

## Stress Detection Indicators: A Review

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### Abstract

*Stress is the way of body's response to any kind of demand in the normal life. The body reacts to these changes in terms of physical, mental and emotional responses. There are sample number of works being carried out to measure stress using physiological parameters such as Galvanic Skin Response (GSR), Blood Pressure (BP), Heart Rate (HR), Breathing Pattern, Speech Signal, ECG (Electro cardiograph) and EEG (Electroencephalography). This paper presents a qualitative analysis of different physiological parameters used to determine the stress level.*

**Keyword:** GSR, Sensors, Blood pressure, Heart rate, Breathing pattern, Speech signals, ECG and EEG

### INTRODUCTION

Stress is a usual issue that influences practically all sooner or later in our lives. It refers to negative experiences that leave us feeling overwhelmed. Stress can affect not only our physical and mental health but also has an impact on our behavior. In order to make our body capable of responding to stress, the body produces chemicals and hormones as a defensive mechanism to stress. Some of the physiological parameters that indicate stress are the increased heart rate, faster working of the brain or to have a sudden burst of energy. All activities that are repeatedly done would certainly create stress.

Stress can be divided into three main categories, namely, acute stress, episodic acute stress and chronic stress. Chronic stress has its impact not only on the physical health but also on physiological health. Stress can sometimes be considered positive. It is good in terms of the motivation, performing daily activities and encouraging creative thinking. On the contrary, stress beyond a certain limit

would have negative impact. Excess stress may result in imbalance of the emotional health which may lead to cardiovascular diseases. Stress could also lessen one's efficiency in doing activities.

The body reacts to Acute Stress through psychological condition and it influences a strong emotional response. Acute Stress is not negative always. On the contrary it influences and trains the body and brain to develop the best response to future stressful situations.

Episodic acute stress results in short-temperament, irritative behavior and anxiousness. It is being the result of a long lasting stress, people would have been persistent to negative health effects and thus it is difficult to overcome the negative impact of the same.

Chronic stress has negative impacts on person's health. It is the response to emotional pressure suffered for a prolonged period of time [1].

The rest of the paper is organized as the

following subparts: Section II gives an insight into different physiological parameters that can be used to identify the level of stress. Section III presents a comparison of the physiological features discussed in the literature for the stress level indication. Finally Section IV gives the concluding remarks.

**PARAMETERS**

Stress is a phenomenon that results in response to a physical or mental activity on day to day basis. So as to oversee pressure, it is required to screen the feelings of anxiety on constant premise. Individual physiological parameters, for example, Galvanic Skin Response (GSR), Heart Rate (HR), Blood Pressure (BP), ECG (Electrocardiography) and breath movement can be utilized as a measure to decide pressure. This section details the different parameters that can be used to determine the level of the stress.

**GSR**

This techniques works owing to the fact that the conductivity of the skin changes with respect to the emotional state of the person. GSR measurements work by detecting the changes in electrical activity of the skin[2]. The electrode must be sensitive to these changes, and should be able to transmit the information to the recording device. It is a measure of the continuous variations in the electrical characteristics of the skin. This change in conductance can be measured by using two electrodes and by passing a small current over the skin. The human body acts as a larger resistor. The resistivity of the skin can be obtained using the GSR sensors. A typical voltage divider circuit is

used for the GSR sensor and hence the output voltage obeys the following relation[3]:

$$V_{out} = V_{cc} \frac{R2}{R1+R2}$$

Many studies have devised a scale to measure the level of the stress condition of a person. The same is as shown in Table 1.

*Table 1:GSR Measurement Levels.*

condition	GSR
Relaxed	<2
Calm	2-4
In Tension	4-7
Stressful	>6

**Blood Pressure**

BP is the measure of the pressure of circulating blood on the walls of blood vessels. BP readings have two components, for example 135/85mmHg. The number at the top indicates the systolic blood pressure.This gives the highest level the BP that can be reached when the heart beats. The bottom number indicates the diastolic blood pressure. It is the lowest level of the BP that can be reached when the heart relaxes between beats. Many studies have showed that the stress levels can be indicated by the measurement and monitoring of the BP [4]. During high stress condition, the body releases certain hormones and thus increases its level inside the body which results in the shrinking of the heart. When heart is shrinking, blood pressure level will be increased [5].

Based on the BP measurements, the levels of the stress can be categorized as shown in Table 2.

*Table 2:BP Measurements Level.*

BP category	Systolicmm Hg	Diastolicmm Hg
Normal	<120	<80
Elevated	120-129	<80
High BP(stage 1)	130-139	80-89
High BP(stage 2)	>140	>90
HypertensiveCrisis	>180	>120

**Heart Rate**

The ordinary resting pulse for grown-ups ranges from 60 to 100 beats for every moment. Generally, a lower HR at rest implies more efficient heart function and better cardio vascular fitness. Stress could also result in breaking of the energy, disturbed sleeps and thus resulting in forgetfulness and short temperament. Stressful conditions would result in a series of changes in the body. It would increase the breathing and heart rate. Thus HR in people with stress will be more than that of the normal people. Stress can change the way blood clots which could increase the risk of heart attack [6-7].

Different studies have revealed the ranges of HR for different stress conditions. This is detailed in Table 3.

*Table 3: Measuring the Heart Rate.*

Condition	HR(bpm)
Relaxed	60-70
Calm	70-90
Tense	90-100
Stressed	>100

**Breathing Pattern**

Breathing is a normal body phenomenon. The respiratory center of the human brain controls the process of breathing. As a response, the breathing rate and the pattern changes when the person is in stress. Different studies have revealed that the respiration process is correlated with the certain emotional situations. Thus the person with stress tends to have increased respiration rate. Increased respiration rate causes a shorter duration of speech between breaths which affects the speech articulation rate [8].

**Speech Signals**

The Production of speech signal involves many parameters including articulator movements, airflow from the respiratory system and the timing of the vocal system physiology. Speech recognition is a technique used in many applications. One such application is the stress level

indication [9]. Many algorithms for speech recognition have been proposed in the literature. Hidden Markov Models (HMM) is one of the very popular techniques which take the speech as a series of a particular recognition unit. Training for the speech recognition is being carried out by the Hungarian Speech Database. The testing is carried out by the first Database for stress distribution in Hungarian sentences [10-11]. During stress detection if syllables (vowel sound) are considered it has results as tabulated in Table 4.

*Table 4: Stress Detection in Vowel Sound.*

Condition	Score
Stressed	1
Neutral	0.5
Unstressed	0

**ECG**

ECG is the process of recording the electrical activity of the heart over certain time duration. It is done using electrodes placed over the skin. ECG is a measure of the current that runs through the heart. Although, each person's ECG has a unique trace, there are certain ECG patterns that indicate the problems in heart. Heart Rate which is one of the important indicators of the stress level in a person can be easily obtained using ECG signal [12]. A two stage classifier is used for the classification of stress into one of the four categories [13-14]. The input to this classifier would be the features that are extracted from the variations in the heart rate.

The efficiencies in classification for a hybrid classifier are as shown in Table 5. Both training and testing phases are considered for the analysis.

*Table 5: Measuring ECG Signal.*

	No Stress	Less Stress	Medium Stress	High Stress
Training phase	92%	98%	96%	93%
Testing phase	84%	96%	93%	91%

**EEG**

EEG is also a primary indicator of the stress level of a person. EEG is a process of determining the electrical activity in the brain. EEG tracks and records brain wave patterns little level metal circles called anodes are joined to the scalp with wires. It is a non invasive test that records electrical patterns of the brain. It not only helps in identifying various disorders including seizures, epilepsy, brain tumors etc but also gives a clear indication about the stress level of a person [15-16].

**COMPARATIVE ANALYSIS**

There are a good number of researches taken place in the area of the detection of

the stress level of a person. Various parameters detailed in Section II have been considered to quantify the level of stress. Each method has its own pros and cons. In this section an attempt is made in analyzing the different methods proposed for the detection of the stress level using various physiological parameters [17-18].

Table 6 gives a detailed tabulation of the various methods that are available in the literature to estimate the level of stress in a person. Different physiological parameters like GSR, BP, Heart Rate, Breathing Pattern, Speech Signals, ECG and EEG have been considered for the analysis.

*Table 6: Comparison of Physiological Parameters.*

Parameter of Interest	Features studied	Inferences
GSR	Skin conductance.	GSR increases as stress increases.
BP	Body hormones.	Based on level of hormones can be used to detect the stress level.
HR	Low and high frequency component.	Stress is detected using the Frequency in Low and High ranges.
Breathing Pattern	Rate of respiration.	Breath rate increases with increase in stress.
Speech Signals	Root Mean Square Energy, Pitch, zero crossing rate, Amplitude minima in the speech signal.	Level of stress can be identifies using the variation in the speech signals.
ECG	RR interval, amplitude of P, R and T wave are fiducial points between Segments and intervals.	Levels of stress are detected using Fiducial points.
EEG	Alpha relative power and $\frac{\alpha}{\beta}$ is K-Nearest-Neighbor classifier and Naive Bayesian classifier. $\alpha$ = Alpha power $\beta$ = Beta power	Stress can be determined using K-Nearest-Neighbor classifier but not Naive Bayesian classifier.

**CONCLUSION**

Stress is a common entity in anyone's life. Although it may be a positive aspect in some of the cases, if it crosses a certain level, it would prove fatal. Thus indicating the level of stress is an essential criterion. In literature many physiological parameters have been considered to measure the level of the stress. In this paper we have considered a few physiological parameters that can be used to quantify the stress level and a

comparative analysis of different cases have been presented. Nevertheless, it can be inferred that the individual physiological parameters alone would not suffice for all cases due to its limited accuracy. Thus the usage of the combination of two or more parameters could lead to better accurate results.

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