International Journal of Engineering Technology and Management Sciences
Website: ijetms.in Issue: 5 Volume No.6 Aug-Sept – 2022
DOI:10.46647/ijetms.2022.v06i05.006 ISSN: 2581-4621

Evaluation of Mental Stress using Different Physiological Parameters: A Review

Monika M. Chauhan[1], Ritesh J. Patel[2]
[1]*Lecturer, Computer Engineering Dept.,N. G. PATEL POLYTECHNIC, Bardoli, GUJARAT, INDIA*
[2]*Lecturer, Computer Engineering Dept.,N. G. PATEL POLYTECHNIC, Bardoli, GUJARAT, INDIA*

Abstract. Mental Stress plays a vital role in everyday life. It is mental state and is accompanied by physiological changes. So monitoring of these significant changes is important, which can help to identify the matter of anxiety at an early stage before some serious health problem. Continuous stress monitoring may help users better understand their stress patterns and provide physicians with more reliable data for interventions. The basic parameters on which stress can be identified are heart rate, galvanic skin response, body temperature; blood pressure etc. combinations of different parameters provide more accurate results. Usage of multiple parameters aids in better determination of stress. Combination of different parameters like galvanic skin response and blood pressure, electrocardiogram, skin temperature and heart rate are used.

Keywords: Stress detection, physiological parameters, heart rate, galvanic skin response, mental stress.

1 Introduction

Stress is a physiological response to the emotional, mental, or physical challenges that become a serious problem affecting people of different life situations, and age groups in day-to-day life[2]. It spoils one’s devotion, performance, behavior, responsibility, thinking ability, etc. Stress can pay to illness directly, or indirectly, through its physiological properties. Different kinds of stress:

- *Mental stress* which is short term stress and does not cause extensive damage. It is easy to detect and treatable. Mental stress is also known as acute stress. Acute Stress is short-lived. It can be beneficial and create motivation. For example, when a deadline is approaching, stress may help you to focus and complete your task before the deadline [1].
- *Episodic* acute stress which makes people anxious. Acute stress that is suffered too frequently is called episodic stress [1]. This type of stress is usually seen in people who make self-inflicted, unrealistic or unreasonable demands [1]
- *Chronic stress* can be detrimental to both physical and mental health. Chronic stress also plays a role in mental illnesses such as generalized anxiety disorder and depression. Chronic stress is difficult to manage because it cannot be measured in a consistent and timely way [1].

The most commonly used physiological parameters of stress are as follows [1]:

- Electrocardiograph
- Blood Pressure
- Galvanic skin response
- Electromyogram
- Skin temperature
- Body temperature
- Glucose level
- Pupil diameter

DOI:10.46647/ijetms.2022.v06i05.006 ISSN: 2581-4621

Electrocardiograph: The most commonly used stress marker parameters derived from the electrocardiograph are the heart rate and Heart rate variability (HRV) [1].
Blood pressure*:* When the body is under stress, it responds by producing a surge of stress hormone causing an increase in blood pressure and heart to beat faster. Individuals who underwent a stressful task had a late recovery of blood pressure making it a good indicator of stress even after some time.
Galvanic skin response*:* Using changes in skin conductivity. During Stress, resistance of skin drops due to increased secretion in sweating glands[1].
Electromyogram: measuring electrical activity of the muscles. Stress causes differences in the contraction of the muscles which can be used to identify stress[7].
Skin temperature: Changes in temperature of the skin are related to the stress level [7].
Body temperature: when we feel cold or chilly, the body wants to increase its body temperature because it is dropping toward the low end within the normal range. But that change is a minor one, and not more than plus or minus 1 F[10].
Table 1 Advantages and limitations of different physiological parameters [14]

Physiological Parameters	Advantages	Limitations
Heart Rate Variability [11]	• Quick to perform • Physically activity can be separated from the other parameters.	• Single HRV value not gives appropriate result. • Does not differentiate different sources of stress reactions.
Blood Pressure [11]	• Non-invasive and Objective • Provides important information for long term health	• Challenging to measure continuously Lacks the direct link to stress factors if measured occasionally
Galvanic Skin Response [11]	• Non invasive	• External variables such as temperature and humidity can affect results as is based on measuring sweat or moisture on the skin Cannot be used during physical activity
Brain activity (EEG) [11]	• Noninvasive and objective measure • Shown to be associated with chronic stress	Not much utilized yet Requires laboratory testing and qualified personnel Difficult to measure long term

Glucose level: When you're stressed, your blood sugar levels rise. Stress hormones like epinephrine and cortisol kick in since one of their major functions is to raise blood sugar to help boost energy when it's needed most[11].

Finally, *Pupil diameter:* The normal pupil size in adults varies from 2 to 4 mm in diameter in bright light to 4 to 8 mm in the dark. The pupils are generally equal in size. They constrict to direct illumination (direct response) and to illumination of the opposite eye (consensual response)[11].
Table 1 show the comparison between various physiological parameters advantages and disadvantages proposed so far. Widely used physiological parameters are Heart rate variability, galvanic skin response, blood pressure, EEG etc.
Section II describes the effects of stress on human body. Section III discusses the various techniques for evaluation of mental stress. Section IV describes comparison of different techniques. Section V contains conclusion.

2 Mental Stress detection using combination of parameters

A number of physiological markers are widely used for stress assessment. Fortunately, miniaturized wireless devices are available to monitor these physiological markers. By using these devices, individuals can closely track changes in their vital signs in order to maintain better health. Individual physiological parameters such as Galvanic Skin Response (GSR), Heart Rate (HR), Blood Pressure (BP), ECG (Electrocardiography) and respiration activity can be used as a measure to determine stress[2]. But, the accuracy of determination is limited by using individual parameters. For example when only heart rate can be used as individual parameter. It cannot give appropriate results. Because when person is running at that time heart rate is high so it can give person is in stress which not accurate results.
sage of multiple parameters aids in better determination of stress. Fernandes et al. used GSR and blood pressure (BP) markers [13] for determining stress. Sun et al. describe mental stress detection using combined data from ECG,GSR, and accelerometer [2]. De Santos Sierra et al. in [16] used GSR and HR. Rigas et al. used ECG, GSR, and respiration for detecting stress while driving [17]. Wijsman et al. used ECG, respiration, GSR, and EMG of trapezius muscles for mental stress detection [18]. Riera et al. combined EEG and EMG markers [19]. Singh and Queyam used GSR, EMG, respiration, and HR [20] for detecting stress during driving. Pupil diameter, ECG, and photoplethysmogram were used as markers by Mokhayeri et al [21]. Baltaci and Gokcay used pupil diameter and temperature features in stress detection [22], while Choi used HRV, respiration, GSR, EMG, acceleration, and geographical location [23].

3 Techniques for evaluation of Mental Stress

1. *Mental Stress Evaluation using ECG:* An electrocardiogram is a graphical representation of the small electric waves being generated during heart activity [1]. It provides information about the heart rate, rhythm, and morphology. Fig.1 shows the basic shape of a healthy ECG heartbeat signal with P, Q, R, S, T and U characteristics and the standard ECG intervals QT interval, ST interval and PR interval [1][3].

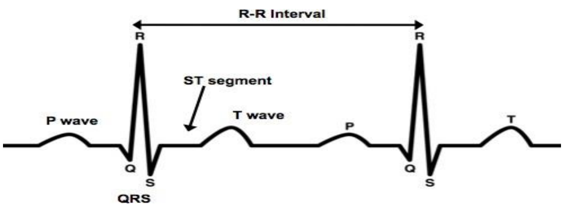

Fig.1: An ECG waveform with the ECG intervals [1]

DOI:10.46647/ijetms.2022.v06i05.006 ISSN: 2581-4621

The ECG is distinguished by a recurrent wave sequence of P, QRS, T and U wave associated with each beat. The QRS complex is the most extreme waveform, caused by ventricular depolarization of the human heart. A typical ECG wave of a normal heartbeat consists of a P wave, R peak (i.e. QRS complex), and T wave. [4]

The raw ECG signal may contain different type of noises, so ECG signal should be processed. There are mainly two parts for ECG signal Feature extraction. First is pre- processing and second one is feature extraction [7]. Then after classification apply on feature vector value.

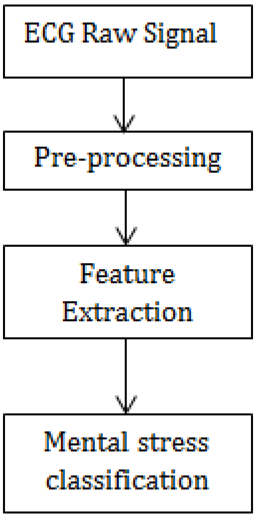

Fig. 2. Human stress measure using ECG Signals

Input parameters: Heart rate is the most commonly used stress marker parameters derived from the electrocardiograph (ECG) are the heart rate and Heart rate variability (HRV) [1].
Pre-processing: ECG signal contains noises due to baseline drift, frequency interference, polarization noise, electrode contact first page footnote as an example. Muscle noise, internal amplifier noise. In most of The ECG recordings the respiration, electrode impedance change and increase body movements creates baseline drift. The common problem in ECG signal processing is base line drift removal and noise suppression [7].

Feature extraction: The purpose feature extraction process is to retain information from original ECG signal. First we detect the R peak i.e. QRS complex which is the highest amplitude in the ECG signal. Then Q and S waves are detected. Then detected two zero crossing of the signal before the Q and after the S waves are selected. And at last P and T waves are detected [7].

Classification: Different classification methods are using including the support vector machine, artificial neural network and decision tree [2]. Datasets isolated the preparation information into two distinct sets with a specific end goal to assess how action data may impact the aftereffects of stress detection. One set of training data only includes the ECG. Using classification we get more accurate results [2].

2. *Mental Stress Evaluation using Galvanic skin response and blood pressure:* The design consists of a GSR and a combined blood pressure and heart rate module which are fed as inputs to a microcontroller. The results after computations are displayed on an LCD module. A user’s stress levels are calculated by the GSR circuit using touchpad’s as input. Copper plate touch pads are

DOI:10.46647/ijetms.2022.v06i05.006 ISSN: 2581-4621

preferred over aluminum foil for more reliability and accuracy. The blood pressure and heart rate of user is also calculated using the BP/HR module. The results i.e. outputs obtained from the stress meter circuit and BP/HR module are given as inputs to the microcontroller through LCD tapping[13].

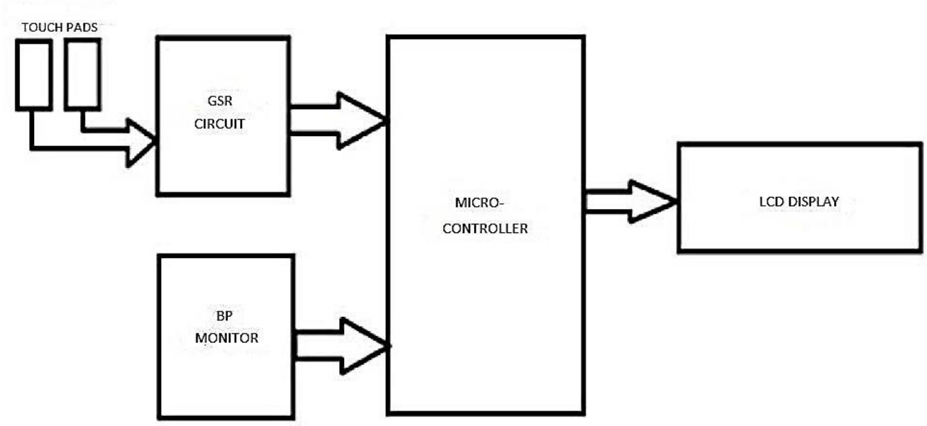

Fig.3. Schematic diagram incorporating galvanic skin response circuit and blood pressure module[13]

Methodology: A total of 25 persons, aged between 18-24yrs, consisting of 17 males and 8 females, were observed. Initially, each person was tested for their stress (GSR) and BP levels under normal / calm conditions, and the values were noted. Each one had to place their fingers on the touch pads of the GSR circuit. The GSR circuit showed three levels depending on the resistance of the skin of the particular person and categorized as either low, medium or high. The person was concluded to be low stressed; medium stressed or highly stressed corresponding to body resistance of 2MegaOhms or greater, 1MegaOhms and 500KiloOhms respectively. The output from the GSR circuit (i.e. low, medium, high) was fed into the microcontroller. The BP level of person was examined by inflating a cuff in line with the heart, around the fore-arm which is again fed to the microcontroller [13]. The BP was concluded to be normal if it was less than the value of (135/85) and high otherwise. The result of this computation was then displayed onto LCD display. Next, each person was told to perform certain physical activities like running up a flight of stairs. Each person was told to run up and down two floors because going through such a situation consisting of two or more floors induces stress on any person irrespective of BMI, lifestyle, or sex. After the session of physical activities, each person was told to sit and breathe slowly to get rid of panting or hyper-ventilation. The GSR and BP of the person were recorded once again using the same procedure as followed above. These parameters were then compared per person to analyzed change in stress levels [13].

Results & analysis: Fig 4 and Fig 5 describe the noted stress and blood pressure levels of persons, before and after performing the mentioned activities respectively. These graphs are then computed together to conclude if the person is either mentally or physically stressed or has normal condition. If the person has a low BP along with low stress, it was concluded to be normal condition. But if the stress level is high, and BP remains the same, the person is analyzed to have mental stress whose severity depends on the level of stress. But if the BP is noted to be high then it was concluded as physical stress [13].

Fig. 4. Graph of stress levels before and after physical activities [13]

Persons 2, 5, 9, 11, 14, 17 and 25 have not shown any change in their stress levels (GSR) after physical activities as seen in Fig 2 and hence there is no change in graphical parameters. A similar case is observed while measuring BP of persons 8, 13, 14, 21, 22 and 25 as shown in Fig. 4.

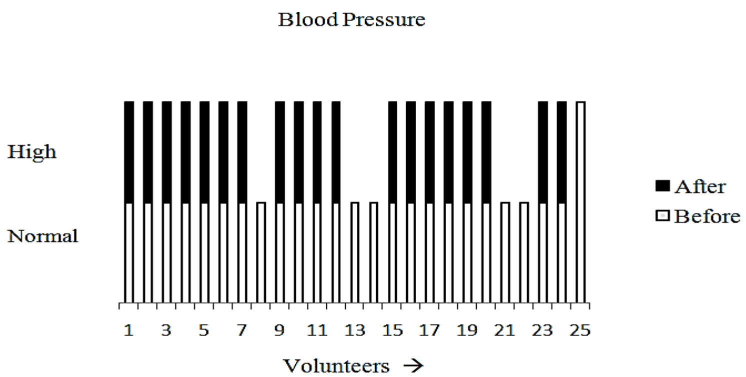

Fig.5. Graph of blood pressure before and after physical activities [13]

A person whose GSR value was high before performing any physical activity were categorized as mentally stressed [13]. Similarly person who had low levels of stress before doing the physical activity and low BP (i.e. less than 135/85) but after performing the physical activity GSR increases and if BP value crosses these level of (135/85) are categorized to be physically stressed. In similar manner if BP value does not increase after the physical activity are termed to be in normal condition. It was observed that, among the persons considered, 80% of the persons had elevated levels of stress and BP after performing the activities which proves these parameters are correlated and together contain relevant information to actual stress suffered. Also, it was observed that the changes in stress and BP levels were not significant to the sex of the person. The final comparison of the stress and BP levels computes the state of that person, i.e. normal condition, mental stress or physical stress [13].

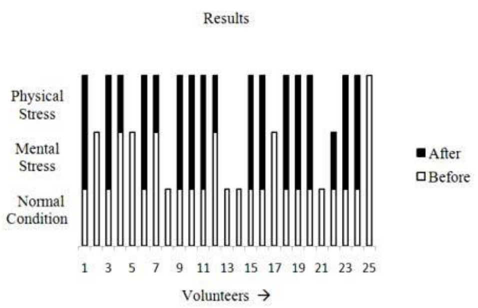

Fig.6. Results of computation (BP & GSR) before and after activities [13]

Fig 5 shows the results of the computation. This shows that among all persons who performed physical activities, 80% of them got physically stressed but the remaining were not physically stressed and remaining were categorized as mentally stressed.

3. *Mental Stress Evaluation using skin temperature and heart rate:* To analyzed the data from the stress detection system and generate result, the decision making module is needed since the physiological signals data read from the body has large scope. It also can analysis the value of each signals and state whether stress or not for the individual. Decision making module is of better ways to give accurate result together with signal processing and feature extraction. The common techniques used are K- Nearest neighbor (k-NN) [11], Support Vector Machine (SVM) [12], Bayesian Network and Fuzzy Logic. However, k-NN has slower character compared to others due to extensive use of memory. There are two types of SVM which is linear and nonlinear. These two types handle based on situation and equation. They can be used to predict future trends after the SVM classifier are trained. The researcher successfully obtained 84% accuracy by using 10 fold cross validation [12]. But, SVM is ineffective because it required more kernel elaborations. In this work, Fuzzy Logic was used [12].

For table 2 shows the reading of low, medium and high stress according to the temperature and heart rate value. A fuzzy logic rule is stated in table 3 and it is used by the fuzzy logic system to get the value of stress level. We can see for the high level of stress stated when temperature lower and beat per minute (BPM) is higher while other consist of medium and low level of stress[14].

Table 2: Two physiological signals threshold values [14]

	Low Stress	Medium Stress	High Stress
Temperature	44 >	41-44	<41
Heart rate(BPM)	< 70	70-90	>90
Stress level	0-50	50-80	80- 100

Table 3: Fuzzy logic rules [14]

BPM	**Temperature**	**Stress level**
L	L	L
L	M	M
L	H	H
M	L	L
M	M	M
M	H	M
H	L	L
H	M	M
H	H	M
H: High	**M**: Medium	**L**: Low

Methodology**:** The experiment is setup by collect physiological signals from 4 participants aged between 21 and 24 (2 women and 2 men). To be recorded by the stress detector system, individuals attached the sensors to their fingers acquiring at the same pulse rate and body temperature to be recorded. The physiological signals are obtained in 3 minutes with 5 seconds sample time for each stage. There are 3 stages in the experiment, which are initial, game and relax [14].

In the initial stages, the participants are ready and start to use the prototype. Game stage is done by the participants play a tricky games and the relax stage refer to the period where the participants will breathe slowly and deeply in 2 minutes. The position of the participants must be in correct ways to ensure the sensor get the right physiological signals from the body [14].

From the survey the summaries of the physiological responses over 3 minutes for initial, game and relax stage. The heart rate show increased obviously after playing the game and reduced after relaxing while temperature not change obviously.

The important part in this survey involved design of prototype which is able to detect pulse rate and body temperature in different situations. It also shows an initial threshold between being relaxed or being stressed. It can be determined that signals increase or decrease depending on the mental effort and the situation of the user with the different data measured [14].

4 Comparison

In previous sections various types of techniques were discussed. Table 4 show the comparison between various techniques.

Classification Methods	Accuracy	Input Parameters
SVM	82.00%[15] 84.00%[14]	ECG, HR, Skin temperature
Decision Tree	78.00%[2]	ECG
Naïve Bayesian network	78.00%[2]	ECG
Fuzzy clustering	Not provided	HR, Skin temperature

5 Conclusion

Stress detection system can help people to manage their stress level especially the person who suffer the mental stress. The main goal of this study was to determine whether activity information can compensate for the interactive effects of mental stress and physical activity, which affect the accuracy of mental stress detection. Based on literature investigated in this survey, there has not been an extensive use of combinations of physiological parameters in research yet where stress can be monitored through social and emotional interactions. They investigated different techniques like combinations of different physiological parameters such as ECG, Skin temperature and heart rate, GSR and BP from the above all heart rate and skin temperature provide more accurate results.

References

1. Dr Des McLernon , Dr L Mhamdi : Analysis and Processing physiological data from a watch-like device to detect stress pattern, The University of Leeds, August 2015.
2. Feng-Tso Sun , Cynthia Kuo , Heng-Tze Cheng , Senaka Buthpitiya , Patricia Collins

: Activity Aware Mental Stress Detection Using Physiological Sensors, Institute for Computer Sciences, Social Informatics and Telecommunications Engineering 2012.

3. Andre J. and Funk P, A Case Based Approach Using Behavioural Biometrics to Determine a User's Stress Level, in Workshop proceedings of the 6th International Conference on Case Based Reasoning, Chicago, editor(s): Isabelle Bichindaritz, Cindy Marling, pages 9. (2005).

4. Jorn Bakker , Mykola Pechenizkiy , Natalia Sidorova : “What's Your Current Stress Level? Detection of Stress Patterns from GSR Sensor Data” Data Mining Workshops (ICDMW), 2011 IEEE 11th International Conference.

5. Mario Salai , Istvan Vassanyi and Istan Kosa : “ Stress Detection Using Low Cost Heart Rate Sensors”,Hindawi Publishing Coorporation journal of health care engineering Volume 2016.

6. Istvan Vassanyi , Mario Salai : “Automatic Stress Detection using simple telemedical heart rate meters” , University of pannonia , April-2015.

7. Kalpesh Patil , Manisha Singh , Garima Singh :”Mental Stress Evalution using Heart rate variability analysis : A review” , ISSN volume 2 , April-2015.

8. de Santos Sierra A., Avila C. S., Bailador del Pozo G. Guerra Casanova J., “Stress detection by means of stress physiological template, Nature and Biologically Inspired Computing (NaBIC)”, 2011 Third World Congress on , vol., no., pp. 131-136, 19-21 Oct. 2011.

9. Zhai J., Barreto A., “Stress Detection in Computer Users Based on Digital Signal Processing of Noninvasive Physiological Variables”, in Engineering in Medicine and Biology Society, 2006. EMBS ’06. 28th Annual International Conference of the IEEE, vol., no., pp. 1355-1358, 30 Aug - 3 Sept 2006.

10. H. Van Steenis and J. Tulen, “The effects of physical activities on cardiovascular variability in ambulatory situations”, in Engineering in Medicine and Biology Society,1997, Proceedings of the 19th Annual International Conference of the IEEE, 1:105-108, Nov. 1997.

11. J. Zhai, A. Barreto, Stress recognition using non-invasive technology in: Proceedings of the 19th International Florida Artificial Intelligence Research Society Conference FLAIRS, 2006, pp. 395–400.

12. C.D. Katsis, et al., Toward emotion recognition in car-racing drivers: a biosignal processing approach, IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans 38 (2008) 502–512.

13. Fernandes, Atlee, et al. "Determination of stress using blood pressure and galvanic skin response." Communication and Network Technologies (ICCNT), 2014 International Conference on. IEEE, 2014.

14. Bin, Muhammad Syazani, Othman O. Khalifa, and Rashid A. Saeed. "Real-time personalized stress detection from physiological signals." Computing, Control, Networking, Electronics and Embedded Systems Engineering (ICCNEEE), 2015 International Conference on. IEEE, 2015.

15. Monika Chauhan, Shivani Vora, and Dipak Dabhi, “Effective Stress Detection using Physiological Parameters”, International Conference On Innovations In Information, Embedded And Communication Systems (ICIIECS 2017), Volume-IV, pp 483-488, 2017, IEEE.

16. A. De Santos Sierra, C. S. ´ Avila, J. Guerra Casanova, and G. B. Del Pozo, “A stress-detection system based on physiological signals and fuzzy logic,” IEEE Transactions on Industrial Electronics, vol. 58, no. 10, pp. 4857–4865, 2011.

17. G. Rigas, Y.Goletsis, andD. I. Fotiadis, “Real-time driver’s stress event detection,” IEEE Transactions on Intelligent Transportation Systems, vol. 13, no. 1, pp. 221–234, 2012.

18. J.Wijsman, B.Grundlehner, H. Liu, H.Hermens, and J. Penders, “Towards mental stress detection using wearable physiological sensors,” in Proceedings of the Annual International Conference of the IEEE Engineering inMedicine and Biology Society, Boston, Mass, USA, August-September 2011.

19. A. Riera, A. Soria-Frisch, A. Albajes-Eizagirre et al., “Electrophysiological data fusion for stress

detection," Studies in Health Technology and Informatics, vol. 181, pp. 228–232, 2012.

20. M. Singh and A. B. Queyam, "A novel method of stress detection using physiological measurements of automobile drivers," International Journal of Electronics Engineering, vol. 5, no. 2, pp. 13–20, 2013.

21. F.Mokhayeri, M.-R. Akbarzadeh-T, and S. Toosizadeh, "Mental stress detection using physiological signals based on soft computing techniques," in Proceedings of the 18th Iranian Conference of Biomedical Engineering (ICBME '11), pp. 232–237, Tehran, Iran, December 2011.

22. S. Baltaci and D. Gokcay, "Role of pupil dilation and facial temperature features in stress detection," in Proceedings of the 22nd Signal Processing and Communications Applications Conference (SIU'14), pp. 1259-1262, Trabzon, Turkey, April 2014.

23. J. Choi, Minimally-invasive wearable sensors and data processing methods for mental stress detection [Ph.D. dissertation], Texas A&M University, 2011, http://hdl.handle.net/1969.1/ ETD-TAMU-2011-12-10674.