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A Study on Physiological Parameters Used To Monitor Stress in Experimentally Induced Stimuli

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Abstract: This study investigates the various physiological parameters that can be used to monitor stress when a person is subjected to stress inducing stimuli in experimental environment. Stress can be defined, as a physical and psychological response of our body towards any external or internal stimuli. Stress is capable of corrupting the way an individual absorbs reality, solves problem, and thinks logically. Repeated exposures to psychological stress can lead to many chronic ailments such as heart diseases and cancer. Lack of robust methods to continuously monitor a person's exposure to stress in the natural environment is the biggest challenge today. There are several methods of monitoring stress such as psychological method, which includes conducting interviews and filling up of questionnaires etc. Behavioral method studies the changes in manner in which a person does his daily activities. Physical method includes studying the changes in physiological features of the body.

Keywords: stress, heart rate, pupil dilation, electroencephalogram, speech, respiration rate, electro dermal activity.

I. INTRODUCTION

In the medical field, stress response is considered as the increasing activity in the sympathetic branch of autonomic system and activation of the hypothalamic-pituitary-adrenal axis. The main purpose of physiological changes under stress is increasing the efficiency of delivering energy (oxygen and glucose) to vital organs. The physiological parameters, which reflect the increased efficiency, are: Heart rate and blood pressure, EEG signals, Respiratory system: Respiration rate and depth, Electro dermal activity. Some of the common things that can cause stress are: physical (such as fear of something dangerous), emotional (such as worry over your family or job.) Some of the most common sources of stress are:

Survival Stress – Human body is prepared for "Fight or flight" common response during a situation which poses danger or is of physical harm. The body naturally responds with a burst of energy so as to enable us to survive the dangerous situation (fight) or escape it all together (flight). This is survival stress.

Internal Stress – worrying about situations or things, which are not in our control, causes it. This is internal stress and it is one of the most important kinds of stress to understand and manage. This often happens by worrying about things, which can't be controlled. Hurried, tense, lifestyle can result in this kind of stress.

Environmental Stress – environmental conditions like noise, crowding, pollution, pressure for work and family can cause stress. Learning to avoid them or deal with can help to reduce stress.

Fatigue and Overwork – continuous working hard for long hours at job, school or home, without taking rest can cause long term fatigue in human body. Poor time management and ignoring one's health can also build up stress in one's body. It is very hard to avoid this type of stress and needs permanent life style changes.

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II. PHYSIOLOGICAL PARAMETERS

There are many limitations in measuring stress in real time as it is difficult to collect the physiological data from real time stressful environment. There is also wide variation between the responses of subjects. Another difficulty is in estimating the level of stress. In order overcome the above limitations, laboratory based experiments have been preferred over real time experiments for estimation of stress.

Following are some of the physiological parameters that have been studied subject to experimental conditions:

A. Heart rate variability (HRV): Heart rate variability can be used to indicate the activity of sympathetic and parasympathetic systems. The high frequency (HF) component reflects parasympathetic activity, and the low frequency (LF) component mainly reflects sympathetic activity. Therefore, HRV may reflect specific patterns of activity in the sympathetic and parasympathetic nervous systems. Wencai Zhang et al conducted a test by giving two stress tasks, which represented operational and emotional stress. By analyzing HRV, it was concluded that sympathetic nerve tone increased relative to the parasympathetic nerve tone in operational stress task and systolic and diastolic blood pressure was significantly increases in emotional task. [1]

The researchers have analyzed HRV signals on various measures like mean of heart rates, mean of RR

intervals, low frequency and high frequency ranges etc to detect stress.

B. Pupil dilation: researchers have also found that there is a direct relation between pupil dilation and stress. The diameter of the pupil changes with changes in the autonomous nervous system. [2]

C. EEG (Electroencephalogram) signals: EEG is spontaneous, rhythmic electrical activity of brain cell populations recorded through electrodes. On the basis of an experimental study, Guoqing Zhao et al, concluded that stress can be determined by three EEG features - Fpz point, LZ-complexity, alpha relative power and the ratio of alpha power to beta power, using K-Nearest-Neighbor classifier, however Naive Bayesian classifier is not suitable for the stress prediction based EEG data. [3]

D. Speech: Elements of speech have been correlated with posttraumatic stress disorder. Zahi N. Karam analyzed a structured speech collected from controlled environment and concluded that speech manic and depressive mood states can be recognized from speech patterns.[4]

E. Respiratory system: The cardiovascular and respiratory systems are functionally related to each other. [5] Zhang et al investigated the effect of mental task on the synchronization between cardiovascular and respiratory systems and found that Mental arithmatic task significantly increased the breath rate, the heart rate

F. Electro dermal activity: EDA is a measure of skin conductance and is related to our body's sympathetic nervous system. EDA changes with respect to changes in stress levels. This technique proves to have 83% success results. The test consists of using electrodes placed on skin through which signals are obtained and analyzed. [6]

III. EXPERIMENTAL SETUP TO MONITOR CHANGES IN PHYSIOLOGICAL PARAMETERS DUE TO STRESS INDUCING STIMULI:

Tomoyuki Hiroyasu et al, measured brain activity in the right / left hemisphere during Stroop test by Functional near infrared spectroscopy. Cognitive conflict occurs when the color of the text does not match the name of the color written in the text and stroop test is used as a physiological test to estimate the cognition functions. Nine male subjects in the age group of 21-22 participated. Paired t-test and ANOVA were the statistical methods used to analyze the results. It was seen that in the incongruent task, the number of correct responses/time was smaller as compared to the congruent task. It shows that the brain activity was increased during the incongruent task. [7]

Driving is a also a cognitive task which induces stress and fatigue in the driver. It can be detected by continuous monitoring of the physiological parameters in order to minimize human error during driving. Jennifer et al conducted an experiment to monitor the stress of drivers while driving. The drivers were made to face three different situations like rest, highway and city, which were assumed to be corresponding to low, medium and high stress situations respectively. They did two type of analysis. The first one was done to identify three levels of stress i.e. low, medium and high. The second one was done to study how physiological parameters of the driver changed continuously during each second of drive. ECG, EMG(electromyogram), EDA and respiratory sensors were used to collect the data. It was observed that skin conductivity and heart rate are most correlated with the driver stress level. [8]

Operational and emotional stress can affect the cardiovascular response of human body. Wencai Zhang et al conducted an experiment on 18 healthy female participants. For the operational stress, the participants had to perform mirror-tracing task in which they were required to move a pencil to trace the diagram of a star while looking at their hand only as a reflection in the mirror. For emotional stress, the participants had to prepare a speech for a given topic. A 5-point scale was used to rate the perceived stress from low to high. Paired t-test and ANOVA were used for data analysis. Blood pressure, R-R interval and HRV were analyzed. It was concluded that operational and emotional stress produce different type of activity in autonomous nervous system. [9]

Stress due to accumulated fatigue can cause changes in the statistical properties of heart rate. Takayuki Gohara et al investigated these changes in an experiment conducted on 6 male subjects in which they had to undergo exhaustive mental and physical tasks. It was observed that the properties of heart rate like mean heart rate, low frequency and high frequency components are significantly affected by the subject's physical and mental activity. [10].

K. Subramanya et al investigated the relation between GSR (galvanic skin response) and blood pressure to use EDA to be able to predict blood pressure (BP) and cardiovascular dynamics. They conducted a pilot study on 15 healthy subjects to find the relation between GSR and 4 BP indices (SBP – systolic BP, DSP – diastolic BP, PP – Pulse pressure, MAP – Mean arterial pressure) during pre and post tread mill exercise. Karl Pearson Correlation analysis was used and it was observed that there is a strong correlation between GSR and 4 indices of BP, being strongest with PP. [11]

Physiological parameters can also be used to investigate the condition of patients with impaired areas of emotional processing, including psychophysiological reactivity. Sungwon Park studied 16 patients suffering from Schizophrenia. They were made to watch two-minute video clips containing five different emotions of anger, disgust, fear, sadness and joy. The same video was also shown to 100 college students and they were asked to choose one of the five emotions they felt and rate their intensity on a five-point scale. The results of the two groups were compared. ECG and EMG were recorded and SPSS was used for statistical analysis. It was identified that patients with condition of schizophrenia may have partially different physiological activity as compared to normal people. [12]

The table below shows a comparison of physiological features and their relation with stress:

Table I. Comparison of Physiological Parameters:

Author	Parameter	Feature studied	Conclusion
Wencai Zhang et al	HRV	Low frequency and high frequency component, mean RR interval.	HRV signals on various like mean of heart rates, mean of RR intervals, low frequency and high frequency ranges are used to detect stress.
Suranga et al	Pupil dialtion	Diameter of pupil	Pupil diameter increased with increase in stress
Zhao et al	EEG	Fpz point, LZ-complexity, alpha relative power and the ratio of alpha power to beta power K-Nearest-Neighbor classifier and Naive Bayesian classifier	Fpz point, LZ-complexity, alpha relative power and the ratio of alpha power to beta power are effective in determining stress but Naive Bayesian classifier is not suitable for the stress prediction based EEG data.
Zahi N. Karam et al	Speech	Pitch, RMS energy, zero crossing rate, minimum value of amplitude of speech waveform.	Speech variations can be used to detect the level of stress
Zhang et al	Respiration rate	Rate of respiration	Breath rate increases with increase in stress.
Atlee Fernandes et al	Electro dermal activity	Skin conductance	EDA increases as stress increases

IV. CONCLUSION

Stress and emotions in daily life affects the performance of individuals, can lea to many chronic ailments and can also aggravate the severity of already prevailing ailments. The main purpose of the response of the autonomic nervous system in situations of stress is to increase the efficiency of vital organs of the body. This is done to prepare the body for immediate response. Thus any kind of stress directly affects the functioning of our body's vital organs like brain, heart, respiratory system etc. Physiological parameters can be used for monitoring stress affectively. Continuous monitoring of stress is therefore e necessary for understanding and timely management of stress, which can harm the vital organs of the body.

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