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Biofeedback Based Computational Approach for Working Stress Reduction through Meditation Technique

J. A. P. H. Perera[1], P. M. C. Perera[2], L. M. Rathnarajah[3] , H. B. Ekanayake[4]
University of Colombo School of Computing, Sri Lanka
[1]japh.perera@gmail.com
[2]madhawa.818@gmail.com
[3]miraz.1091@gmail.com
[4]hbe@ucsc.cmb.ac.lk

***Abstract*— Working stress is recognized as one of the major challenges faced by the working community around the world. Working Stress is the response of the people, when presented work demands are not matched to their knowledge and ability and which challenge their ability to cope. Increased stress at work cause depression and anxiety. Working stress cannot be avoided, so mechanism to cope with the stress positively should be identified and practiced. Mindful meditation together with biofeedback helps to reduce the working stress.**

Quantitative classification of mental stress is important to cope up with the stress effectively. This paper proposes a novel approach for detecting and classifying stress using galvanic skin response and image based biofeedback assisted mindfulness meditation to cope with the stress positively in real time. Stress was classified into two levels and meditation was identified as separate level using a statistical framework and during the evaluation of the framework proposed method obtained the accuracy of 82.418%, 73.945% and 64.96% for each respective level.

***Keywords*— Galvanic Skin Response, Biofeedback, Mindfulness Meditation, Mental Stress**

I. INTRODUCTION

Health is not a condition of absence of diseases nor physical or mental weakness, but is a condition of complete physical, mental and social well-being [1]. It is becoming common serious problem all over the world as work is taking the major part of the life of the people [2]. Gabriel in the year 2000 [3] found that increased stressors at work were significantly related to increased incidence of depression and anxiety, and states that depression costs the US economy over $47 billion, and 200 million lost working days per year. In Sri Lanka, inability to cope with stressful situations is considered as one of the major reasons for suicides [4].Stress is not always a negative. Stress is simply the body's response to changes that creates demand [5, 6].

Acute stress is a common type of stress and it is short term in nature. It is inducted as a reaction to an immediate threat and anticipated demands [7, 8]. If acute stress is not solved and last for long periods of time, it becomes chronic stress. Chronic stress will create detrimental effects to several serious diseases and health risks [7, 8].long-term working stress is chronic stress.

Mindfulness meditation helps to broaden the conscious awareness of the current moment and helps to observe the idea thoughts and emotions, and to pass it without any judgment. It produces a deep state of relaxation and calm mind [9]. Stress activates the "fight or flight" part of our nervous system, whereas mindfulness meditation activates the "rest and digest" part of our nervous system, helping with stress management.

Biofeedback is a technique in which people are trained to improve their health by using signals from their own bodies by harnessing the power of mind and becoming aware of what's going on inside the body, will then help to gain more control over the health. [18].

Stress management consultants confirm that it is important to identify someone's stress level, as it helps them to determine the treatment to be given to the patient [10]. Quantitative evaluation of mental stress is important to cope up with the stress , but currently there are no methods to determine stress using quantitative measures [11].

Psychophysiological approach based on GSR can be used to detect the stress. Galvanic skin Response (GSR) activity is viewed as a sensitive and convenient measure indexing changes in the sympathetic arousal associated with emotion, cognition and attention which is associated with stress [12]. The focus of this research is to propose a quantitative techniques to classify stress and identify the possibility of mindfulness meditation and biofeedback techniques to reduce stress.

II. RELATED WORKS

A. Stress Inducing Stimuli

Mental Arithmetic Test (MAT), Public Speaking Test (PST), and Stroop Word - Color and cold pressor test, to induce stress artificially in the laboratory environment [13].

Mental arithmetic Test:- Mental arithmetic task increase the mental activity which will increase the stress level in the person [10]. Further, MAT is can be used to increase the stress level gradually from one level to another by increasing mental demand from easy to hard by the increasing the hardness of the mathematical question [11].

Public Speaking Test:- Uncertainty reduction theory addresses the source of speech anxiety. When an individual face an uncertain or unfamiliar situation, their level of anxiety increase. For most speaking in public is not an everyday situation, the change in regular everyday interaction with others to an unfamiliar public interaction naturally will create stress in a person [14]. Previous

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researchers have proved that changing the uncertain factor speaker's idea (How well the speaker knows the topic), different levels of stress can be simulated [15].

B. Stress Detection

i). Psychological approach:

When a specific event cause a major disruption in the mental status of the person, the source of stress is usually apparent. But in most instances, the impact of a stressor is less obvious. In those instances, psychological approaches like questionnaire and interviews provides more specific information about the source of stress [16, 17].

ii). Bio physiological approach:

Stress can be measured on a real-time by monitoring the bio physiological signals through an invasive method like heart rate variability (HVR), Galvanic skin response, blood volume pulse, and brain wave pattern and noninvasive method like pupil diameter, facial image based recognition. Bio physiological signals identify the stress levels based on how the current signal pattern the deviation from the normal pattern.

Galvanic skin response:- The Galvanic Skin Response (GSR) is defined as a change in the electrical properties of the skin. The signal can be used for capturing the autonomic nerve responses as a parameter of the sweat gland function. It is measured by connecting the electrodes to a voltage amplifier and the voltage varies with the emotional state of the subject. GSR activity is viewed as a sensitive and convenient measure indexing changes in the sympathetic arousal associated with emotion, cognition and attention [18].

C. Meditation

According to previous researcher it is explained that meditation is a practice which can be used to train the mind to make the emotional balance and the consciousness. There are several meditation types of Meditation Techniques such as Basic meditation, Focused Meditation Techniques, Activity-Oriented Meditation Techniques, Spiritual Meditation and Mindfulness Techniques [19].

Mindfulness Technique: - This is a form of meditation that, similar to activity-oriented meditation and this technique really does not feel like meditating. This technique helps to meditator to state the mind in the present movement by avoids thinking about the future or the past and make the conscious. Researches have proved that mindfulness meditation has the ability to cure chronic stress and even tamper off the medication in the long run [12].

D. Biofeedback

Biofeedback promotes relaxation and relieves a number of conditions that are related to stress. During a biofeedback session, electrodes are attached to the body, then these electrodes/sensors send signals to a monitor, which displays either in the form of a sound, or an image which represents the galvanic skin response. Eventually, the person will learn how to control these body functions on their own, without the help of the biofeedback equipment [20].Image is considered as better approach to provide the biofeedback. Neuro scientists have proved that visual images have the potential to increase attention, comprehension, and influence positive health behaviours [21]. Further more than 50% of the surface of the brain, is devoted to processing visual information so that it interpret images that the eye sees rapidly in just 13 milliseconds [22].

E. Mindfulness Meditation and Biofeedback

Mindfulness-Based Biofeedback (MBBT) is a practical and scientifically grounded method of learning self-regulation [23]. It is a simple methods help to cope with flowing of stressors and responding resiliently to life's challenges, both physical and psychological. It is achieved by combining the ancient skills of mindfulness training with advanced physiological monitoring technology, by first sensing, and then displaying the functioning of core body systems in real-time [23]. Researches have proved biofeedback aids the meditation to reduce the stress and it can't be used as an alternative to meditation to reduce the stress.

III. RESEARCH DESIGN AND METHODOLOGY

Based on the knowledge gathered from literature review researchers have selected to use bio physiological signal, Galvanic Skin Response for stress detection and mindfulness meditation and image based biofeedback mechanism as stress coping methodologies. Main study of this research was grounded by the observations of five pre studies.

A. Pre Study 01 – Can mental arithmetic is used to create different level of stress?

Literature suggests that mental arithmetic test can be used to create different levels of stress by increasing the level of hardness of the task. This study was conducted in order to verify whether mental arithmetic test with different level of hardness can create significant variation in galvanic skin response data. The hardness of the tests are created based on previous researches [13]. Protocol of the test is adapted from the previous studies which use Mental Arithmetic Test to induce stress and tested with 6 subjects differentiated based on the hardness of the test.

The first half of the figure 1, shows that during the MAT test level 1, GSR level has gradually increased from its normal state and during the second level test the GSR level gradually decreased. Based on the qualitative data gathered through questionnaire it is verified that the GSR dropped during the second level MAT because participants gave up the task when they felt they can't cope with the task given to them. It is identified that mental arithmetic test cannot be used to create different levels of stress.

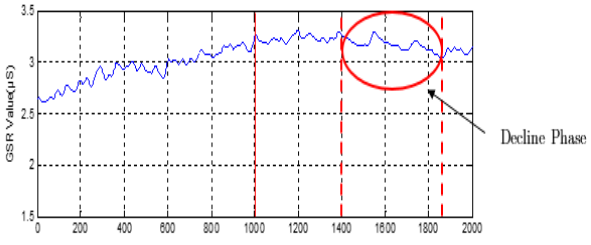

Fig 1: Mental Arithmetic Test

B. *Pre study 02:- can public speaking test be used to create different levels of stress?*

Previous studies suggest that the public speaking test can be used to create different levels of stress by increasing the level of hardness of the task by changing the familiarity of the topic. This experiment was conducted with 6 samples in order to verify whether public speaking tasks with different level of task with different levels, hardness such as self-introductory presentation and impromptu speech can create significant variation in GSR levels which can be used to classify stress.

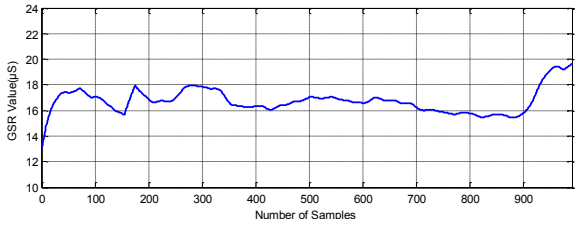

Fig 2: Public Speaking Test 01

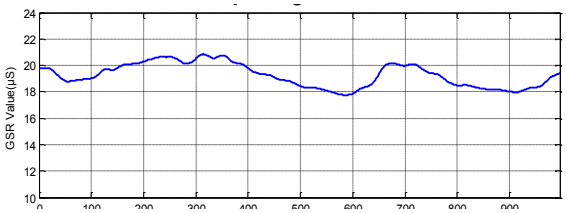

Fig 3: Public Speaking Test 02

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C. *Pre study 03 - can non meditation practitioners reach the meditative state while meditating?*

Meditation is a clinically approved method for stress reduction. The purpose of this study was to understand and observe how the GSR values variates when a subject going through a mindfulness meditation technique. Three practiced meditation subjects and three non-practiced meditation subjects were participated in this study. During the study sample's normal state GSR data and GSR data during meditation was obtained.

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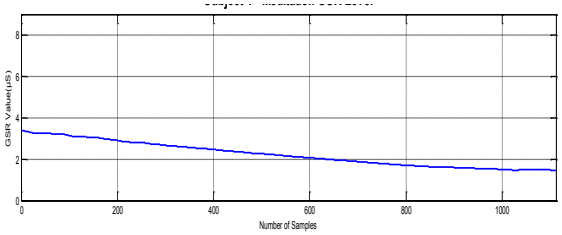


Fig 4: Subject 1 – meditation practitioner

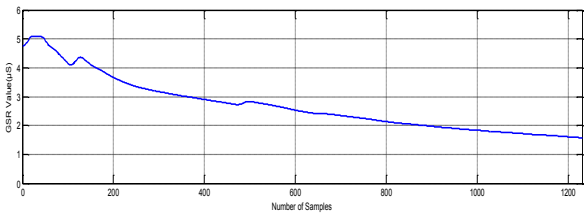


Fig 5: Subject 2 – meditation non - practitioner

According to the observation, it is inevitable that while non-meditation practitioners practicing mindfulness meditation, their GSR level variations gradually decrease from their normal state over the time as similar to the meditation practitioners'. However, the experienced meditation practitioners were able to quickly reduce their GSR levels from their regular state through mindfulness meditation than the non-meditation practitioners. Therefore, based on these findings and observations, researchers conclude that mindfulness meditation is an effective stress reduction method, even for non-meditation practitioners.

D. *Pre study 4 - can image based biofeedback be used to increase the effectiveness of mindfulness mediation?*

In this test, as the biofeedback technique, image was shown to the subject with different opacities. The opacity of the image changes according to the GSR value in real time. This pre study was conducted With 6 subjects the experiment was conducted over the two days. Whether can image based biofeedback can be used to increase the effectiveness of mindfulness meditation.

According to the observations the decrease of the GSR level during the biofeedback assisted mindful meditation is higher over mindfulness meditation. This result was further verified by the responses given by the six subjects. They all stated that image based biofeedback assisted mindfulness meditation helped to increase their level of concentration. Based on these experiments findings and observations researchers' conclude image based biofeedback increase the effectiveness of mindfulness meditation and to use the image based biofeedback assisted mindfulness meditation technique as the stress reduction technique in the phase 2 data collection of this research.

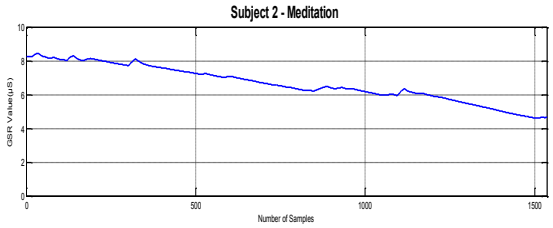


Fig 6: Subject 2 Meditation

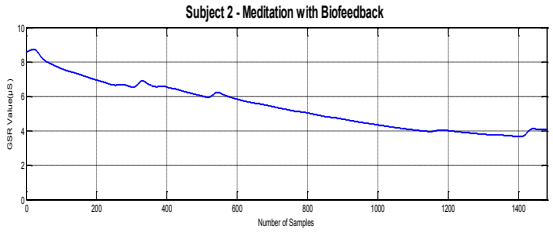


Fig 7: Subject 2 Meditation and Biofeedback

E. *GSR Device and Software Implementation*

Galvanic Skin Response can be measured by placing two electrodes on the fingers [24]. A person's skin acts as a resistance to the passage of electrical current and using a voltage divider circuit it is possible to capture this resistance value.

As shown in the following diagram researchers has designed a GSR sensor device to capture body potential using Arduino Uno board. Reserchers also have designed a Communication Port (Comport) reading software using

Java programing language. The Java Rx-Tx Arduino library was mainly used in this software development.

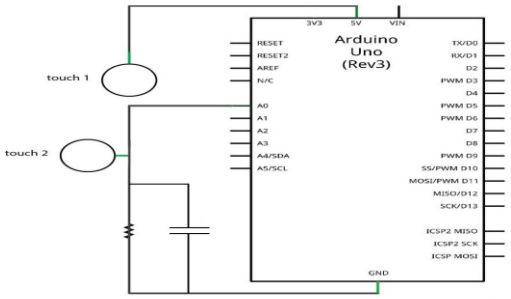
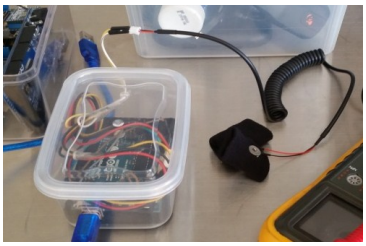
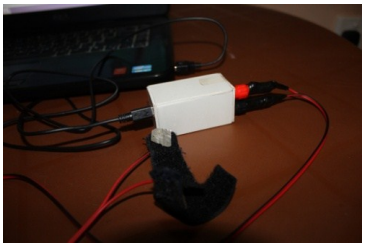


Fig 8: GSR Device circuit





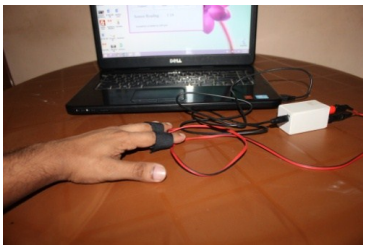


Fig 8.1: GSR Device

F. *Main Study Data collection*

The main study data collection consists with nine tasks which was designed based the observations of the pre studies and knowledge gained though the literature review. Data was collected from the 21 (male 11 and female 10 between the age range 24 - 26) subjects and the data was cleansed to remove the signal notices caused from the **poor contact between the sensors and the skin, Local disturbance of the signal, Sudden disturbance while the data collection process**. Then the GSR signals were smoothened by using the moving average technique before analyzing the data.

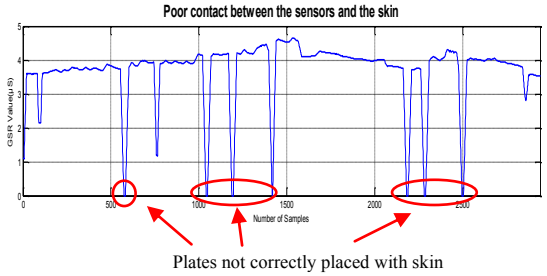


Fig 9: poor contact between the sensors and the skin

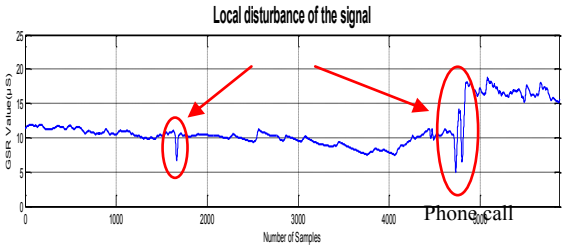


Fig 10: Local disturbance of the signal

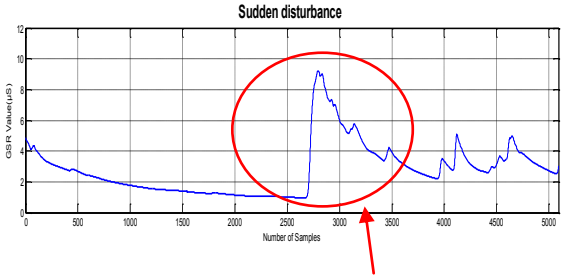


Fig 11: Sudden disturbance

Following procedure was used in the data collection process.

TABLE I
DATA COLLECTION PROCESS

Steps	State	Duration
01	Relax the Subject	10 min
02	Pretest questionnaire	15 min
03	Connect the GSR device	10 min
04	Relax the subject	5 min
05	Normal State GSR	10 min
06	Level 1 Stress GSR(Self introductory speech	10 min
07	Level 2 Stress GSR(impromptu Speech)	10 min
08	GSR during image base biofeedback assisted mindfulness meditation	15 min
09	Posttest questionnaire	15 min

Subjects were relaxed in the first stage because there is a probability that the subject may come from a rush full situation to the procedure and if not relaxed it might affect the baseline of the subject. The step 04 relaxation will be helpful for them to get used with the sensor device which will be useful to gather the accurate data. Same as in the pre experiment on the level one speech test participant was instructed to deliver a self-introductory speech for a period of 2 minutes in front of the panel of judges. Self-introductory presentation is considered to be the first level stress test and Impromptu speech is considered to be the

second level stress test based on the knowledge obtained from phase one data collection. In stage 8 participants were instructed to start practice 15minute image based biofeedback assisted mindfulness meditation. This step was done to gather data to be analyzed to observe whether biofeedback based meditation significant influence to reduce the working stress.

IV. DATA ANALYSIS

Steps followed in this phase are summarized in the following diagram.

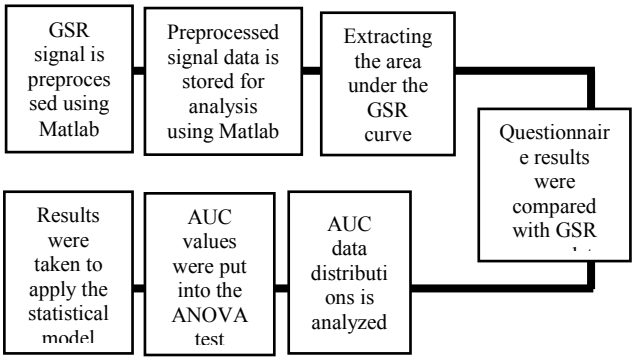


Fig 12: Flow of Analysis

After cleansing the data as mentioned above, those cleansed data is fed into the MatLab program to conduct signal preprocessing and for the feature extraction. The MatLab program which we have developed then filters the GSR signal in order to reduce noise and to eliminate the effect of phase component when calculating the area under the curve. Processed signal is then displayed on the MatLab GUI as in the following figure in order to calculate the area under the curve.

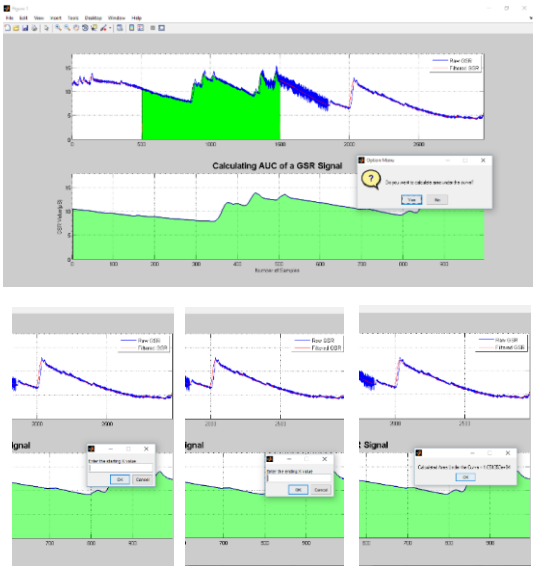


Fig 13: Developed MatLab AUC calculating program

Area Under the Curve (AUC) - In order to analysis of GSR homeostasis changes in human body we have chosen AUC as the interpretation method of the filtered GSR signals. Analyzing GSR signals, especially in Psychophysiology based experiments is one of the major challenges in this research domain. Therefore, we have settled with one of the common and an efficient way of interpreting GSR data (based on the literature) to assess the skin conductance activity level which is AUC that represents the change in skin conductance over a given time interval.

The area under the curve is measured as the area bounded by the curve, the starting point of the sample and end point of the sample and the Y = 0 axis of the graph. Then this area was divided by the length of the time interval, in seconds, resulting in units of μS/Sec. The following figure shows the AUC has taken from a sample filtered GSR signal.

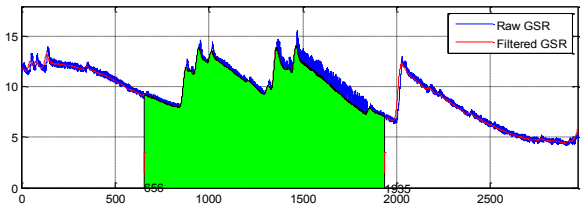


Fig 14: Calculating AUC

After capturing AUC values of all 8 phases those GSR data is ready for the analysis. Analysis was based on two major sections. The quantitative analysis of the GSR sensor data and the qualitative analysis of the participants stress states. The qualitative analysis was conducted using the questionnaires that were given on the data collection stage. These questionnaires were analyzed along with the GSR sensor data (quantitative analysis).

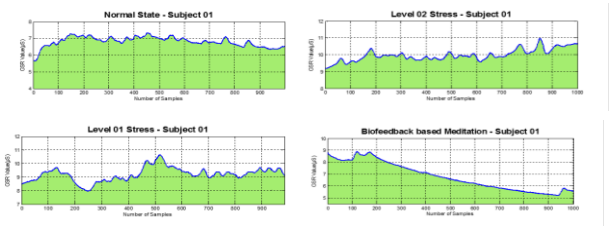
A. Quantitative analysis

After the cleansing of data we have considered 21 data samples for the quantitative analysis. Also, it is important to notice that although the data collection is done is 8 major phases we have only considered 4 major phases of the data analysis. The main reason behind this is all the eliminated phases are there to increase the accuracy of the 4 phases which are shown in the table below. Each of the pre-processed GSR signal data relevant for these phases are loaded as Matlab vectors prior to the further analysis. In this process all the vector dimensions are fixed to a size of 1000 x1 with the data type of 'double'. In terms of number of samples this is equal to 1000 samples, whereas in time domain it's 200 seconds' data at each stage of the experiment.

TABLE III
FOUR STAGES OF DATA ANALYSIS

Phase Name	Number of Samples	Time interval
Normal State (X_0)	1000	200ms x 1000
Level 01 Stress State(X_1)	1000	200ms x 1000
Level 02 Stress State(X_2)	1000	200ms x 1000
Biofeedback based Meditation(X_{3S})	1000	200ms x 1000

Notice that all these graphs are in different Y axis scales in order to display the patterns clearly. When calculating the AUC it does not affect the algorithm that researchers have



used. It will compute inside a boundary of Y = 0 lines and X= 0; X = 1000 and the upper boundary of the curve.

After that, all the values were compared with the questionnaire results. This is the first tep of the analysis. This has been carried out in order to make sure the subject is actually stressed out due to the stress provided by the experiment. This qualitative study makes sure that neither any other external or internal emotional or psychophysiology matters has not impacted on the results that we have collected during the experiment. Therefore observational analysis, qualitative analysis of the questionnaire and the GSR signal's quantitative analysis has been done in order to prove that all these phases are different from each other.

This analysis reveals that all the 21 subjects are participated to the research while having no external stressors. Except 3 subjects all the other 18 subject said that they felt the difference when we change the stressors in the two stages. None of the subjects were habitual meditators. All 21 subjects have agrees with the point, image based biofeedback help their meditation process. After comparing these responses with the quantitative data we moved to the second stage of the analysis which is deriving the separate stress classes or level from the GSR data that we have gathered from each subject.

All the AUC values of each phase as described in the above table were compared related to the every participant's normal state which is known as the baseline value of a person. The difference between the AUC values was taken as the comparison parameters. Furthermore the in order to evaluate the difference between the two levels of stress we have created the X2 – X1 parameter (which is the different between stress level 01 and level 02 but not with the baseline) and it also calculated for each participant.

After separating the classes or the levels, each of these classes are analyze separately in order to identify the population distribution each class is holding. . In order to apply a suitable statistical model to represent the core-relation between these values it was very important to analyze the distribution of the dataset. For this purpose we have used the histogram with a distribution fit.

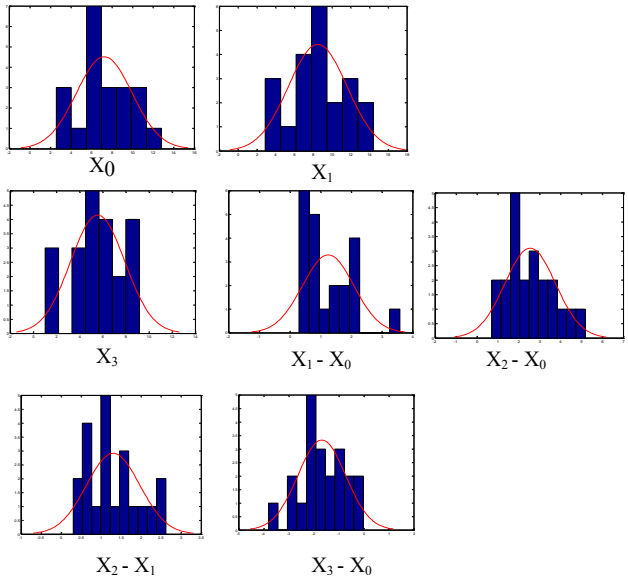


Fig 16: Histograms analysis of distributions

After analyzing the acquired distribution it was clear that all 4 different states (levels) samples and other 4 samples which researcher gained through the difference of these levels were having Gaussian or normal distribution. All sample set is upholding and spread in accordance with the following equation.

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{(X-\mu)^2}{2\sigma^2}}$$

where μ is the expected mean for a sample distribution with n number of samples and σ^2 is the variance of the data set. After analyzing the distribution we had to check the dependability of the each of these classes among themselves in order to see whether they are actually suitable of representing a separate level.

Therefore, we have used one-way ANOVA to check whether there is an inter-dependability between these stages or else can they be considered as totally separate value set which is actually representing a separate state of participants' stress levels. Here the one-way ANOVA was used to determine whether data from several levels (In this case it is the different set of values for different stress levels) have a common or interrelated mean value. Additionally to increase the accuracy of the sample set that is run through ANOVA we had to use the normal distribution plotting as well. The result of this analysis is shown below.

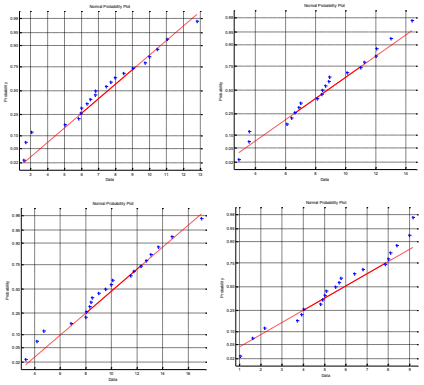


Fig 17: Normal Probability Plots

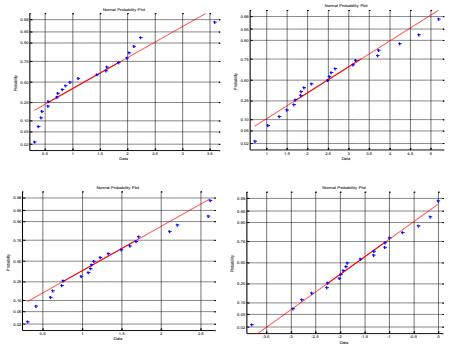


Fig 17.1: Normal Probability Plots

ANOVA test is carried out in three stages. Firstly researchers applied ANOVA test for the all the sample sets. This includes levels, X0, X1, X2, X3, (X1 - X0), (X2 - X0), (X2 – X1) and (X3 - X0). The matrix y prepared to do the ANOVA test for above levels is as follows. Same way then it is done for the (X1 - X0), (X2 - X0), (X2 – X1) and (X3 - X0) and finally by eliminating the (X2 – X1) level and only considering the stress level 01, 02 and biofeedback based meditation level.

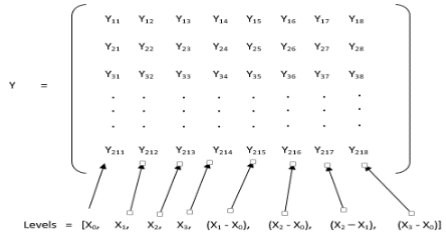


Fig 18: ANOVA calculation matrix

In all three phases it gives out the P values of s2.044668x10-19, 1.0x10-4 and 3.5148x10-46 respectively. Each of these P-values which are less than 0.05 (>0.05) indicate that the in all three tests it indicates that every time it indicates an independence between each sample set. Therefore, in all three tests the null hypotheses (H0) were rejected and affirmed the alternative hypothesis which conveys that each of these levels are different from each other.

Following box plots illustrate this fact clearly.

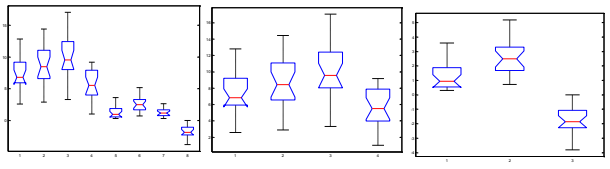


Fig 19: ANOVA box plots

After sanctioning (X1 - X0), (X2 - X0), and (X3 - X0) are three independent classes we used statistical measurements to represent each of this separate class. by looking at the distribution, best way to characterize this populations are to assume that the GSR values are randomly scattered around a central value that provides the best estimate for the each phase, or “true” GSR value of the each phase (When we say ‘phase’ we refer to the four separate levels or class that they have mentioned as (X1 - X0), (X2 - X0), and (X3 - X0)). Therefore by using central tendency measures we represent each of this class as follows along with the standard deviation.

We have considered both mean $\ddot{X}$, which is the numerical average for a data set and median $\tilde{X}$ in order to represent each sample set as shown below. But we suggest $\ddot{X}$+STD as the primary representation.

TABLE IIIII
DATA REPRESENTATION

Statistical Measurements	*A.* ***$(X_1 - X_0)$***	*B.* ***$(X_2 - X_0)$***	*C.* ***$(X_3 - X_0)$***
Mean	*D. 1.24520*	*E. 2.54695*	*F. - 1.67896*
Median	*G. 0.94350*	*H. 2.47951*	*I. - 1.86526*
Standard Deviation	*J. 0.83481*	*K. 1.21113*	*L. 0.95530*

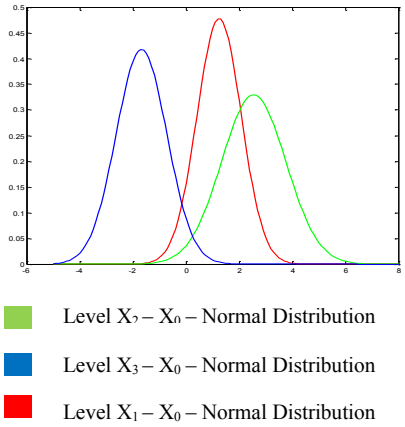


Fig 20: Distribution results

V. EVALUATION

First, note that in the above figure (figure number) each normal distribution has a single maximum corresponding to μ, and that the distribution is symmetrical about this value. Therefore, taking this value (central tendency, mean) along with the variance is a better representation of the each level. Second, increasing the population’s variance will only increases the distribution’s spread and decreases its height, but the area under the curve, however, is the same for all the distributions. Therefore the values obtained from the analysis have the proper representation of each level.

In the evaluation we have taken 6 samples in order to find answers to following questions. First, does the suggested measures of central tendency of $(X_1 - X_0)$, $(X_2 - X_0)$, and $(X_3 - X_0)$ levels equally represent these 6 random sample? Second, How much variability is there in the individual and group (all 6 samples) results when compared with the central tendency of $(X_1 - X_0)$, $(X_2 - X_0)$, and $(X_3 - X_0)$ levels? The procedures that were followed to find answers to these two questions are similar as in the analysis. All 6 subjects were driven through the same stressors and gave the

biofeedback based meditation. For the data collection the same number of samples under same sampling frequency is used as in analysis. GSR signals were cleansed, pre-processed and AUCs were extracted. Afterwards the central tendency of this group was calculated. Then along with the group central tendency values each individual values are evaluated with respect to values (the level representation values) that we have obtained at the end the end of the analysis.

The procedure of the evaluation was measuring the accuracy of the values that researches obtained from the analysis by comparing them with a set of random subject's GSR values. Accuracy is a measure of how close a measure of central tendency is to the expected value, μ. Accuracy is expressed using both absolute error, e;

$$e=\ddot{X} - \mu$$

and the percent relative error, which is denoted as %e;

$$\%e=(\ddot{X} - \mu)/\mu \times 100$$

We evaluate each subject's individual value and also the mean ($\ddot{X}$) and median ($\tilde{X}$) of the evaluation data set with the respective values which obtained from the analysis. After that, total means of 'e' and '%e' in order to get the central tendency of the error was calculated. As a percentage representation value of each (X1 - X0), (X2 - X0), and (X3 - X0) states accuracy in the terms of absolute error, these representation values that researchers have obtained from them main analysis has an accuracy of 82.418%, 73.945% and 64.96% respectively.

As per the results of the evaluation it shows that in terms of absolute error each of these three stages are having relatively above 60% accuracy for all three states. Because each state has a mean value of 0.17582, 0.26055 and 0.35040 absolute errors with ±0. 16002, ±0. 31274 and ±0. 66366 standard deviations respectively. Since this is a novel approach in quantifying stress levels this is a comparatively a higher accuracy. Furthermore, in terms of percent relative error these three states ((X1 - X0), (X2 - X0), and (X3 - X0)) are holding a comparatively low percentage of error. They are 18.63393% ±17. 64024, 12.92949%±13.53605 and 9.84455%±28.86422 respectively to each state.

Finally, we have further evaluate the these state ((X1 - X0), (X2 - X0), and (X3 - X0)) representation values using the one-way ANOVA test also to check the relation between the data obtained from the main analysis and the evaluation data. This time, we have used the 'unbalanced one-way ANOVA' test due to the unbalance sample sizes when comparing the samples for analysis and evaluation.

All three occasions we have obtained p-value of 0.4407, 0.9491 and 0.6043 respectively which is greater than 0.05(<0.05). Therefore, it confirmed the fact that each of these sample sets are bearing a dependence characteristic.

In conclusion, we say that each of these sample states is similar to each other. In other words, they are holding a statistical relationship. Relative figures also illustrate the same result. For the three ANOVA test plots, the red bar shows the comparison for each level median, which has similar values on the y axis.

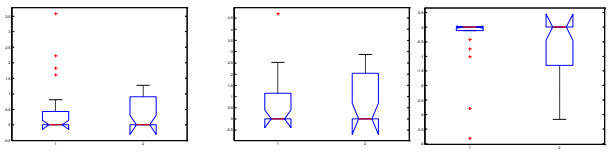


Fig 22: Evaluation ANOVA box plots

Therefore, as the conclusion of the evaluation, it is possible to can say that the values obtained for the (X_1 - X_0), (X_2 - X_0), and (X_3 - X_0) was truly represent the above three states.

In that case any random participant who faces the stressor that researchers are providing should show a similar value to the (X_1 - X_0), (X_2 - X_0) means $\bar{X}$ with the respective standard deviations σ. Also in the state of biofeedback aided meditation they should show a similar AUC GSR homeostasis change with a mean of (X_3 - X_0) state under its relative standard deviation.

VI. CONCLUSION AND FUTURE WORKS

This research is mainly addressing three main questions. Firstly, we have classified the chronic stress quantitatively based on GSR homeostasis changes in the human body. In order to do that we have used the methodology of AUC for analyzing GSR signal. Secondly, in this research, we have proven that with the aid of biofeedback meditation can be used to regulate chronic stress within working environments. The outcome of this research is the computational approach to reduce the stress using image based biofeedback assisted meditation. In order to provide a proper biofeedback to the participant to aid the meditation process, we have developed a prototype program based on Java to provide the image based biofeedback to the participant.

As a future work of this study, we propose a multimodal approach, that is using more than one bio physiological signal to detect stress, can increase the reliability of the stress detection model. The proposed statistical model for stress level classification using quantitative measurement using a sample population of 21 male and female. In order to get a more accurate reading, the sample size can be further accumulated.

TABLE IV
COMPUTING ABSOLUTE ERROR AND THE PERCENTILE RELATIVE ERROR

Analysis Outcomes						Subject 1			Subject 2			Subject 3		
Level	Mean	Median	Range	Standard Deviation	Variance	Value	e	%e	Value	e	%e	Value	e	%e
X_1-X_0	1.24520	0.94350	3.28122	0.83481	0.69691	0.95087	0.29433	30.95420	1.14310	0.10210	8.93183	1.27323	-0.02803	-2.20144
X_2-X_0	2.54695	2.47951	4.47261	1.21113	1.46684	2.27791	0.26904	11.81083	2.31072	0.23623	10.22339	2.88099	-0.33403	-11.59441
X_3-X_0	-1.67896	-1.86526	3.79748	0.95530	0.91259	-2.19556	0.51660	-23.52935	-1.88982	0.21086	-11.15765	-1.59883	-0.08013	5.01206

This study classifies the stress level into two levels. Further research can be conducted to identify how many more levels of stress can be classified using quantitative measures. Currently wired GSR sensor is used to collect data for analysis and to give Biofeedback. Wired GSR is obstructive for the user to use it while working. Hence, we recommend to make this GSR sensor wireless one like a ring or embedding it the commonly used devices like a mouse.

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