capable of using this Stroop tet in different levels of difficulty. These levels of difficulty can lead to stimulate mental stress in different levels. Moreover, monitoring the electrophysiological signals during these mental stressors should be analyzed to understand how much stress person can handle, and consequently can estimate his performance and activity.In this study, a modified version of Stroop color test is verified by its influence on the mean heart rate (mHR) in different levels with advanced signal filtration by the aid of gaze point location. This paper is organized as follows: section II discusses the experimental setup, while section III shows the results of the experiment. Section IV manifest the extracted conclusions and future work.

II. MATERIAL AND METHODS

1. Experimental setup:

Thirteen healthy subjects participated in the data acquisition experiments. All subjects are engineering students (post and undergrad students), with age of (29.5 ± 6.5) years, and mean value of (28.23) years. The selection criteria of subjects stated that:

1.1 Right-handed subjects.
1.2 All selected subjects should have no complaints about any critical diseases.
1.3 Pass colorblind test.
1.4 More than five years' experience in using computer.
1.5 Heart, blood pressure and eyes diseases free.
1.6 Subjects did not underwent any surgical operation in last 2 years.

All subjects have to signed consent forms before the start of the experiment. Moreover, some general conditions were applied to all subjects, such as:
1.1 Subjects have to carry out the test before 12 PM.
1.2 All the subjects perform their test in front of a laptop computer with screen 15.4 inch.
1.3 The direction of light and the surrounding light intensity was almost the same.
1.4 All subjects have to take a mandatory relaxation period for 3 minutes and drink fruit juice before the experiment.

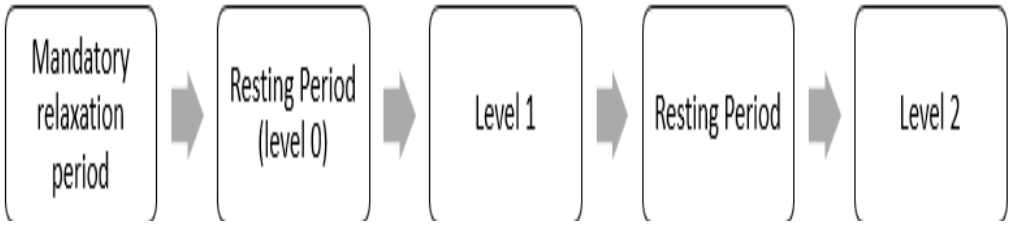

Fig. 1. The experiment flowchart

Figure 1 shows the experiment flowchart, which is consists of:
1.1 Two levels of mental stress, each level takes 150 second.
1.2 Mandatory relaxation period for 180 second.
1.3 Two resting periods, each resting period takes 150 second.
1.4 The first resting period is monitored and its captured data is defined as level zero

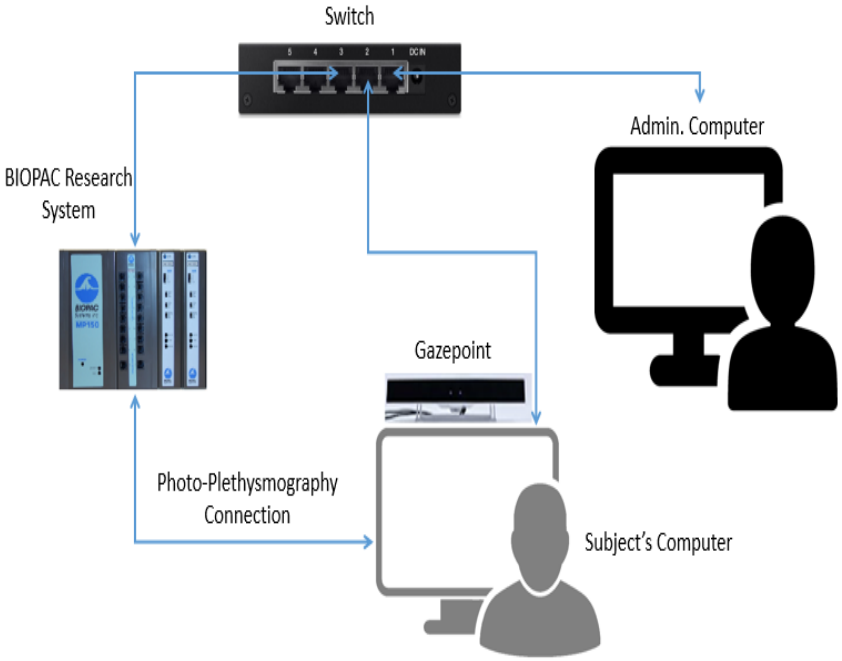

Figure 2. Block diagram of the experimental setup and data flow.

The experiment was carried out to identify the effect of changing the difficulty level of mental stress on subject's mHR. Figure 2 shows the block diagram of the experimental setup including data flow paths and the acquisition devices used in the experiment, where BIOPAC MP150® is used to acquire the mHR value with Photo-Plethysmography module (module No. PPG100C) and Data acquisition module (module No. UIM 100C). The sampling frequency of Photo-Plethysmography is 100 Hz with band pass filter between 0.5 Hz and 3 Hz.

Moreover, Gazepoint® Model No. (GP3 Desktop) is used to detect subjects' point of gaze in the subject's computer with sampling frequency of 61 Hz.
Two Computers were used in the proposed system, the subject perform the Stroop color test on Subjects computer, and the research team to capture and analyze the acquired data uses the administrator computer.

III. MENTAL STRESS TEST

The proposed mental stressor is selected to be based on Stroop color test for its short time of training, the experiment was performed as a word from six colors (Pink, Yellow, Green, Blue, Red, and Black) appears in front of the subject with the same color of the word's meaning. The subject has to select one of the six buttons with respect to the word's color in 1.8, or 0.9 seconds for first, or second level respectively. The answer of subjects is counted to a certain aspects, which are:

1.1 The trial is counted as correct if the subject correctly selects the correct button.
1.2 The trial is counted as wrong if the subject selects wrong button.
1.3 The trial is counted as missed, if the subject did not select any button before the available trial ends up.

A voice correction message is announced to show the state of each trial, "Wrong" if the trial is wrong, or "Missed" if the trial is missed. Moreover, each level of difficulty in the experiment takes 150 second as well as the resting recovery period, the whole experiment takes about 13 minutes, 7.5 minutes of mHR and gaze location recording in the resting period before the test, and through the two levels of Stroop color test. Fig.3 shows the graphical user interface (GUI) of the mental stressor based on Stroop color test, MATLAB® version No. (R2015b) was used as a software-programming tool to build the GUI of the proposed mental stressor.

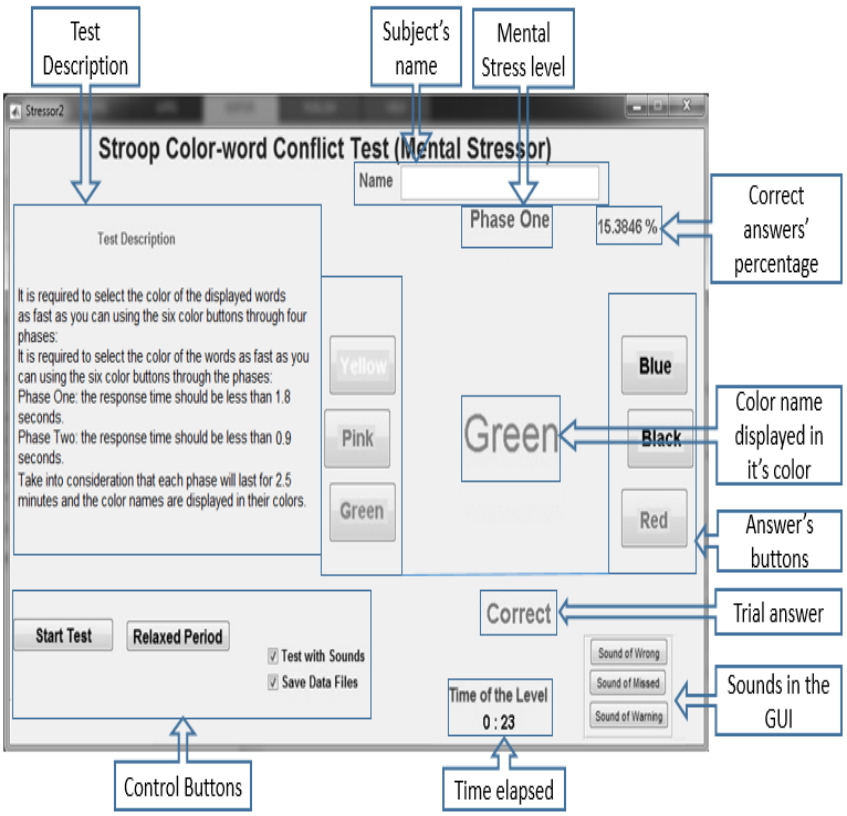

Fig. 3 shows the GUI of the Stroop color test.

IV. MARKERS EXTRACTION

MATLAB® was used as a software-programming tool to build the analysis and markers extraction program. Furthermore, The BIOPAC® Hardware API tools allow MATLAB® to be capable of controlling BIOPAC® research system.Photo-Plethysmography signal underwent hardware filtration by using BIOPAC® Research System with band pass filter between 0.5 Hz and 3 Hz. mHR value was extracted from this signal by calculating the reverse of time distance between peak values. Moreover, mHR acquired from the first resting period is identified as the zero level for the proposed system. Furthermore, Gaze point location values was acquired for both X and Y coordinates.The position of eye gaze location is calibrated by using the built-in tool in Gazepoint® control software, where the upper left border of the screen is location (0,0), and the lower right

border of the screen is location (1,1). Furthermore, the upper left border of the Stroop color test is calculated to be (0.22, 0.093), and the lower right border of the Stroop color test is (0.766, 0.623). However, outside those ranges is in the surrounded ambient area and outside the computer screen border. Figure 4 shows the border area of every region for gaze location, the captured data in Figure 4 shows that the subject's gazing points was inside the area of Stroop color test.

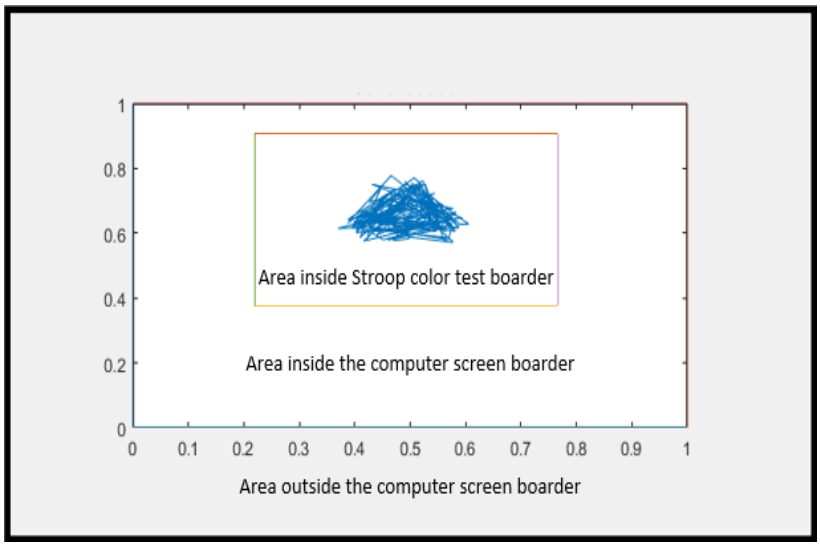

Fig. 4. The Border areas for gaze locations

V. RESULTS AND DISCUSSION

Gaze point is used in the proposed experiment as a disengagement factor, the subject is engaged with the mental stressor unless his gaze point is outside the test border. In other words, the subject is not under mental stress if he looks outside the area of the Stroop color test, and the corresponding HR values should be eliminated to get accurate results.

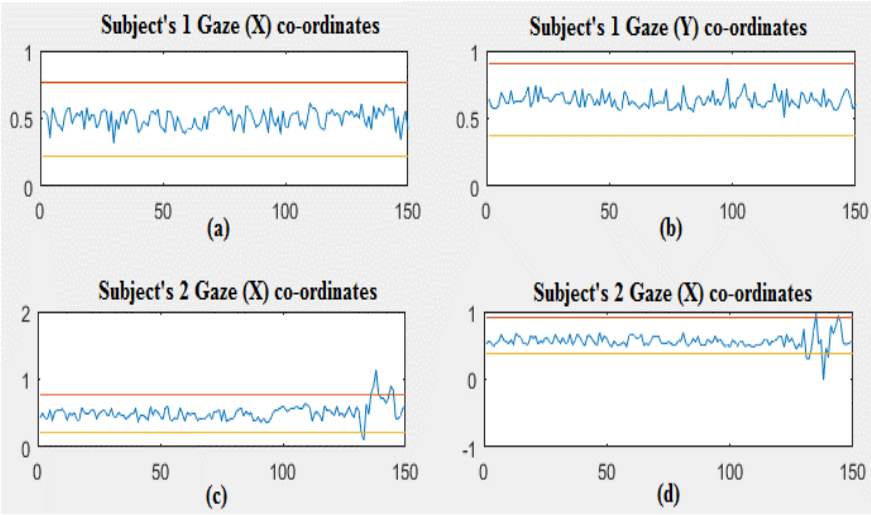

Fig. 5. The gaze location for different subjects in (X), and (Y) coordinates.

Figure 5 (a), and (b) shows the gaze location for (X), and (Y) coordinatesrespectively for one subject, where the gaze locations are inside the border of the Stroop color test for all the 150 second of the test. However, Figure 5 (c), and (d) shows the gaze location for (X), and (Y) respectively for another subject, where the gaze locations are deviated outside the border of the Stroop color test for the last 19 second, which indicate that the subject had been disengaged from the Stroop color test in this period. Consequently, the HR values corresponding to this 19 second had been eliminated. In this study, there were thirteen subjects underwent three level of mental stress including the resting period, where the only independent factor is mental stress. Consequently, a one-way analysis of variance test (ANOVA) is used to test general differences rather than specific differences among means. In other words, the null hypothesis tested by ANOVA is that the subjects'

means for all levels are the same. However, if the null hypothesis is rejected, then it can be concluded that at least one of the subjects' means is different from at least one other subjects' mean.The one-way ANOVA analyze the change in mHR between different levels of difficulty by using MATLAB and the results is shown in table 1

Table 1. The results of HR analysis by one-way ANOVA

Source	SS	DF	MS	F	Prob>F
Columns	579.88	2	289.941	14.38	2.57233e-5
Error	725.95	36	20.165		
Total	1305.83	38			

The change in HR's results shows a significant difference and reject the null hypothesis for subjects' means as p-value <0.01. In other words, there is at least one of the levels' means is different from at least one other levels' means, which need to be analyzed by another tool to find the difference between every two levels. Further processing was accomplished by Tukey's Honestly Significant Difference test (HSD), which is a post-hoc test based on the studentized range distribution, it is used to find out which specific groups' means are different by comparing with each other.

The following HSD formula that is used to test all pairwise comparisons among means:

$$HSD = \frac{M_i - M_j}{\sqrt{\frac{MS_w}{n}}} \qquad (1)$$

Equation 1 is used to calculate the HSD value between mental stress levels' means, where Mi– Mj is the difference between the pair of means, MSw is the Mean Square Within, and n is the number of subjects in the each level.

Table 2. HSD results of mHR regarding different levels of mental stress

Comparison between different levels	HSD results of mHR	p-value
M1 vs M2	3.8199	P<0.05
M1 vs M3	7.5834	P<0.01
M2 vs M3	3.7634	P<0.05

Table 2 shows the HSD results of the change in mHR between every two mental stress levels. HSD results for HR was looked up in the studentized range distribution and it shows that all levels of mental stress are significantly different from each other, the adjacent levels have p<0.05, and there are high significant difference between non- adjacent levels p<0.01and reject the null hypothesis.

Furthermore, to validate the obtained results, a graphical one way ANOVA representation was carried out by using 'multcompare' function from Statistics and machine learning toolbox in MATLAB®. Figure 5 shows exhibit disjoint intervals between different values of mHR, which corresponding to different levels of mental stress.

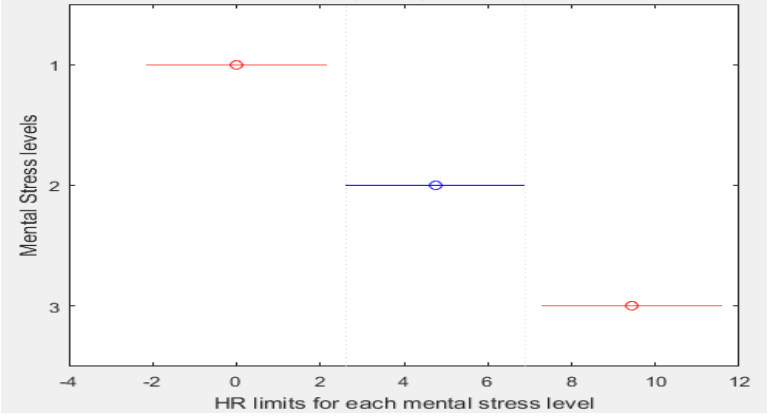

Fig.5 Multi-Comparison between mHRs for the three levels of mental stress

VI. CONCLUSION

Mental stress is a state at which refers to the consequence failure of subjects to respond adequately to mental demands, and it can be defined as how the body reacts to a stimulusthat causes stress. Consequently,

mental stressor should be carefully designed to stimulate the required mental stress, and capture the subject's physiological response related to that mental stress level.The mHR is one of the old markers that is used to identify mental state for subjects underwent different mental stress levels, the proposed mental stressor with gaze location was verified to be capable of stimulating the required mental stress levels, which was reflected on subjects' mHRs.Significant differences between subjects' mHRs were verified between different mental stress levels, and it shows great performance to quantify and evaluate the mental stress state

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