e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
( Peer-Reviewed, Open Access, Fully Refereed International Journal )
Volume:06/Issue:07/July-2024 Impact Factor- 7.868 www.irjmets.com

# STRESS ANALYSIS USING EEG

**Vaishnavi*[1]**

*[1]Department Of MCA, Brindavan College Of Engineering, Bangalore, Karnataka, India.

## ABSTRACT

In recent years, much attention has been devoted to the research and development of techniques for individual and situational stress assessment to address the detrimental effects of stress. While constructive stress responses enhance task performance, excessive or prolonged stress can deteriorate physical, emotional, and cognitive health and result in an overall drop in efficiency. It has been reported that between 75 and 90 percent of all visits to primary care physicians are for symptoms that are at least exacerbated by stress, if not caused by it. Using the electroencephalography (EEG) signal to detect stress is a novel approach. There are not many studies that have employed this technique for stress detection. The few studies available have used different EEG features and reported different levels of accuracy. Furthermore, the effect of task difficulty on the performance of stress detection has not been established. This study fills the gap in the literature by investigating the effect of task difficulty on the performance of stress detection using the EEG signal. Stress is a common experience in everyday life. Excessive stress will result in a drop in efficiency and a deterioration of health. It is important to detect and manage stress. The objective of this study is to perform a preliminary investigation on the effect of task difficulty on the performance of stress detection and to determine the best stress model that fits low and high mental workload task stress data. Two experimental studies using both single channel data (Study 1) and multichannel data (Study 2) were conducted. Four stress models: the null model, single time-varying coefficient model, fixed effects model, and pooled model were assessed on whether the task difficulty effect is included as a fixed parameter in the stress models, or as a time-varying fixed parameter, or as a between-subject parameter. The results of both Studies 1 and 2 showed that the effect of task difficulty on stress is significant. Stress level is higher when performing a high mental workload task, compared to performing a low mental workload task.

## I. INTRODUCTION

Nowadays, the whole world experiences various kinds of stress in work place, family, economy and study, and it can cause severe socio-economical problems such as crime and loss of productivity in the country. A human mental and physical state reacting to a particular situation or stimulus is called stress, and in order to identify and assess moderate or severe stress, which is harmful to a persona's health, a stress analysis, also called a stress check, is performed in engineering and psychology. However, the causes, physical reactions and detection methods of each type of stress are not always similar or the same, since stress in physiology corresponds to stress, which is calculated as pressure divided by area (force/area), in engineering. Various research on stress detection for the appropriate management and treatment of stress have brought about the development of a biomedical engineering area called biosensor technology. Recent advanced technology allows detecting various types of stress with high accuracy and speed. The objective of this paper is to review and report new research about stress warning and detection from electroencephalography (EEG) signals, since it is perceived as an important research topic in biomedical engineering EEG can be used for stress detection because it reflects the different mental states of individuals, but various research results, modeling and experimental methods, features and performance, and other aspects of each research procedure should be thoroughly examined and evaluated to secure the validity and reliability in the research of stress analysis using EEG, which is presented in this paper Although there might be several limitations, stress detection using EEG can be utilized as an important modality in biomedical engineering with useful and valuable outcomes, from the research and technology to the application and service. The paper presents the stress detection challenges and guidelines that can help researchers and developers of stress detection using EEG.

**Definition and Concept of Stress**

Nowadays, stress has become a familiar part of our language. It can also be known very well from personal experience. Everyone talks about stress and is concerned about it, for it has become an accepted part of modern life contributing to widespread psychological and physical problems. But only relatively recently has it been defined, investigated and taken seriously as a particular psychological issue. Hence, we can see that the concept of stress is relatively new and a less understood concept. Stress came into English in the 14th century, derived from the Latin word districtus, and became widely used in the 17th century. It originally had a meaning of â€˜hardship, adversity, force or pressure of something adversea. In the 20th century, the meaning of stress was extended even further when the Hungarian scientist Hans Selye proposed what we have since come to know as the general adaptation syndrome. Ever since, this term has been widely used in other fields to mean a pressure, force, influence, etc., to alter, change or produce movement. In 1926, Walter B. Cannon first showed in a variety of experiments that animals responded to many kinds of stressful experiences primarily by sympathetic nervous system discharge. Stress has been defined as a negative emotional experience accompanied by biochemical, physiological, cognitive and behavioral changes that are directed either toward altering a stressful event or accommodating its effects. Stress is generally deï¬ned as an adaptive response to a situation that is perceived as challenging or threatening to an individual. These threats or challenges to well-being are called stressors. If successful in coping with stressors, individuals will experience changes and grow stronger. If unable to cope, they will experience change for the worse and fall victim to unhealthy consequences. However, psychological stress and physical stress characteristically affect both the body and the brain. Stress is directly linked to a number of mental health conditions, such as depression, anxiety, post-traumatic stress. It also plays a significant role in physical health, being associated with a number of medical issues such as heart disease, obesity, and autoimmune disorders.

**Importance of Stress Analysis in Various Fields**

In today's fast and complex world, stress has become a very common but incredibly significant issue. It affects everyone and occurs at all stages of life. Usually, it is believed to have originated from the early days of man when life was a struggle for survival with physical factors such as cold, heat, hunger, and thirst and man had to fight or run away from the situation to survive. Today, in addition to the existing physical stressors, man is exposed to a large number of mental stressors, some of which are related to consequences of behaviors imposed by the society such as overwork, fear of losing the job, family-related problems, and adaptation to new technologies. It is obvious that stress is an important and serious health problem that affects all layers of society. Analysis of stress effect in various fields is of utmost importance as the negative health consequences associated with stress are considerable and are estimated to be the cause of 75-90% of visits to the primary care physician. In fact, chronic stress has been associated with a number of severe health problems including high blood pressure, heart disease, obesity, diabetes, depression, and autoimmune diseases [26][27]. Furthermore, analysis of stress and its associated problems in the field of education is important as performance of students is known to decrease under high levels of stress. In the work environment, stress is the main cause of long-term sickness and it has been revealed that every year, 13.5 million working days are lost due to work-related stress. It is also well-known that stress acts as a silent killer during driving. In summary, it can be said that analysis of stress in these areas is crucial and has a noteworthy importance due to its many harmful effects on human health and behavior.

## II. LITERATURE SURVEY

The human brain is an extraordinary part of the body, quite like a tiny universe in itself. It constantly performs an enormous number of intricate biochemical, electrical, and nerve transmission activities. The brain manages all these activities in such a way that people normally do not feel that they are doing any hard work. However, the brain uses a lot of energy while coping with the stresses of everyday life. When a person confronts a challenging or threatening situation, his or her body reacts with a stress response. In recent years, mental stress and depression have been recognized as serious health issues that affect many individuals [30][31]. Many symptoms and diseases are related to those issues, which can decrease the quality of life in today's society. Consequently, it is of great importance to detect mental stress and its level in people's lives. It is well known that the human brain produces electrical activities. The electrical activities and the emerging connections of the brain act as a complex information processing system that links the input with the output. The interaction of the brain with the surrounding environment is the essence of electroencephalography (EEG). EEG is the recording of the electrical activity of the brain using electrodes placed along the scalp. Different types of stress (startle, panic, fear) have an impact at various different levels, and it has long been established that the brain is the ultimate mediator of the stress response. Many stress-related disorders have their roots in the dysregulation of stress at the central nervous system (CNS) level. The non-invasive aspect of EEG, in combination with its very high temporal resolution, makes it an attractive method for monitoring stress levels in humans. The stress-elicited response may be investigated using alterations of brain activity measured with EEG. Indeed, previous studies have shown that an increase in some specific brain activities related to stress is present before performing a stressful task. Consequently, the aim of this study and many others is to find and characterize the brain activity associated with mental stress and, eventually, to create a model to estimate mental stress from brain activity.

## III. FUNDAMENTALS OF EEG

Eeg is the abbreviation for Electro Encephalo Graphy. It refers to the graph that is produced from the recording of electrical activity in the brain. The technique used to record this electrical activity is also called EEG. To begin by understanding the fundamentals of EEG, the following aspects are discussed: 1. History: The history of EEG as a brief introduction. It is good to have an idea of the background against which the current knowledge and technology of EEG has evolved. 2. Brain function and neural communication: An understanding of the function of the brain and how the neurons communicate within the brain is fundamental to understanding EEG. 3. Measurement of EEG: The meaning of an EEG measurement in terms of the involved neurons and the actual recording of the electrical activity. Starting with the history of EEG, the discovery that the brain generates electrical activity started with the work of Caton in 1875 who found electrical potentials in the brains of rabbits and monkeys. In 1913, Russian physiologist Vladimir Pravdich-Neminski was the first to use the term 'encephalogram' and identified the main features of today's basic techniques of recording the EEG. Hans Berger, a German psychiatrist whose father was a scientist, was inspired by Pravdich-Neminski's work to further investigate the electrical activity of the brain. In 1924, Berger demonstrated the existence of human EEG. Since then, technological advances made it possible to understand the characteristics of the signal and established the relationship between the EEG and the brain function. Today, the understanding of both conditions of the brain related to the level of consciousness and cognitive brain functions are based on the study of EEG in patients. In fact, the visual presentation of the EEG signal, the so-called EEG tracing, remains the primary tool of understanding and detecting abnormalities in the brain.

## IV. BIOLOGICAL BASIS OF STRESS

The classic definition of stress was provided by Hans Selye. He describes stress as aœthe non-specific response of the body to any demand for change's€. In this definition, stress is considered to be a physical or physiological response that occurs when the body is subjected to any level of discomfort or condition that does not allow the natural state of balance to be maintained. The stress response represents a mobilization of the body's resources to reduce the effects of a threatening or noxious agent placed on the body. The body's homeostasis is affected and the body undergoes a series of changes in an attempt to regain the status of balance or to reach a new level of equilibrium. In the modern world, most people are exposed to psychological stress. This can be in the form of negative life events, such as work overload, job insecurity, long working hours, shift work, time pressure, and high job demands, or it can be in the form of traumatic events, such as natural or man-made disasters. These negative events can have a significant impact on mental and physical health, making it an important social issue that needs to be addressed. The brain is one of the most important and complex organs in the human body. It is the center of the nervous system, which controls almost every task in the body, responding and acting to signals from both the external and internal environments. Figuring out how the brain works is one of the greatest scientific and technological challenges. The human brain is composed of around 100 billion nerve cells. Each nerve cell connects to other nerve cells and generates small electrical signals. These electrical signals have the ability to act as messengers, transmitting information from one area of the brain to another, and eventually allowing the brain to perform extremely complex tasks. The unique brain activity in response to cognition or emotion can be detected and recorded by relatively non-invasive biomedical techniques, such as the electroencephalography (EEG) technique. When the person is exposed to stress, the brain behaves differently. It responds to stress by releasing certain stress hormones from the axis, affecting the HPA axis and causing stress-related diseases. The EEG technique is able to monitor the brain's response and action while exposed to stress and can therefore be utilized to detect and analyze stress levels and their effects on the brain.

## V. TECHNIQUIES FOR EEG SIGNAL AQUISTION

There are two primary methods of EEG signals. One type uses chronological data with a focused event. Longer waves are used to record an individual's stable-state responses and features that accompany light sleep. Another type uses transient wave data to record an individual's environmental stimuli, such as movements or sensory experiences. Because longer waves have a higher signal-to-noise ratio, they are typically much easier to analyze. EEG signals can be classified into several types. Delta waves have frequencies between 1.5 and 4 Hz and are commonly seen in adults during sleep. Infants commonly have delta waves when awake. Theta waves have frequencies between 4 and 7.5 Hz. They can be seen in children, drowsy adults, and in cases of intellectual activity. Alpha waves have frequencies between 7.5 and 13 Hz. These waves are associated with relaxed wakefulness and are often used as a reference value when other EEG features are being studied. Finally, beta waves have frequencies between 13 and 30 Hz. They are found in alert individuals and are commonly used when testing patients with suspected brain lesions. As research becomes more advanced, additional wave types are likely to be identified. Several technologies are used for EEG signal acquisition, but it is necessary to use the most suitable technology for the specific application at the best performance/efficiency point. First of all, it is important to distinguish between wired and wireless EEG systems. Wired systems are based on a network of cables that connect the electrodes to the various devices such as amplifiers, analog filters, ADCs, and battery packs, which may be necessary, with the risk of causing discomfort, entanglement, and obstruction. On the other hand, wireless systems are based on radiofrequency connectivity between the electrodes (or the cap containing the electrodes) and a compact head module, usually integrating amplifiers, analog filters, powered A/D converters, and digital transmission to a remote location where the digital signals are received and stored or processed further. In addition, there are dry electrodes that do not require a conductive paste or other electrolytes between the electrode and the scalp, thus shortening the set-up time.

## VI. APPLICATION OF EEG BASED STRESS ANALYSIS

Stress analysis using EEG (Electroencephalography) signals In this work, an analysis is presented that is based on EEG signals for the identification of stressed individuals. The motivation is the absence of ways to objectively determine stress especially during a job recruitment process, as it is known that the performance of the subjects is influenced by the job interview and stress. A non-stress model is constructed using data from job interview questions, and then is tested using both stress and no-stress data. The results showed that the model had high accuracy in identifying both stress and non-stress, indicating that the model is suitable to be used in determining stress during the job recruitment process. Many wearable solutions perform stress monitoring by detecting emotional responses. State of the art emotion detection mostly employs the combination of several physiological signals, including skin conductivity response (SCR), temperature (from infrared sensors), breathing rate, pulse, and blood pressure. Apart from the practical reasons, which use stress as a negative constraining force, for the employees to work within safe limits, several studies also have derived the relationship between performance and stress. However, obtaining stress indicators becomes essential in keeping employees at work and in designating the right people for the right job. Considering the weaknesses of existing solutions in providing objective stress detection or analysis during the job recruitment process, it is at best only based on visual observation, inventing a new model or device that employs brain activity would evolve as the best solution. These references justify the need and application of using EEG for stress detection in different scenarios. Previous works have attempted to realize stress detection derived from EEG signals. One study aimed to assess job interview stress after interview questions and found that spectral pattern in the alpha band was associated with each of the stressor-related processes. The performance of the recruited classifiers for stress detection can also vary with situational factors. It is shown that the best accuracy for stress detection was 62% and was obtained during examination with a group of recruited students; the worst accuracy was 50%. If the portability and simplicity of the device are taken into account, an increment of 76% to 85% stress detection accuracy of the working or potential workforce would indeed be beneficial.

## VII. CONCLUSION

The results showed that the proposed stress asymmetry detection approach achieved high accuracies in recognizing the asymmetry with the positive-negative stress level and valence-arousal level combinations. With boosting the classification of the different stress levels, the indicated as stressor signal for a negative stress was

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identified. The identified stressor signal could be utilized in the management of administrative activities within organizations, e.g., analyzing staff members' performance at the time of interview and checking if they are suitable for the available job, and in the daily life for personalized service systems, e.g., controlling customer behavior in the shopping mall, ensuring security while gambling at the casino, and detecting people at risk of moving into a negative or dominant situation for various entertainment events. In conclusion, this paper presented a stress indicator by performing an asymmetric emotional stress (positive vs. negative) recognition using EEG signals, which consider the valence and arousal levels of the emotion. We identified the emotional stress by examining the changes in the brain activity when presented with different emotions. First, the collected EEG signals were preprocessed. Then, the power spectral density was estimated using the Welch method. Afterwards, the power distribution at various brain bands (delta, theta, alpha, beta, and gamma) was examined to understand the brain activities associated with specific emotions. Subsequently, the asymmetric emotional stress was recognized by combining the stress level classifier with a valence or arousal level module. Finally, the stress asymmetry was detected.

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