DEVELOPMENT OF EEG-BASED PARADIGM TO OBSERVE STRESS-INDUCING STATES IN COLLEGE STUDENTS USING NEUROSKY AND MATLAB

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology with Honours

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology with Honours.

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DEDICATION

To my beloved mother and father, Noraini binti Ab Rahim and Zainal bin Mohd Diah,

and

To my lovely siblings, Nur Nazmi Afiq and Nur Syaza Wirda,

and

To my closest friends, Nur Iffah Maisarah binti Azman

ABSTRACT

The rise in stress and anxiety among college students has raised the demand for effective as well as noninvasive techniques for monitoring these psychological states. EEG shows potential because it enables continuous monitoring of brain activity in real-time. The current paper describes an EEG-based study using the Neurosky MindWave headset to evaluate the levels of anxiety and stress among college students. The Neurosky device was selected because it is easily transportable and affordable, and the experiment concentrated on attaining values for validity, including attention, meditation, and selected EEG bands, such as alpha and beta. The paradigm used consisted of designing controlled experimental tasks—stress-generating activities, such as time-limited tasks and tasks with numerous errors, as well as relaxation tasks. Initial findings regarding beta wave patterns and attention in response to stress and non- stressful conditions of the participants have shed light on alterations between the two states. The results suggest that there is merit in using EEG-based paradigms as objective markers of anxiety and stress which can be used to monitor and/or treat such conditions in real time. Therefore, this study shows the feasibility of inexpensive EEG in mental-health research and signaling the utilization of stress management and academic contexts in the future.

ABSTRAK

Peningkatan tekanan dan kebimbangan dalam kalangan pelajar kolej telah meningkatkan permintaan untuk teknik yang berkesan serta tidak invasif untuk memantau keadaan psikologi ini. EEG menunjukkan potensi kerana ia membolehkan pemantauan berterusan aktiviti otak dalam masa nyata. Kertas semasa menerangkan kajian berasaskan EEG menggunakan alat dengar Neurosky MindWave untuk menilai tahap kebimbangan dan tekanan dalam kalangan pelajar kolej. Peranti Neurosky dipilih kerana ia mudah diangkut dan berpatutan, dan percubaan menumpukan pada mencapai nilai untuk kesahihan, termasuk perhatian, meditasi dan jalur EEG terpilih, seperti alfa dan beta. Paradigma yang digunakan terdiri daripada mereka bentuk tugas eksperimen terkawal—aktiviti menjana tekanan, seperti tugasan terhad masa dan tugasan dengan banyak ralat, serta tugas relaksasi. Penemuan awal mengenai corak gelombang beta dan perhatian sebagai tindak balas kepada tekanan dan keadaan bukan tekanan peserta telah menjelaskan perubahan antara kedua-dua negeri. Keputusan menunjukkan bahawa terdapat merit dalam menggunakan paradigma berasaskan EEG sebagai penanda objektif kebimbangan dan tekanan yang boleh digunakan untuk memantau dan/atau merawat keadaan sedemikian dalam masa nyata. Oleh itu, kajian ini menunjukkan kemungkinan EEG yang murah dalam penyelidikan kesihatan mental dan menandakan penggunaan pengurusan tekanan dan konteksakademikpadamasahadapan.

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CHAPTER 1

INTRODUCTION

1.1 Background

College students experience anxiety and stress as common mental health issues affecting nearly half of the full population of the entire college-studying students all over the world. All these psychological states are otherwise known to hamper academic performance, health and quality of human life. Screening and assessment for anxiety and stress is important to establish good timing for the desired intercessions and students' well-being. EEG is one of the most effective and objective techniques to assess and track cognitive and/ or affective states, such as anxiety and stress.

Neurosky is a low cost and non invasive EEG system which is widely used in many fields of research because of its availability and ease in use. However, its use in understanding anxiety and stress related conditions in college students is still a topic that has been reviewed only to a limited extent. The purpose of this research is to establish an EEG based paradigm with help of Neurosky device to analyze and measure anxiety and stress states in college students.

The proposed paradigm is a method that coupled with a controlled experiment where different stimuli that cause anxiety and stress if known should be used. Such stimuli may be academic evaluation situations, social pressure conditions, or cognitive workload manipulations that are replicas of everyday stress that students encounter in college. For the assessment of anxiety and stress response, EEG signals recorded from the participants during these controlled condition along with the signals obtained from Neurosky device would help researchers find out biomarkers or patterns related with the above said conditions.

The Use of EEG Analysis for Observer -Based Assessment of Anxiety and Stress Inducing States in College Students Using the proposed EEG based paradigm for observation of anxiety and stress inducing states has the following advantages. First, it is useful for making future investigations and creations of efficient interventions and support based on the understanding of neurophysiological correlates of these psychological states. Second, it can help give an actual numerical value as to how much anxiety and stress the subject has, offering an additional approach over the ones based on self-reports which might be impacted by various biases. Third, it is non invasive, which makes Neurosky device easy to use in research study, especially in education context.

These findings may influence academic support, counseling and mental health for students, and the creation of individualised intervention plans for learners. When possible students that are deemed vulnerable to increased levels of stress and anxiety should be offered method and approaches to help them do well despite the given pressure.

1.2 Problem Statement

Anxiety and stress are significant psychological challenges faced by college students, impacting their academic performance, overall well-being, and quality of life. While self-report measures and clinical assessments are commonly used to evaluate these states, they may be subject to biases and limitations. There is aneed for an objective and quantifiable approach to detecting and monitoring anxiety and stress levels in college students.

Electroencephalography (EEG) has shown promise in assessing cognitive and affective states, including anxiety and stress. However, traditional EEG systems can be expensive, complex, and require specialized expertise, limiting their widespread application in educational settings. The Neurosky device, a low- cost and user-friendly EEG system, presents an opportunity to address this gap.

The primary problem addressed in this study is the development of an EEG- based paradigm using the Neurosky device to observe and quantify anxiety and stress-inducing states in college students.

By addressing this problem, the study aims to contribute to the understanding of the neurophysiological correlates of anxiety and stress in college students and provide an objective and accessible tool for monitoring these psychological states. The findings can inform the development of targeted interventions, support services, and personalized strategies to mitigate the negative impacts of anxiety and stress on student well-being and academic performance.

1.3 Project Objective

The objective of this project is to develop an innovative EEG-based paradigm utilizing the Neurosky technology:

- To design an EEG paradigm to observe the gradual increase of stress
- To implement the paradigm on college students
- To analyze EEG data and the factors related stress-inducing states

1.4 Scope of Project and Limitations.

This project aimed to develop and validate an EEG-based paradigm for detecting stress in college students. The scope of the work includes;

- a thorough review of existing research on EEG-based methods for detecting anxiety and stress was conducted, focusing on identifying gaps, challenges, and opportunities for innovation.

- Neurosky technology and its applications in EEG data acquisition were investigated to assess its suitability for the project and to understand its limitations in capturing stress and anxiety-related brain activity.
- Neuroexperimenter software was used to record the EEG data. The data was then analyzed using MATLAB.
- At least five subjects among college students volunteered to be part of the study.
- Similar paradigm were repeated across the subject to observe the gradual appearance and increase of stress level.

The project comes with certain limitations but not so much that it hinders the main obejctives. The limitations are mainly the;

- accuracy and resolution of the Neurosky EEG device, which may not have captured all nuances of brain activity associated with stress and anxiety.
- The study focused on college students, so findings may not generalize to other populations without additional research.
- Ethical and practical constraints limited the sample size and diversity of participants, which may have affected the robustness of the results.

By addressing these scope and limitations, the project contributed to the development of a reliable, non-invasive tool for detecting stress in college students, with potential applications in mental health monitoring and intervention.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The project has involved a great deal of research and investigation. Books, articles, journals, websites, and other relevant sources provided data and studies for the project. The data was an invaluable resource for verifying if the project could be finished in the allotted time. The research and data collection centered on important and pertinent project-related subjects.

This section examined several theses and publications from journals found on the Google Scholar and Mendeley websites. A few keywords such as "stress", "anxiety", " stress recognition; user interface; EEG, and Monitoring were necessary to locate the relevant content.

2.2 What is EEG?

EEG stands for electroencephalography, which is a technique used to record the electrical activity of the brain. EEG measures the electrical signals generated by brain cells by placing electrodes on the scalp.[2] This method is commonly used in the diagnosis of neurological disorders, monitoring brain activity during sleep, or in research on brain function. EEG is a non-invasive and painless procedure that provides valuable information about brain activity.[8] EEG is an efficient modality that helps to acquire brain signals corresponding to various states from the scalp surface area. These signals are generally categorized as delta, theta, alpha, beta, and gamma based on signal frequencies ranging from 0.1 Hz to more than 100 Hz.

2.2.1 What is a signal of EEG?

The signal strength of EEG (electroencephalography) typically ranges in the microvolt (µV) range. The amplitude of EEG signals generally ranges from about 0.5 µV to 100 µV when measured at the scalp. Typical brain activity for most frequencies (alpha, beta, theta, delta) falls within this range, with common activities usually around 10-50 µV.

EEG signals are divided into different frequency bands:

i. Delta (0.5 - 4 Hz): Associated with deep sleep.
ii. Theta (4 - 8 Hz): Linked to light sleep, relaxation, and meditation.
iii. Alpha (8 - 13 Hz): Related to relaxed wakefulness, often seen when the eyes are closed.
iv. Beta (13 - 30 Hz): Associated with active thinking and focus.
v. Gamma (30 - 100 Hz): Linked to higher mental activity and consciousness.

EEG signals are inherently weak and susceptible to noise from muscle activity, eye movements, and external electrical sources. Proper electrode placement and good contact with the scalp are essential for obtaining clear and reliable signals.

2.2.2 Where is the location of the electrode of EEG?

Electrodes are placed on the head of the participant concerning anatomical landmarks such as the inion, nasion, and left and right pre-auricular points, such that the central electrode Cz is approximately aligned with the vertex. There are two methods for the EEG electrode placement introduced by the International Federation of Clinical Neurophysiology which is the international 10- 20 system, and the second method was shown by the American Electroencephalographic Society with added intermediate 10%.

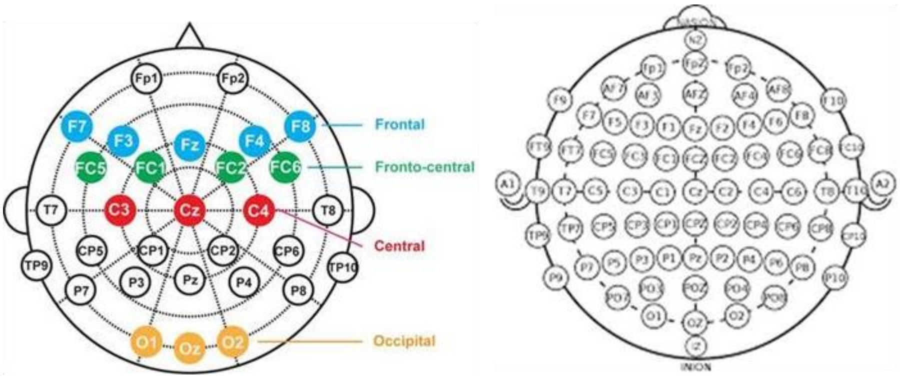


Figure 2.1 The 10-20 system EEG electrode placements (left) and with the intermediate 10% electrodes (right).

2.3 What is stress?

Stress is a multifaceted phenomenon that affects individuals both psychologically and physiologically. It arises when an individual perceives a situation as challenging or threatening, triggering a cascade of responses aimed at coping with the pressure. These stressors can be external, such as work demands, financial pressures, or relationship conflicts, or internal, like personal beliefs and fears. [17]

Acute stress is the body's immediate reaction to a new and challenging situation. This short-term stress can be beneficial, providing the necessary energy and focus to overcome obstacles. For instance, the adrenaline rush before an important presentation can enhance performance. However, when stress becomes chronic, persisting over long periods, it can have detrimental effects on health. Chronic stress is associated with a variety of health issues, including cardiovascular diseases, depression, anxiety, and weakened immune function. The body's stress response is primarily managed by the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis. When a person encounters a stressful situation, the sympathetic nervous system triggers the "fight or flight" response, releasing adrenaline to prepare the body for immediate action. Concurrently, the HPA axis releases cortisol, a hormone that helps manage energy and suppress non-essential functions during the stress response.[18]

Stress manifests in numerous ways, impacting physical, emotional, cognitive, and behavioral aspects of life. Physically, individuals may experience headaches, muscle tension, fatigue, and sleep disturbances. Emotionally, stress can lead to anxiety, irritability, and mood swings. Cognitively, it can impair concentration and memory, making decision-making more challenging. Behaviorally, stress might result in changes in eating habits, social withdrawal, and increased reliance on substances like alcohol or drugs.

Managing stress effectively is crucial for maintaining health and well-being. Lifestyle modifications such as regular exercise, balanced nutrition, and sufficient sleep can significantly reduce stress levels. Relaxation techniques, including deep breathing, meditation, and yoga, also play a vital role in stress management. Additionally, seeking professional help through counseling or therapy can provide individuals with strategies to cope with and alleviate stress.

In conclusion, stress is an inevitable part of life, but understanding its mechanisms and impacts can help individuals manage it more effectively. By adopting healthy habits and seeking appropriate support, one can mitigate the negative effects of stress and enhance overall quality of life.

2.4 What is Anxiety?

Anxiety is a natural response to stress, characterized by feelings of worry, nervousness, or fear about future events or uncertain outcomes. It is a common emotion that everyone experiences at some point in their lives, often as a reaction to challenging situations such as job interviews, public speaking, or major life changes. However, when anxiety becomes excessive, persistent, and interferes with daily activities, it may be indicative of an anxiety disorder.[15]

Anxiety disorders are the most common mental health condition, affecting millions of people worldwide. They manifest in various forms, including generalized anxiety disorder

(GAD), panic disorder, social anxiety disorder, and specific phobias.

Generalized anxiety disorder involves chronic and excessive worry about a wide range of topics, while panic disorder is characterized by sudden and intense episodes of fear known as panic attacks. Social anxiety disorder involves an overwhelming fear of social situations, and specific phobias are intense fears of particular objects or situations.

The symptoms of anxiety can be both physical and psychological. Common physical symptoms include increased heart rate, sweating, trembling, dizziness, and gastrointestinal issues. Psychologically, anxiety can lead to excessive worrying, restlessness, difficulty concentrating, and a sense of impending doom. These symptoms can be debilitating and significantly impact a person's quality of life, affecting their work, relationships, and overall well-being.

The exact causes of anxiety are complex and multifaceted, involving a combination of genetic, environmental, and psychological factors. Traumatic events, chronic stress, and a family history of anxiety disorders can increase the risk of developing anxiety. Neurobiological factors, such as imbalances in brain chemistry, also play a role in the onset of anxiety.

Managing anxiety often requires a comprehensive approach, including lifestyle changes, therapy, and sometimes medication. Cognitive-behavioral therapy (CBT) is one of the most effective treatments, helping individuals identify and change negative thought patterns and behaviors. Medications such as selective serotonin reuptake inhibitors (SSRIs) can also be prescribed to help balance brain chemistry. Additionally, relaxation techniques, regular physical activity, and mindfulness practices can help reduce anxiety symptoms and improve overall mental health.[16]

In conclusion, while anxiety is a normal human experience, it can become a serious and debilitating condition when it interferes with daily functioning. Understanding the nature of anxiety, recognizing its symptoms, and seeking appropriate treatment are crucial steps in managing this condition and improving one's quality of life.

2.5 What is the Relationship Between Anxiety and Stress: How It Relates to EEG?

Anxiety and stress are intrinsically linked psychological states, often co-occurring and influencing each other. While stress is a response to an external pressure or demand, anxiety is a stress reaction, characterized by worry and fear about potential future events. This interplay creates a cycle that can significantly impact an individual's mental and physical health. Understanding this relationship and how it manifests in the brain is crucial for developing effective interventions.

Electroencephalography (EEG) offers a valuable tool for observing the neural underpinnings of anxiety and stress, providing insights into their relationship and potential treatments.

2.6 Relationship Between Anxiety and Stress

Stress is a natural response to challenging or threatening situations, triggering the body's "fight or flight" response. This response involves the release of stress hormones like cortisol and adrenaline, which prepare the body to deal with the perceived threat. Short-term stress can be beneficial, enhancing performance and focus. However, prolonged stress, known as chronic stress, can lead to numerous health problems, including anxiety disorders.

Anxiety, on the other hand, is characterized by persistent and excessive worry about potential threats or adverse outcomes. While stress is typically a reaction to an immediate external stimulus, anxiety often persists even in the absence of an immediate threat, focusing on future uncertainties and potential dangers. The chronic activation of the stress response can contribute to the development of anxiety, creating a feedback loop where stress leads to anxiety, which in turn exacerbates stress.

2.7 EEG and Its Role in Understanding Anxiety and Stress

Electroencephalography (EEG) is a non-invasive method used to measure electrical activity in the brain. By placing electrodes on the scalp, EEG records the brain's electrical signals, known as brainwaves, which reflect the synchronous firing of neurons. EEG is particularly useful for studying the neural mechanisms underlying psychological states like anxiety and stress due to its high temporal resolution.

I. EEG Patterns Associated with Stress

Stress is often associated with increased activity in the beta frequency band (13-30 Hz). Beta waves are linked to active thinking, focus, and heightened alertness, all of which are typical responses to stress. Additionally, stress can lead to increased synchronization in the frontal regions of the brain, reflecting heightened cognitive load and emotional processing.

II. EEG Patterns Associated with Anxiety

Anxiety, similar to stress, is also associated with changes in EEG patterns. Individuals with anxiety disorders often exhibit increased beta activity, particularly in the frontal cortex. This reflects the excessive worry and cognitive processing associated with anxiety. Moreover, anxiety can lead to decreased alpha activity (8-13 Hz), which is associated with relaxation and a calm state of mind. Reduced alpha activity indicates difficulty in achieving a relaxed state, which is a common symptom in anxious individuals.

The use of EEG in studying anxiety and stress provides several advantages. It allows researchers to observe real-time changes in brain activity in response to stressors or anxiety-inducing stimuli. This can help in identifying specific neural markers associated with these states, leading to better diagnostic tools and targeted interventions. For instance, neurofeedback, a technique that uses real-time EEG data to teach individuals how to regulate their brain activity, has shown promise in reducing symptoms of anxiety and stress.

2.8 Literature Review based on several research papers.

2.8.1 EEG-Based Stress Monitoring.

The article's primary thesis is the development of an algorithm to identify various stress levels from Electroencephalogram (EEG) signals. Through the use of a Stroop color-word test, nine people are used in an experiment designed to validate the algorithm. The study team experiments with several feature combinations and classifiers to precisely determine stress levels by evaluating EEG data obtained during the experiment. The ultimate objective is to create CogniMeter, a real-time stress monitoring system that displays the user's stress level on a meter. Applications in mental health, stress management, and other areas where stress level monitoring is essential are made possible by the incorporation of EEG technology for stress recognition. [4]

The Stroop colour-word test was used in the experiment to produce four levels of stress in the subjects while EEG data was being recorded. The SVM and k-NN classifiers were used to examine various feature combinations.The system recognized four stress levels with an average accuracy of 67.07%; for three levels, the accuracy was 75.22%, and for two levels, it was 85.17%. In order to provide users with quick feedback on their stress level, the algorithm was incorporated into the CogniMeter system for real-time stress monitoring.Promising results were shown in the accurate recognition of different stress levels when the SVM classifier was combined with statistical data and Fractal Dimension. Stress management for high-stress occupations such as air traffic controllers and operators can benefit from the practical uses of EEG-based stress monitoring.

2.8.2 Threat of Scream paradigm: a tool for studying sustained physiological and subjective anxiety.

The main objective of the paper "Threat-of-Scream Paradigm: A Tool for Studying Sustained Physiological and Subjective Anxiety" is to present a unique paradigm for conducting experiments in which subjects are subjected to aversive screams to successfully elicit sustained anxiety. The goal of the project is to advance our knowledge of the origins of pathological anxiety by offering a straightforward, reliable, and controlled approach to examining the physiological and subjective components of anxiety. The research results demonstrate how well the 'Threat-of- Scream' paradigm works to generate elevated subjective ratings of anxiety and skin conductance levels, providing important new information for the study of prolonged anxiety reactions.[8]

Participants in the "Threat-of-Scream Paradigm" study indicated higher subjective anxiety and higher skin conductance levels during threat blocks compared to safe blocks when exposed to low-intensity unpleasant screams (< 80 dB). Anxiety responses were effectively regulated by the random delivery of low-intensity screams, resulting in continuous anxiety for more than an hour. The results demonstrated that the paradigm could consistently elicit consistent physiological and subjective anxiety responses without appreciable variations over the course of two experimental runs.

2.8.3 Analysis of Single-Electrode EEG Rhythms Using MATLAB to Elicit Correlation with Cognitive Stress.

The key objective of the EEG analysis carried out in MATLAB for this work was to use EEG data from a single-electrode Brain-Computer Interface (BCI) to examine the efficacy of a cognitive stress identification system. The purpose of the study was to examine EEG signals obtained from 25 participants when they were under stress using the Stroop color-word test. The Stroop test individuals' self- perceived stress scale used as the classification goal output. The Discrete Cosine Transform (DCT), a dimension reduction technique, and MATLAB were used in the analysis to drastically reduce the amount of data. Reduced DCT coefficients were used to train three pattern classification algorithms to categorize cognitive stress levels: Artificial Neural Network (ANN), k-Nearest Neighbor (KNN), and Linear Discriminant Analysis (LDA).

In comparison to other classification algorithms like Artificial Neural Network (ANN) and Linear Discriminant Analysis (LDA), the study found that the highest average classification rate of 72% was achieved by utilizing the Discrete Cosine Transform (DCT) in conjunction with the k-Nearest Neighbor (KNN) algorithm. This suggests that the best method for categorizing EEG patterns associated with cognitive stress levels was to combine DCT and KNN. The research showed that categorization results obtained with a single-electrode BCI (NeuroSky MindWave) were on par with those obtained with multi-electrode BCIs. This implies that a single-electrode BCI would be a sensible and affordable choice for stress recognition and EEG research.

2.8.4 Anxiety Controlling Application using EEG Neurofeedback System

The main aim of the research project on Anxiety Controlling Application utilizing EEG Neurofeedback System is to look into the relationship between a sample of sixteen young athletes, ages 17 to 21, and their anxiety levels as measured by EEG band oscillations. The purpose of the study is to compare the contrast between the open and closed eye states using a mobile EEG equipment to gather data on EEG band oscillations during relaxation.[1]

There was a statistically significant difference ($p \leq 0.006$) in the prefrontal cortex's alpha-band activity between the eyes open and closed circumstances. The study found a substantial relationship between anxiety levels in young athletes and the alpha band of the EEG in the frontal cortex, with lower activity in the alpha rhythm observed in those with high anxiety.

An examination of the data revealed a statistically significant link, with the alpha band displaying a negative slope ($p \leq 0.029$), suggesting a connection between young athletes' anxiety levels, eye location, and EEG alpha-band oscillations. These results advance our knowledge of the connection between anxiety levels and EEG oscillations as well as the prospective applications of neurofeedback systems in the treatment of anxiety.

2.8.5 ECG and EEG-based detection and multilevel classification of stress using machine learning for specified genders: A preliminary study.

To improve classification performance, the project intends to distinguish between mental states typical of stressful tasks and normal states, work with psychiatrists to distinguish between patients with anxiety and depression and healthy individuals, and create a meta-model. For more dependable models and applications, the study highlights how crucial it is to take gender variations in stress detection and classification into account. The study's key findings on stress detection and multilevel classification using ECG and EEG signals are as follows:

RBF-SVM and kNN achieved the highest average classification accuracy for females (79.81%) and males (73.77%) in low&high combined stress conditions. Combining ECG and EEG signals increased average classification accuracy to at least 87.58% (male, high stress) and up to 92.70% (female, high stress). kNN showed the highest average classification accuracy for low stress detection in mixed genders (69.13%), females (70.45%), and males (68.25%). The stacking technique, utilizing LR, NB, AdaBoost, kNN, RF, SVM, and RBF-SVM classifiers, outperformed individual classifiers for multilevel stress classification across genders.

The proposed models achieved an accuracy of 62.60% for females and 71.57% for males in multilevel stress classification. Overall, the study highlights the efficacy of machine learning models in detecting and classifying stress levels using physiological signals, with the integration of ECG and EEG signals enhancing classification accuracy for different stress conditions and genders.

2.8.6 EEG-Based Anxious States Classification Using Afective BCI-Based Closed Neurofeedback System

This article reviews the potential of EEG-based neurofeedback (EEG-NF) as a therapeutic intervention for treating depression, particularly in the context of the COVID-19 pandemic. The document highlights the prevalence of depression worldwide and the impact of the pandemic on people's mental health. It presents a systematic review of recent literature on EEG-NF training for treating depression, summarizing 12 studies that reported significant cognitive, clinical, and neural improvements following EEG-NF training. The article suggests that EEG-NF is worth exploring as an augmented tool for patients receiving standard medications but remain symptomatic, positioning it as an effective supplementary treatment for depression. Additionally, the document addresses the limitations of existing studies and emphasizes the need for more high-quality research to understand the efficacy of EEG-NF in treating depression.

The findings of the systematic review on EEG-based neurofeedback (EEG-NF) as a treatment for depression revealed that 12 published studies were included in the review, supporting the use of EEG-NF as an evidence-based treatment for depression. The review highlighted the potential of EEG-NF as an effective supplementary treatment for depression, with several studies showing reductions in symptoms related to depression over both short-term and long-term follow-ups. However, the evidence was noted to be limited due to the complexity of NF as an intervention, including various independent factors in the experimental design. The review emphasized the need for larger sample sizes and longer follow-up periods in future studies to better understand the efficacy and clinical effects of EEG-NF.

Additionally, it was suggested that further research comparing participants without pharmacological therapies, participants with depression, and healthy control participants is needed to gain a deeper understanding of the benefits of EEG-NF. Overall, the review shed light on how EEG-NF can be utilized as a treatment for depressive symptoms, while also highlighting the need for more comprehensive research to understand its efficacy and clinical effects.

2.8.7 "Consumer Grade EEG Measuring Sensors as Research Tools: A Review"

The main objective Consumer Grade EEG Measuring Sensors as Research Tools: A Review" is to provide an in-depth analysis of the use of consumer-grade EEG sensors in research applications. The review discusses the capabilities, limitations, and potential of these sensors in various research fields, including cognitive functions, neuroscience of gaming, and brain-to-brain synchrony. It also highlights studies that have utilized consumer-grade EEG devices for tasks such as monitoring brain activities during emotional experiences, assessing cognitive functions like attention and working memory, and exploring brainwave patterns in different scenarios. Additionally, the document addresses the challenges and opportunities associated with consumer-grade EEG sensors and suggests future directions for research in this area. [21]

In the review article "Consumer Grade EEG Measuring Sensors as Research Tools" provides valuable insights into the utilization of consumer-grade EEG sensors in various research applications. The study highlights the increasing popularity of non- invasive functional neuroimaging techniques, particularly EEG, in both academic and commercial settings. Consumer-grade EEG devices offer advantages such as affordability, portability, and ease of use, making them attractive for researchers in different fields.

2.8.8 Early Stress Detection and Analysis using EEG signals in Machine Learning Framework

The objective of the study on Early Stress Detection and Analysis using EEG signals in a Machine Learning Framework is to explore the potential of EEG signals in detecting and analyzing stress levels. The research aims to develop a novel architecture that leverages EEG signal analysis, particularly through the use of fractal dimension for feature extraction, in conjunction with machine learning processes such as Random Forest and Artificial Neural Network. By focusing on early-stage stress detection and differentiating between mild, moderate, and high stress levels, the study seeks to provide a framework for enhancing performance and coping with stress effectively. Additionally, the research aims to compare various machine learning algorithms based on accuracy, precision, and sensitivity to optimize stress detection using EEG signals.[5]

The study on Early Stress Detection and Analysis using EEG signals in a Machine Learning Framework concludes that EEG technology, combined with machine learning algorithms, holds promise for early stress detection and analysis. By utilizing EEG signals and applying advanced machine learning techniques such as Random Forest and Artificial Neural Network, the research demonstrates the potential to accurately detect and differentiate between mild, moderate, and high stress levels. The proposed system architecture offers a comprehensive approach to monitoring health and wellness, assessing treatment efficacy, and providing interventions for stress management. The incorporation of signal-processing techniques like Fast Fourier Transform or Discrete Wavelet Transform, along with statistical features derived from EEG signal analysis, is recommended to improve accuracy in stress detection. The study suggests that classification algorithms utilizing fractal dimension for feature extraction tend to yield better results, with Artificial Neural Networks (ANN) and Deep Neural Networks (DNN) outperforming classic machine learning algorithms in real-world applications.

Overall, the research highlights the significance of EEG-based stress detection and emphasizes the potential for enhancing well-being and performance through early stress intervention strategies.

2.9 Summary

This literature review examines the current research on the development of electroencephalography (EEG)-based paradigms to monitor anxiety and stress in college students, focusing on the application of the Neurosky device. The review begins with an overview of anxiety and stress in the context of higher education, highlighting their prevalence and impact on students' mental health and academic performance.

The use of EEG in psychological research is explored, emphasizing its effectiveness in measuring brain activity associated with emotional states. Key studies are reviewed to illustrate the specific brainwave patterns linked to anxiety and stress, such as increased beta and decreased alpha activity. The Neurosky device is introduced as a cost-effective, user-friendly EEG tool, suitable for both laboratory and real-world settings. Its technical

2.10 Journal Comparison from Previous Work Related to the Project

No.	Year	Journal/ Article	Title	Paradigm	Hardware/Software
1.	2015	Article	Analysis of Single-Electrode EEG Rhythms Using MATLAB to Elicit Correlation with Cognitive Stress	Cognitive Task (Visual) – Use Stroop color-word test	- NeuroSky MindWave single- electrode EEG headset. - Matlab
2.	2020	Report	The ‘threat of Scream’ paradigm: a tool for studying sustained physiological and subjective anxiety	Cognitive task (audio) - hearing aversive screams	- EEG headsets for emotion recognition - Machine learning algorithms for emotion recognition
3.	2020	Article	EEG-Based Emotion Recognition: A State-of-the-Art Review of Current Trends and Opportunities (Human Emotion)	Cognitive Task (Visual) - music, music videos, pictures, video clips, and virtual reality (VR) were used to evoke emotions in participants.	- Machine Learning Algorithms such as SVM, KNN, CNN. - EEG Headsets - Virtual Reality (VR) Devices
4.	2015	Article	EEG based Stress Monitoring	Cognitive Task (Visual) – Use Stroop color-word test. Different stress levels: resting state (most relaxed), congruent section (low stress), incongruent section 1 (mild stress), and incongruent section 2 (high stress).	Hardware: Emotiv EPOC Software: - Psychology Experiment Building Language (PEBL) - Python library that includes machine learning algorithms. The authors used this library to implement the SVM and k-NN classifiers for stress level recognition. - Emotiv API - Visual Studio 2010

5.	2024	Journal	Dissecting Stress and Anxiety Through EEG-based Deep Learning Approaches	Deep learning Process	Hardware: - GPU Acceleration: Deep learning models, such as CNN and LSTM networks. - High-Performance Computing (HPC) Systems. Software: - Deep Learning Frameworks - Signal Processing Libraries - daBoost Implementation
6.	2022	Journal	Stress recognition using Electroencephalogram (EEG) signal	Tested using the Neurosky Mindwave Mobile EEG device. The participants were exposed to two different states of mind: a calmed state and a stressed state .	Hardware - Neurosky Mindwave Mobile EEG device. Software: - Data Acquisition Software. - Signal Processing Software: MATLAB or Python
7.	2022	Article	Human state anxiety classification framework using EEG signals in response to exposure therapy.	recited scenarios to induce anxiety in the participants	- Recorded using the Emotiv EPOC wireless headse
9.	2023	Article	EEG-Based BCIs on Motor Imagery Paradigm Using Wearable Technologies: A Systematic Review	- Visual: Participants are instructed to imagine movements while their brain activity is recorded using EEG technology.	Hardware: Wearable EEG devices Software: In terms of software, signal processing algorithms, feature extraction techniques, and machine learning models are utilized to analyze EEG data and decode the user's intentions during motor imagery tasks.

10.	2022	Article	A Novel Stress State Assessment Method for College Students Based on EEG	Cognitve task (Visual) : watching Video that can be being emotional. The participant need to answer their question such as Basic Information, included stress self- evaluation items that allowed the students to self- assess their stress levels and emotional states.	Hardware: EEG Signal Acquisition Equipment. Wearable EEG Devices: non-invasive and portable monitoring of brain activity. Software: Extreme Learning Machine (ELM) and the Improved Extreme Learning Machine (IELM)
11.	2024	Article	Anxiety Controlling Application using EEG Neurofeedback System	Focuses on analyzing brain wave oscillations during relaxation and comparing the contrast between eyes open and eyes closed states to investigate the correlation between EEG band oscillations and anxiety levels in young athletes	Hardware and software: - NeuroSky Think Gear - MindCap XL - Wireless EEG Headset System
12.	2023	Article	ECG and EEG based detection and multilevel classification of stress using machine learning for specified genders: A preliminary study	Cognitive Task : stress-inducing tasks mental arithmetic tasks exposure to audio distractions cognitive challenges that are known to provoke stress reactions in individuals.	Hardware and Software: - EEG or ECG - MATLAB, Python with libraries such as sci-kit-learn, TensorFlow.

13.	2021	Article	Early Stress Detection and Analysis using EEG signals in Machine Learning Framework	The study on Early Stress Detection and Analysis using EEG signals in a Machine Learning Framework follows a research paradigm that integrates EEG signal analysis with machine learning techniques to detect and analyze stress levels. By combining advanced technologies and methodologies, the research aims to provide insights into early stress detection and intervention strategies using EEG signals within a machine learning framework	The study on Early Stress Detection and Analysis using EEG signals in a Machine Learning Framework does not explicitly mention the specific software or hardware used in the research. However, based on the methodology described in the paper, it is likely that the EEG signal analysis and machine learning processes were implemented using software tools such as MATLAB for data processing, feature extraction, and classification algorithms. In terms of hardware, EEG signals may have been acquired using EEG devices or headsets capable of capturing brainwave activity non- invasively. The research focuses on the integration of EEG signals with machine learning techniques, emphasizing the importance of the methodology and algorithms employed rather than specific software or hardware details.
14.	2020	Article	Consumer Grade EEG Measuring Sensors as Research Tools: A Review	Stress Detection: Studies have employed consumer-grade EEG sensors to detect stress levels in individuals by analyzing brainwave patterns and physiological responses. These studies have utilized features extracted from EEG data to classify stress levels with the help of machine learning algorithms.	Hardware: Consumer-Grade EEG Devices: Various consumer-grade EEG devices are discussed in the review, including products from manufacturers such as NeuroSky, Emotiv, interaXon, and OpenBCI. These devices are known for their affordability, portability, and ease of use, making them attractive for research applications.

				Mental Stress Investigation: Research groups have used consumer-grade EEG devices to record EEG data before and after activities to assess mental stress levels. Participants' self-reported stress levels were used to classify data into stressed vs. non-stressed or three stress level categories . Facial Recognition and Subconscious Mind: Visual recognition tasks have been designed to capture visual event-related potentials (ERPs) usingconsumer grade EEG sensors to investigate subconscious recognition and conscious recognition of familiar faces . Artistic Preference: Consumer grade EEG headbands have been deployed to measure EEG correlates of individuals' artistic preferences during art exhibitions. The study found unique brainwave patterns associated with participants' favorite art pieces	Portable Muse Headbands: Muse headbands were used in a study to measure EEG correlates of individuals' artistic preferences during art exhibitions. The study found unique brainwave patterns associated with participants' favorite art pieces . Software: Classification Algorithms: Studies have utilized machine learning algorithms such as support vector machine (SVM), k-nearest neighbors (kNN), Bayesian classifiers, hidden Markov models, and neural networks for data analysis and classification of EEG features related to attention, stress, and other cognitive functions . EEG Processing Software: EEG processing software tools have been used for data analysis and feature extraction in research studies involving consumer grade EEG sensors. These software tools help researchers process and interpret EEG data collected from the sensors .

specifications, including the ability to capture and process EEG signals with reasonable accuracy, are discussed.

The review also delves into previous research utilizing Neurosky to detect emotional and cognitive states, demonstrating its potential in identifying anxiety and stress. Methodologies employed in these studies, such as experimental setups, stimulus types, and data analysis techniques, are critically analyzed to inform the design of the proposed paradigm.

Finally, gaps in the existing literature are identified, particularly the need for more comprehensive studies on diverse college populations and the integration of multi-modal data to enhance the reliability of stress detection. The review concludes by outlining the proposed study's aims to address these gaps by developing a robust EEG-based paradigm using Neurosky to observe anxiety and stress in college students, thereby contributing to the development of effective interventions and support systems.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This work attempts to establish an EEG-based protocol to study stress-elicited conditions among college students by employing a NeuroSky headset. The strength of the study lies in the combination of sophisticated equipment and software with a familiar cognitive task that elicits and indexes the stress, which in turn leads to a systematic collection and interpretation of the responses.

NeuroSky headset is used as the primary means of implementing EEG capture devices mainly because of the portability, ease of use, and reliability that this headset provides to capture the brainwave activity. Real time acquisition and primary interpretation of EEG data is done using NeuroSky Experimenter Version 6.6 software. MATLAB is the main tool for data analysis on the higher level, whether on preprocessing, features computation or statistical analysis.

We then instruct participants to complete the Stroop Color-Word Test, a well-known cognitive exercise in which the participants are asked to read the color of ink in which the word is printed; often, the word and the color are conflicting or incongruous (for instance, the word “red” in blue ink). The current task was specifically chosen to elicit cognitive interference and stress; thus, the environment in which participants are situated is carefully managed for EEG data collection.

An important characteristic of the methodology as the emphasis on ethical issues. All the participants are supposed to fill consent form documenting the study objectives, activities, harms, and advantages. This is important to guarantee that people participation is voluntary and that the research exercise is conducted qualified ethically.

Using a clinically tested EEG machine, strong signal processing algorithms, and a well-validated cognitive task, this paper aims to generalize EEG patterns of anxiety and stress among college students to better understand associated emotional and cognitive responses to stressors.

3.2 Hardware

3.2.1 Neurosky Mindwave Mobile EEG headset

An EEG headset that is portable and enables real-time brainwave tracking is the NeuroSky MindWave Mobile. The human brain's electrical activity is measured by a single lead (Fp1) that is affixed to the forehead. These signals are separated into multiple bandwidths, such as beta, gamma, theta, alpha, and delta, which represent various emotional and mental

states. For instance, "Alpha waves" are associated with calm and "Beta waves" with activity and stress.

Figure 3.1 Neurosky EEG Headset

In order to comment, visualise, and update the data analysis in real-time, the gadget is portable and needs a cable to connect to a computer or mobile device. It was specifically designed to be simple: it contains moisture-type sensors that work well for both type I and type

III users and don't require conductive gel.

The NeuroSky MindWave Mobile headset is a good and efficient technique to capture brain activity connected with mental states like anxiety and stress when it comes to building an EEG-based paradigm for observing the anxiety and stress-provoking state of college students.

i. Tracking Cognitive States: Alpha waves are captured during low activity or relaxation, but beta waves are recorded during elevated mental activity, anxiety, and stress. Researchers may examine how students' brain activity varies in response to demanding tasks thanks to capabilities offered by the MindWave Mobile.

ii. Test-Induced Stress

The Stroop Color-Word Test, a cognitive test that has been shown to induce stress and cognitive interference, can actually be used by the MindWave Mobile to detect changes in real time. The beta and alpha waves that the device collects while the pupils are working on the task are among the changes that show how stressed or anxious they are during the test.

iii. Real-Time Feedback

NeuroSky MindWave Mobile's ability to provide data on meditation and attention levels in real time is another feature that sets it apart. For the overall evidence of the paradigm's effectiveness in capturing the subject's emotional and cognitive response, this allows for ongoing evaluation of the students' responses to stress-inducing stimuli and walking accountability.

iv. Portability and Accessibility

However, given that the MindWave Mobile is inexpensive, portable, and user-friendly, college students should ideally be included in research projects that make use of it. The ability to enrol a large number of people and get pertinent data without the requirement for extensive and costly equipment or the establishment of a specific setting—both of which are necessary for studies involving bigger numbers of participants—is one of the PDP's greatest advantages.

v. Practical and Ethical Considerations

MindWave Mobile's closed, inconspicuous design and relatively simple calibration make it an invaluable tool for upholding ethical standards in research, particularly when student samples are the emphasis. Additionally, the instrument facilitates effective data collection inrestricted and controlled environments, such as a lab or classroom, which makes it suitable for eliciting stress and anxiety reactions in everyday situations.

The NeuroSky MindWave Mobile headset is very beneficial for developing an EEG-based paradigm for identifying anxiety and stress-related states in college students. Because it can identify frequencies of certain brainwave bands linked to stress, it is therefore straightforward to use and portable, allowing it to record mental states in real time during task activities like the Stroop Color-Word Test. This tool can contribute to the advancement of theory and practice related to stress management and treatment by expanding our understanding of stress and anxiety within the neural arousal paradigm.

3.3 Software

3.3.1 Neurosky Experimenter Version 6.6

An application called NeuroSky Experimenter Version 6.6 is used to operate NeuroSky's brain computer interface (BCI) equipment. An electroencephalography solution called NeuroSky makes it possible to track and identify signals produced by the brain. As previously described, the Experimenter program facilitates the collection, processing, and visualisation of EEG data from various NeuroSky devices, such as the MindWave Mobile and MindWave headsets. In addition to expanding interface with other platforms for further data analysis, it has the capability for real-time visualisation of raw brainwaves, which allows one to identify various cognitive states like attentiveness and meditation.

Under such a paradigm:

i. A NeuroSky headset would be used to record the participants' (in this example, college students') brain waves in order to collect EEG-based data.

ii. Electroencephalogram activity would be collected, exhibiting low frequency alpha (found in calm) and high beta (correlated with stress and/or worry).

iii. Researchers can ascertain the impact of stress and anxiety on the body by comparing the contents of stressful activities (such as during an exam, performance, or communication).

iv. The study may concentrate on documenting the real-time manifestations of stress and anxiety, which could give the researcher insights into how these conditions affect learning and overall wellness, among other aspects.

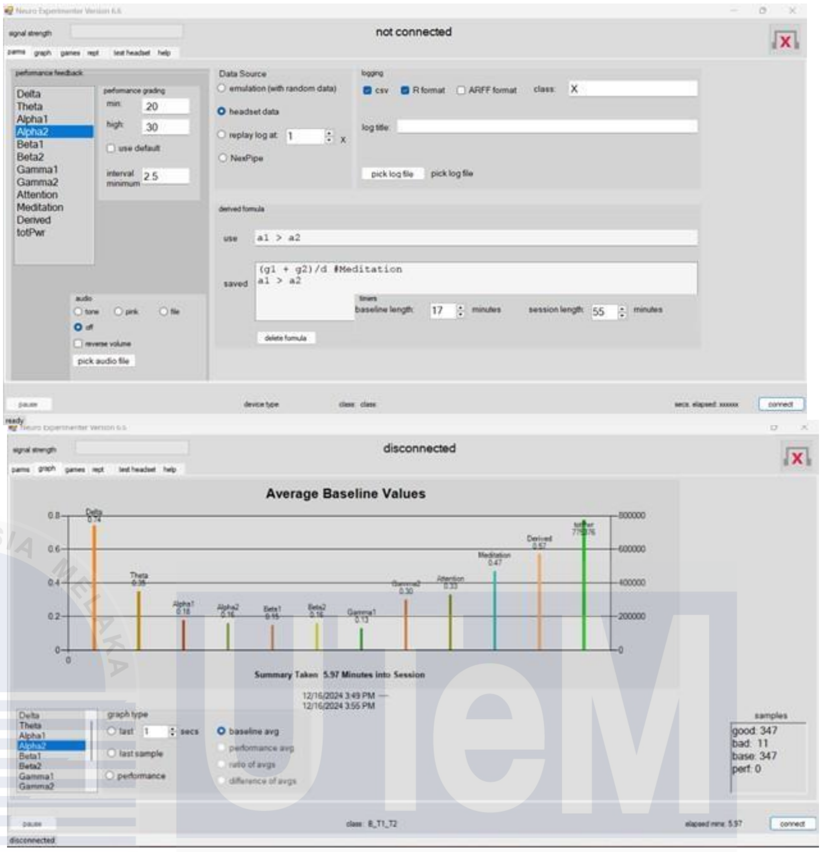


Figure 3.2 Neuroexperimenter Version 6.6

3.3.2 MATLAB

For the fields of mathematics, computers, and engineering, MATLAB is a sophisticated third-generation programming language and computing environment. All of these tools are available for functions such as graphical representation, statistics, signal processing, and matrix calculation. MATLAB is widely used in academic settings, engineering, and scientific research because of its amazing features for processing large amounts of data and performing a variety of computations. MATLAB can be utilised in a number of ways when creating an EEG-based paradigm to monitor stress-inducing and anxiety-producing conditions in college students using NeuroSky. This could involve pre-processing the signal to see if unwanted noise is removed, removing extraneous movement (such eye blinks), and structuring the data into appropriate time frames for study.Fourier Transform (FFT): The EEG signal's frequencies can be displayed using the Fourier Transform in MATLAB. This allows power in frequency bands (beta and alpha waves) to be identified.

Figure 3.3 MATLAB Software

Certain frequency bands can also be chosen by using bandpass filters. For example, filters that assist in extracting alpha waves, which have a frequency of 8–12 Hz, or beta waves, which vary from 13–30 Hz, from the raw EEG data can be used to investigate these waves. Features pertaining to stress, anxiety, etc., can be found by filtering the data. Given that the alpha and beta waves are linked to distinct emotions and even IQ levels, this may entail analysing their respective strengths. While strong beta activity is linked to an organism's wakefulness, anxieties, and stress, alpha activity is linked to rest, inactivity, and meditation. EEG data can be subjected to statistical tests and comparisons for between-condition analysis, such as stress versus relaxation activities. For instance, you could investigate if high-pressure tasks result in increased beta wave levels. Plotting functions in MATLAB can also be used to graph the data. This could comprise frequency-domain representations, such as "spectrograms or power spectral density plots," and time-domain signals, such as "raw EEG waveforms," to ascertain changes in brain activity associated with stress and anxiety. The researcher can quickly explain the participant's state during stressful activities if the EEG data is gathered in real-time and can be readily analysed in MATLAB to display the participant's brainwave activity in real-time. This could be incorporated into a stress and anxiety intervention plan or biofeedback.

3.3.3 Stroop Color Word Test

The Stroop Color-Word Test is a useful tool for evaluating a wide range of cognitive abilities, especially executive, attention, and cognitive control. It is used in both clinical and research settings. This exam provides valuable insights into people's perceptions of stimuli and multitasking abilities.

RED	YELLOW	BLUE	GREEN	BLACK
PINK	ORANGE	BROWN	GRAY	PURPLE
GREEN	GRAY	BLACK	BLUE	YELLOW
GRAY	BROWN	PINK	ORANGE	BLUE
YELLOW	RED	GREEN	BLACK	GRAY
BLACK	BROWN	PURPLE	ORANGE	PINK
PURPLE	BLACK	YELLOW	RED	GREEN
ORANGE	PINK	BROWN	GRAY	PURPLE

Figure 3.4 Stroop Color Word Test

Stroop Color-Word Test Applications:

- Evaluating Attention

  The Stroop test measures the degree of interference, and selectivity is the other stream of attention. To assess participants' capacity to focus on certain task aspects, the incongruent condition requires them to overlook the meaning of the work they read and instead focus on the taste of the ink.

  In addition to assessing automatic reactivity, it also offers components that define patience by rating the amount of time a person will be able to focus on a specific task.

- Assessing Mental Adaptability

  The ability to switch between different mental sets, concepts, or even tasks is known as cognitive flexibility. Because the individual must identify the ink's colour when presented with a word, the Stroop test reduces cognitive flexibility. The inability to switch between tasks could be a sign of executive functioning deficiencies or possibly a result of flexibility issues.

- An Examination of Mental Regulation and Cognitive Inhibition

  The Stroop test's features include the ability to assess cognitive inhibition, or the suppression of the automatism process. The brain must focus on naming the ink colour while suppressing the reading mechanism in the incongruent scenario. The ability to block out distractions and focus on the important details of a task is a key theoretical pillar of the test.

- Performing an Executive Function Check

  Cognitive processes known as self-regulation skills aid in behaviour control, decision-making, problem-solving, and foresight. These functions are also assessed using the Stroop test, which is an activity that assesses a person's capacity to restrain their own impulses.

  This is a common neuropsychological test used to evaluate for executive dysfunction in a number of contexts, including TBI, dementia, and ADHD. Particular Alzheimer's Disease and Other Dementia Diagnosis

  The Stroop test, which was created for clinical use, is a widely used diagnostic and assessment tool for cognitive disorders. Due to their difficulties with inhibition and attention control tests, people with disorders such as Attention Deficit Hyperactivity Disorder (ADHD) may exhibit specificity, a delayed reaction time, or poor performance on incongruent task.

  Changes in the Stroop test, which measures cognitive capacities in people with dementia or other neurodegenerative disorders, indicate impaired mental performance early in the course of disability. This is especially evident in the parameters of processing speed, attention, and mental control.

  An essential component of a battery of cognitive or neuropsychological tests is the Stroop Color-Word Test. Additionally, it provides helpful information about cognitive processes like inhibition, attention, and set changing. Its applicability to both patient groups and healthy individuals highlights its value in cognitive research and the differential diagnosis of illnesses that affect these processes. The Stroop test is still one of the most crucial instruments in cognitive psychology, regardless of whether it is used to examine the fundamental systems of cognition or assess the effects of neuropsychological deficiencies.

3.3.4 Consent Form

In a nutshell, informed consent is an essential ethical norm worldwide, particularly in research involving human subjects. It ensures that participation in research is voluntary and that participants are fully informed about the study's purpose, possible benefits and risks, and expected results. Obtaining consent is important for both legal compliance and research ethics, which protects participants and ensures the validity of the study. This is especially true when the investigation includes college students using instruments with psychological or physiological characteristics, like electronic EEG sensors, to measure stress and anxiety, as is seen in the current study.

The goal of reasonable informant consent is to ensure that all participants are informed about the nature of the study and the experiment being performed on them without any coercion. In actuality, it is a procedure rather than a formal exercise that is conducted to protect the participants' liberty and self-respect. Before or after the experiment, I will unavoidably inform the students of the consequences and how their participation will impact their physical and mental well-being.

Initially, voluntary participation is ensured by informed consent. In order for participants to give their free permission, they must be given complete control over their decision to participate in the study. Participants should be informed that they are free to withdraw from the study at any moment without facing any consequences. Participants must be explicitly informed that they are free to leave the study at any moment if they feel uncomfortable or decide they do not want to continue, which is especially important in research that may put them under stress or worry.

They also assist in making sure that participants are fully informed about the study's advantages and potential hazards. It is crucial to characterise any psychological influence on the participants in this experiment, where we anticipate the presence of some anxiety and stress-inducing states in the students, as an increase in stress levels or the emergence of anxiety states. Participants must be aware of the potential discomfort they may feel, even though the study may have scientific benefits, such as helping to better understand a bodily process's stress response. It's also necessary to disclose the possible benefits people might receive, such as taking part in research that could lead to stress-reduction techniques.

Involving participants in the study's goal and methodology is, of course, the third efficacy of informed consent. At the very least, they should be aware of the goals of the study, the duties they will be performing, and the procedures for collecting and processing the data. For example, students should be told what this will entail, the duration of the study, and how the data will be gathered before they are requested to wear an EEG equipment to record their brain activity during stressful activities.

The degree of confidentiality is another important consideration that should be adhered to under informed consent. People need to understand how their data will be used, handled, and protected. They should feel secure knowing that neither their identities nor their PI will be revealed in any way. As is well known, your research may collect additional private data, such as the stress and anxiety levels of your students; therefore, it is essential that you handle this data properly. In order to guarantee that all data will be anonymised and kept safe, all data must also be informed of consent forms.

Additionally, a participant should have the opportunity to ask questions during the informed consent procedure. He or she will have the freedom to ask questions about as many study-related topics as they would like. Because of this, private and/or civil participations or contributions are able to make well-informed decisions about whether or not to engage, taking into account both the potential benefits of doing so and the potential costs or losses.

It will be crucial to develop a very clear informed consent statement in order to obtain the students' consent. They should explain the experiment's goals, tasks, potential risks, and withdrawal rights in straightforward English, free of technical jargon.

Concerns about data use and the necessary data protection procedures should also be covered in the text. Once the form is complete, you should also thoroughly go over each component with the participants. Only when they have freely filled out the consent form may you demand their participation on the grounds that they have consented to it.

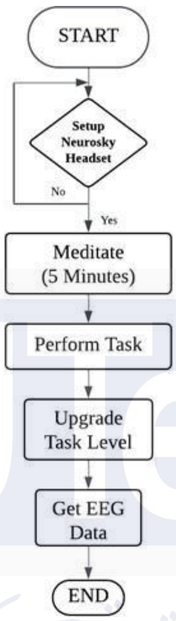
The participant's written consent serves as official confirmation that they are willing to take part in the study. Maintaining documentation of any consent forms you sign while performing research is another suggestion provided. These forms offer proof that the participant was aware of all the information prior to taking part in the study. Participants should be aware that they are free to leave at any moment and without giving a reason if they so choose. This indicates that the company respects their control over the decision-making process.

Lastly, it may be said that using informed permission is essential to carrying out moral research. It makes it possible for participants to comprehend the goals, procedures, precautions to be taken in the event of danger, and all the advantages of the study. As a result, the process of obtaining consent will safeguard participants' rights, and their involvement will always be informed and voluntary. This morally upright

Since you are experimenting with the stress and anxiety reactions of college students, practice is essential. In addition to protecting the participants, it also enhances the legitimacy and reliability of the research process and raises the degree of trust that exists between the participant and the researcher.

3.4 Project Flowchart

The flowchart outlines a methodical procedure for carrying out an EEG-based study to use the NeuroSky headgear to track stress-inducing circumstances. For optimal performance, the NeuroSky headset must be configured. To lower their initial stress levels or create a baseline of relaxation, participants meditate for five minutes after setup. Participants then carry out a predetermined task to induce tension or mental activity. The stress or cognitive load is then gradually increased for additional monitoring by making the work more difficult. Brainwave patterns during task execution are captured by EEG data obtained via the headset during the procedure. Once



the necessary data has been acquired, the procedure is complete. A controlled environment for researching stress levels is ensured by this methodical technique.

Figure 3.5 Flowchart

3.5 Project Procedure

Setting up the NeuroSky EEG headset is the first step in developing an EEG-based paradigm to track stress-inducing conditions in college students using NeuroSky and MATLAB. This involves verifying that the headset can communicate with the NeuroExperimenter software and that it is properly plugged into the laptop in order to obtain EEG data. The experiment involves the patient meditating for five minutes after everything is set up. In order to help establish a baseline for brainwave activity, the person is instructed to remain calm and relaxed during this meditation period.

Figure 3.6 Subject doing the task

After the meditation, the subject completes a task, such the Stroop Color-Word Test, designed to increase cognitive stress or involvement. The exam contains tasks with varying degrees of complexity, as indicated by the number of rows and columns, in order to gradually increase cognitive strain. EEG data is collected using NeuroExperimenter software when the task is completed. The gathered data, including brainwave data, is converted into an Excel file for further analysis. The research mostly focusses on alpha and beta waves, which indicate levels of stress or relaxation, although theta waves are also investigated for additional emotional or cognitive data. This meticulous procedure ensures precise data collection for studies on the stress responses of college students.

3.5 Calculated Theta/Beta ratio

When examining EEG signals, the theta/beta ratio is a crucial statistic for evaluating emotional and cognitive states like stress, focus, and attention. It is defined as the power of the beta frequency band (13–30 Hz), which is linked to tension and active thinking, divided by the power of the theta frequency band (4–8 Hz), which is linked to relaxation and slumber. The EEG signal is preprocessed using methods like Independent Component Analysis (ICA) to eliminate artefacts and use bandpass filters to isolate the theta and beta frequency ranges. Each frequency band's power spectral density (PSD) is calculated using techniques like Welch's approach for stable estimate or the Fast Fourier Transform (FFT). Next, the formula is used to determine the theta/beta ratio:

Theta/Beta Ratio=Pbeta/Ptheta

where Ptheta represents the theta band's power (4–8 Hz) and PbetaPis represents the beta band's power (13–30 Hz).

While a smaller ratio denotes greater cognitive engagement or focus, a higher ratio frequently denotes a state of relaxation or inattention. When examining mental states during stressful or cognitively demanding tasks, like the Stroop Color-Word Task, this statistic is particularly pertinent.

3.6 Sustainable Development Goals

Sustainable Development Goals 3 (Good Health and Well-Being) and 9 (Industry, Innovation, and Infrastructure) are closely aligned with the creation of an EEG-based paradigm to monitor stress-inducing states in college students using NeuroSky and MATLAB.

By detecting stress-inducing states in students—a crucial demographic at risk for mental health issues—this initiative helps to promote mental health and well-being. The study sheds light on how stress impacts emotional and cognitive states by tracking and analysing stress patterns using EEG technology. In the end, these findings can improve mental health outcomes by assisting in the development of early treatments, individualised stress management plans, and awareness campaigns. Additionally, the research may help students adopt better lives and prevent stress-related diseases, which would promote their general well-being.

By combining technology and neuroscience, this research demonstrates innovation by developing a scalable and effective system for stress measurement and detection. The application of cutting-edge technologies to solve practical problems is demonstrated by the use of MATLAB for sophisticated data processing and NeuroSky, an affordable EEG equipment. The creation of such a paradigm aids in the construction of technological infrastructure that can be extended for more extensive uses, including the monitoring of stress at work or the evaluation of mental health in a variety of demographics. Additionally, the project is a step towards developing biomedical engineering research and encouraging innovation that unites technology and health for the good of society.

By concentrating on these objectives, the initiative not only tackles the important problem of students' mental health but also stimulates creativity and encourages the use of sustainable, easily accessible technology to enhance wellbeing.

3.7 Summary

This chapter presents the proposed methodology to leverages the NeuroSky EEG headset to create a cost-effective and accessible means of studying anxiety and stress in a college student population. The combination of EEG data and self-reported measures provides a comprehensive view of the participants' psychological states, contributing valuable insights into the relationship between brainwave activity and stress/anxiety.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The findings of the EEG-based analysis carried out to use the NeuroSky EEG headset to observe stress-inducing states in college students are presented in this chapter. This study's main goal was to investigate the effects of stress-inducing cognitive tasks, such the Stroop Color-Word Task, on several brainwave frequencies, particularly alpha, beta, and the theta-beta ratio (TBR).

Finding patterns in brainwave activity that correlate to individuals' stress levels is the main goal of the analysis and outcomes. In particular, the link between stress states and alpha and beta waves was examined, and the theta-beta ratio was a crucial indicator for assessing the general equilibrium between cognitive effort and relaxation. To guarantee accurate waveform analysis, the data were gathered in real-time and examined using MATLAB.

The results of the EEG data analysis will be shown in this chapter together with statistical comparisons, visualisations, and descriptive statistics. The significance of these findings for comprehending stress reactions in a population of college students and the potential of EEG-based paradigms in stress detection will be examined.

4.2 Data from Neuroexperimenter Version 6.6

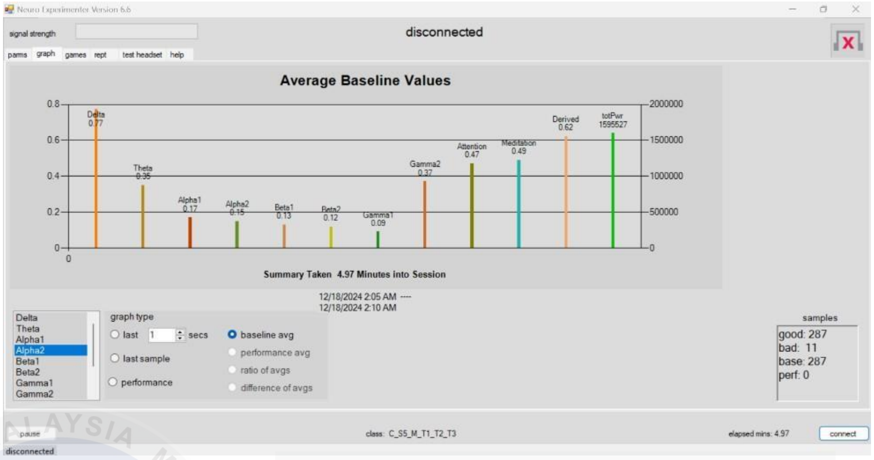
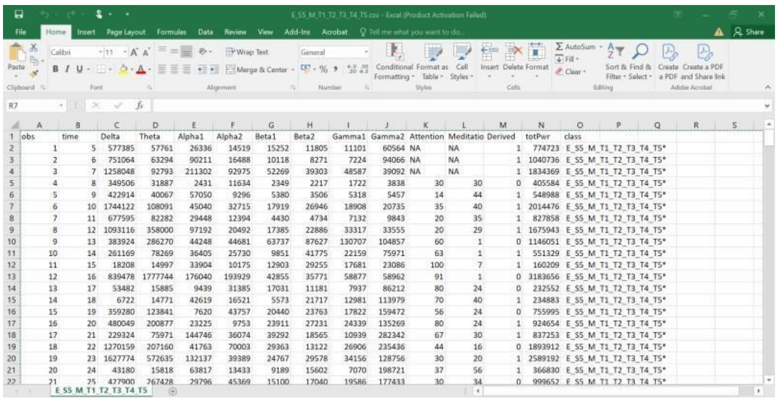


Figure 4.1 Data from NeuroExperimenter

This figure illustrates the visualization of raw ECG data using Excel. The NeuroExperimenter provided a dataset containing 45,000 data points, representing the electrical activity of the heart over time. This raw dataset is crucial for analyzing cardiac function and serves as the foundation for subsequent preprocessing and analysis steps.

4.3 Data from Excel



obs	time	Delta	Theta	Alpha1	Alpha2	Beta1	Beta2	Gamma1	Gamma2	Attention	Meditatio	Derived	totPwr	class
1	5	577385	57761	26336	14519	15252	11805	11101	60564	NA	NA	1	774723	E_S5_M_T1_T2_T3_T4_T5*
2	6	751064	63294	90211	16488	10118	8271	7224	94066	NA	NA	1	1040736	E_S5_M_T1_T2_T3_T4_T5*
3	7	1258048	92793	211302	92975	52269	39303	48587	39092	NA	NA	1	1834369	E_S5_M_T1_T2_T3_T4_T5*
4	8	349506	31887	2431	11634	2349	2217	1722	3838	30	30	0	405584	E_S5_M_T1_T2_T3_T4_T5*
5	9	422914	40067	57050	9296	5380	3506	5318	5457	14	44	1	548988	E_S5_M_T1_T2_T3_T4_T5*
6	10	1744122	108091	45040	32715	17919	26946	18908	20735	35	40	1	2014476	E_S5_M_T1_T2_T3_T4_T5*
7	11	677595	82282	29448	12394	4430	4734	7132	9843	20	35	1	827858	E_S5_M_T1_T2_T3_T4_T5*
8	12	1093116	358000	97192	20492	17385	22886	33317	33555	20	29	1	1675943	E_S5_M_T1_T2_T3_T4_T5*
9	13	383924	286270	44248	44681	63737	87627	130707	104857	60	1	0	1146051	E_S5_M_T1_T2_T3_T4_T5*
10	14	261169	78269	36405	25730	9851	41775	22159	75971	63	1	1	551329	E_S5_M_T1_T2_T3_T4_T5*
11	15	18208	14997	33904	10175	12903	29255	17681	23086	100	7	1	160209	E_S5_M_T1_T2_T3_T4_T5*
12	16	839478	1777744	176040	193929	42855	35771	58877	58962	91	1	0	3183656	E_S5_M_T1_T2_T3_T4_T5*
13	17	53482	15885	9439	31385	17031	11181	7937	86212	80	24	0	232552	E_S5_M_T1_T2_T3_T4_T5*
14	18	6722	14771	42619	16521	5573	21717	12981	113979	70	40	1	234883	E_S5_M_T1_T2_T3_T4_T5*
15	19	359280	123841	7620	43757	20440	23763	17822	159472	56	24	0	755995	E_S5_M_T1_T2_T3_T4_T5*
16	20	480049	200877	23225	9753	23911	27231	24339	135269	80	24	1	924654	E_S5_M_T1_T2_T3_T4_T5*
17	21	229324	75971	144746	36074	39292	18565	10939	282342	67	30	1	837253	E_S5_M_T1_T2_T3_T4_T5*
18	22	1270159	207160	41763	70003	29363	13122	26906	235436	44	16	0	1893912	E_S5_M_T1_T2_T3_T4_T5*
19	23	1627774	572635	132137	39389	24767	29578	34156	128756	30	20	1	2589192	E_S5_M_T1_T2_T3_T4_T5*
20	24	43180	15818	63817	13433	9189	15602	7070	198721	37	56	1	366830	E_S5_M_T1_T2_T3_T4_T5*
21	25	427900	267428	29796	45369	15100	17040	19586	177433	30	34	0	999652	E_S5_M_T1_T2_T3_T4_T5*

Figure 4.2 Data from Excel

Figure 4.2 shows the visualization of raw ECG data extracted from Excel. The dataset represents the electrical activity of the heart over time. This raw data, obtained from Excel, is crucial for analyzing cardiac function and serves as the foundation for further preprocessing and analysis steps.

4.4 Data analysis in MATLAB

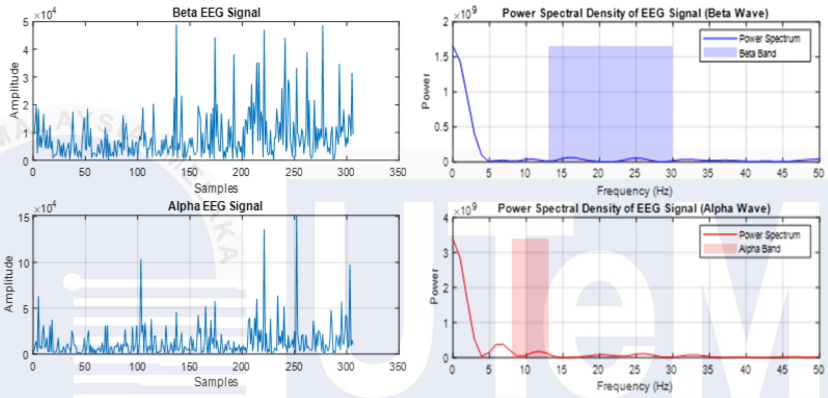


Figure 4.3 Data during Meditate

The subject's EEG data during meditation is displayed in Figure 4.3. The alpha (8–12 Hz) and beta (13–30 Hz) bands are the main focus of the power spectral density (PSD) plots. Reduced power in beta waves, which are linked to focused attention and active thought, indicates less mental activity. Alpha waves, on the other hand, which are associated with calmness and relaxation, exhibit greater power and represent a peaceful and meditative state. During meditation, this change from beta to alpha dominance indicates that the person has attained a calm mental state.

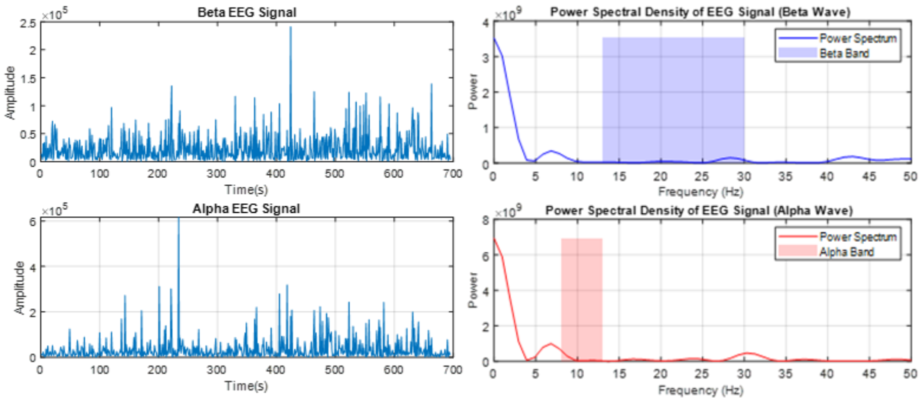


Figure 4.4 Data during task

The subject's brain activity during a task is displayed by the EEG data. Increased neuronal responses are seen by spikes in the time-domain plots. While lower alpha wave power (8–12 Hz) indicates less relaxation and higher cognitive load, high beta wave power (13–30 Hz) indicates mental involvement or tension. This demonstrates the subject's level of concentration and stress during the assignment.

4.5 Theta/Beta ratio calculation in MATLAB

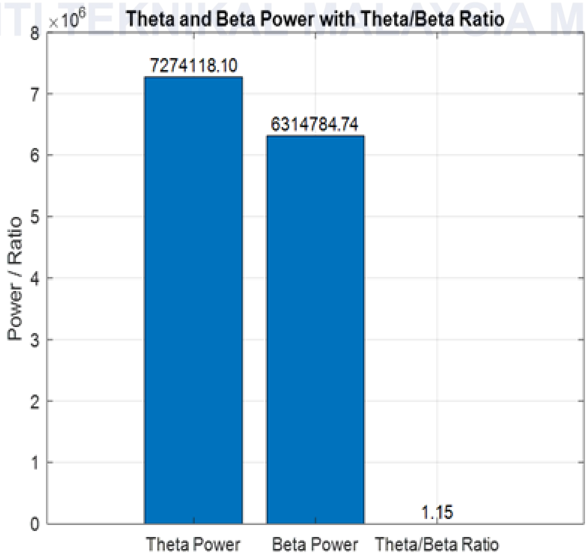


Figure 4.5 Theta/Beta Ratio during Meditate

Theta power, beta power, and the Theta/Beta ratio obtained from EEG data during meditation are contrasted in the graph. Theta power is 72,741.18, whereas 63,147.87 is the beta power. 1.15 is the Theta/Beta ratio. Given that Theta activity tends to increase relative to Beta during meditation, the subject may have been in a meditative state based on the raised Theta power and Theta/Beta ratio.

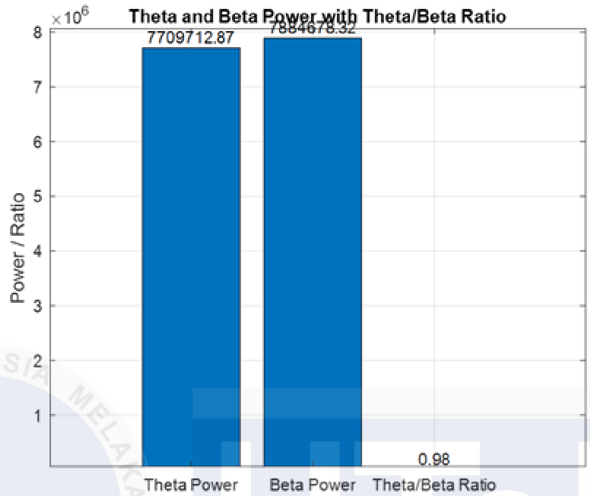


Figure 4.6 Theta/Beta ratio during Task

Theta power, beta power, and the Theta/Beta ratio obtained from EEG data are all compared in the graph. With a value of roughly 7.7 × 10^6, the first bar represents the Theta power. The beta power, represented by the second bar, is around 7.8 × 10^6 and is marginally more than the theta power. The Theta/Beta ratio, which is 0.98, is shown in the third bar. This implies that while beta power is slightly larger than theta power, the two powers are roughly equal in magnitude. A almost equal balance between the two brain wave energies is indicated by the Theta/Beta ratio of 0.98, which may be important for assessing elements such as stress levels, focus, and attention in the EEG study.

4.6 Comparative Results

WAVES	FREQUENCY	INDICATOR
Alpha	13Hz – 30Hz	Relaxation, calmness, and a meditative or restful state.
Beta	8Hz – 12 Hz	Thinking, focus, problem-solving, and sometimes stress or anxiety during heightened mental activity.
Theta	4Hz – 8 Hz	Deep relaxation, reduced alertness, creativity, and light sleep or daydreaming states. Often linked to meditative or introspective moments.

Table 1 Indicator of Brainwaves

The table lists the various brain wave frequencies along with the markers that correspond to them. Alpha waves, which range from 13 to 30 Hz, are linked to tranquility, relaxation, and a state of meditation or rest. Thinking, concentration, problem-solving, and occasionally tension or anxiety during periods of increased mental activity are all linked to beta waves (8 Hz–12 Hz).Deep relaxation, decreased attentiveness, creativity, and mild sleep or daydreaming states are all linked to theta waves (4Hz–8Hz). They are frequently associated with periods of introspection or meditation.

This data sheds light on the many emotional and cognitive states that can be connected to the different frequencies of brain waves. Comprehending these correlations can prove beneficial in situations such as clinical evaluation, performance improvement, and meditation.

	Activity	Theta/beta Ratio
Subject 1	Meditate	1.15
	Task 1	2.97
	Task 2	2.25
	Task 3	0.49
	Task 4	1.02
	Task 5	0.98
Subject 2	Meditate	1.48
	Task 1	0.18
	Task 2	0.47
	Task 3	0.75
	Task 4	1.09
	Task 5	1.23
Subject 3	Meditate	1.10
	Task 1	1.09
	Task 2	0.18
	Task 3	0.75
	Task 4	0.47
	Task 5	1.23
Subject 4	Meditate	1.12
	Task 1	0.25
	Task 2	0.52
	Task 3	0.51
	Task 4	0.96
	Task 5	0.34
Subject 5	Meditate	1.06
	Task 1	0.13
	Task 2	0.29
	Task 3	0.38
	Task 4	0.09
	Task 5	1.71

Table 2 Theta/Beta Ratio

Ranges:

i. Calmness: 1.5–4.0 (theta > beta)

ii. Stress/High Alertness: 0.5–1.5 (beta > theta)

iii. Severe Stress or Anxiety: Below 0.5 (very high beta dominance)

The table displays the theta/beta ratio of five subjects throughout various activities based on the given ranges. These subjects can be divided into three mental states: Severe Stress/Anxiety (below 0.5), Stress/High Alertness (0.5–1.5), and Calmness (1.5–4.0). Understanding how each individual reacts to different tasks and meditation is made easier by this classification.

The theta/beta ratio for Subject 1 after meditation was 1.15, which suggests a state of stress or hypervigilance as opposed to relaxation. Their ratio rose to 2.97 and 2.25, respectively, during Tasks 1 and 2, indicating a more relaxed condition. Task 3, on the other hand, caused the ratio to fall to 0.49, placing them in the severe stress/anxiety category. With ratios of 1.02 and 0.98, respectively, tasks 4 and 5 similarly demonstrated significant levels of tension and alertness. This implies that whilst certain tasks promoted mental calmness, others caused tension or anxiety. Subject 2 fell into the stress/high alertness category after meditation, with a theta/beta ratio of 1.48. With rates of 0.18 and 0.47, respectively, Task 1 and Task 2 demonstrated extreme tension or anxiety. But their mental condition somewhat improved in Task 3, where the ratio rose to 0.75—still indicating stress. With ratios of 1.09 and 1.23, Tasks 4 and 5 substantially enhanced their state, but they were still unable to achieve a state of calm. This implies that Subject 2 experienced extreme stress during the initial activities but gradually improved.

Since Subject 3's theta/beta ratio was 1.10, placing them in the stress/high alertness category, meditation did not help them relax. With a ratio of 1.09, Task 1 had a comparable outcome. Task 2, on the other hand, had a precipitous drop to 0.18, suggesting extreme tension or worry. With a ratio of 0.75, Task 3 showed a small improvement, while Task 4 caused extreme stress once more (0.47). The ratio rose to 1.23 by Task 5, indicating some respite but remaining within the range of stress and high alertness. This individual seemed to have the most difficulty with Tasks 2 and 4, which both caused a great deal of tension.

Subject 4's meditation resulted in a stress/high alertness ratio of 1.12. With values of 0.52, 0.51, and 0.96, respectively, Tasks 2, 3, and 4 demonstrated modest improvements but still fell within the stress/high alertness range, whereas Task 1 caused extreme stress (0.25). But Task 5 caused their score to plummet to 0.34, which sent them back into a state of extreme tension and worry. With very slight gains in certain tasks, this individual continuously displayed high levels of stress across all activities.With a ratio of 1.06 for Subject 5, meditation indicated stress/high alertness as opposed to relaxation. Tasks 1 through 4 had incredibly low ratios of 0.13, 0.29, 0.38, and 0.09, respectively, indicating significant tension or worry. The sole task, though, where the ratio considerably rose to 1.71 and entered the calming zone was Task 5.

This implies that although the subject was under a lot of stress during the majority of the tasks, Task 5 offered a great deal of respite.Overall, the findings show that the majority of participants did not experience a state of calm during meditation, indicating that either they were unable to effectively relax or that their mental state was influenced by outside influences. All respondents tended to experience tension or anxiety after completing tasks 1–4, with some exhibiting extremely high levels of stress. Fascinatingly, Subjects 1 and 5 found that Task 5 was more calming, achieving a theta/beta ratio inside the calmness zone, but other subjects remained stressed. This study demonstrates how different people react to different occupations and implies that while some activities may reduce stress, others may make anxiety worse.

4.7 Conclusion

The data shows different brain wave states associated with various emotional and cognitive processes. Alpha waves are a sign of a calm, peaceful state. Beta waves are linked to focused thought and problem-solving, but they can also indicate stress or anxiety. Theta waves are related with states of deep relaxation, creativity, and contemplation.This framework can be used to analyse brain activity patterns in the study and learn more about participants' mental states in different tasks or environments. For example, individuals may have higher alpha activity during meditation, higher beta during challenging problem-solving, and more theta during creative thinking.The brain wave data provides information on the neurological underpinnings of affective and cognitive experiences. Analysing these patterns can provide valuable information on the relationships among task demands, subjective moods, and brain activity. This knowledge may help contribute to analysing and conclusions about the mechanisms and implications of the study's findings.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The goal in this experiment was to investigate how EEG technology might aid in our understanding of college students' stress. We created a system to track changes in stress levels and how they can impact attention using NeuroSky. Our goal was to identify patterns that would show how stress and focus are related by concentrating on beta and alpha brainwaves. We used NeuroExperimenter version 6.6 to record the data and MATLAB to analyze it.

Participants in the study completed two straightforward yet informative tasks. To calm their minds, they first meditated for five minutes. They then completed the Stroop Color-Word Test, a well-known cognitively taxing and stress-inducing exercise. We were able to clearly see how stress and relaxation manifest in brainwave activity thanks to this two-part method. Our main focus was on alpha waves, which are frequently connected to peace and relaxation, and beta waves, which are linked to tension and mental strain.

We discovered, among other things, how beneficial meditation is for lowering stress. We noticed trends in the data that indicated participants' Alpha waves rose and their Beta waves fell when they meditated. This demonstrates that meditation actually facilitates the brain's transition to a more relaxed state, which is consistent with numerous other studies on the advantages of mindfulness exercises.

The Stroop Test provided the second important revelation. When you are asked to identify the color of a word that spells out a different color (for example, "red" printed in blue), the test is meant to cause mental conflict. It should come as no surprise that during this test, we observed an increase in beta waves, confirming that the task was stressful and cognitively demanding. Alpha waves also tended to diminish during this period, indicating that participants felt less at ease while attempting to complete the task.

The link between stress and focus was another crucial lesson learned. The data suggested that participants had greater difficulty on the Stroop Test when their stress levels (as indicated by beta waves) were higher. They either took longer to reply or made more blunders. Conversely, individuals appeared to perform better when their stress levels were lower and their Alpha waves were more noticeable, suggesting that a calmer mind may result in more focused attention.

This study demonstrates the potential value of EEG technology for stress monitoring on a larger scale. We can learn more about how stress affects people and how it affects their capacity to focus in real time by monitoring brainwave activity. There may be practical uses for this in the fields of education, mental health, and even workplace efficiency. For example, knowing these trends may enable us to create more effective stress-reduction and performance-enhancing tools or therapies.

In conclusion, this experiment demonstrates how EEG data might provide a window into college students' mental health. We learned how the Stroop Test raises stress, how meditation lowers it, and how stress affects focus. These results highlight the significance of stress management for general wellbeing as well as for enhancing focus. Future research into other brainwave patterns, stress-inducing activities, and innovative strategies for stress management and cognitive function would be fascinating.

5.2 Future Development

The research we are doing on stress and cognitive function may develop considerably in the future, advancing our knowledge of stress and how it affects all facets of life. As we incorporate cutting-edge technology, especially EEG equipment, into stress management and cognitive performance enhancement, a number of significant advancements may become apparent. The development of portable, real-time EEG equipment that can instantly assess stress levels is one exciting avenue. These gadgets might offer instant feedback by integrating sophisticated algorithms, warning users of their stress levels and facilitating prompt responses. Furthermore, using AI or machine learning models to the processing of EEG data might improve both proactive and reactive stress management strategies by enabling more precise forecasts of stress-related conditions.EEG data may be used to suggest customized stress-reduction methods as we go toward personalized wellbeing. Systems that track brainwave patterns may recommend stress-reduction techniques like mindfulness, breathing techniques, or meditation. Additionally, combining EEG with wearable technology, such as smartwatches, may enable continuous monitoring, enabling people to instantly control their stress levels while integrating into their regular activities. Stress management is essential for students to preserve concentration and cognitive function, particularly during tests or long study sessions. In this sense, EEG-based teaching resources may be extremely important, assisting students in recognizing stressful situations and directing them toward methods for regaining concentration. Additionally, systems for adaptive learning could be created, enhancing learning experiences while lowering the danger of burnout by modifying task complexity based on current stress levels.

In the future, research may help clarify the long-term impacts of stress on cognitive function and mental health, especially in educational environments. Interventions and policies targeted at promoting students' well-being may benefit from an understanding of how stress affects their skills over time. Additionally, exploring the function of various EEG markers, such theta and gamma waves, may provide a more complex understanding of the ways in which stress affects cognitive and attentional functions. Neurofeedback devices may prove to be a useful tool in therapeutic settings for teaching people stress management techniques. By monitoring and modifying brainwave activity, these technologies would give people more control over their mental health. Furthermore, EEG-guided therapies may be investigated as a possible treatment for stress-related conditions like anxiety, depression, and burnout, providing fresh hope to those who are facing these difficulties. The study of stress responses in a range of groups, including working professionals, sports, and those with mental health disorders, may be made possible by this research, which could go beyond student populations. Examining how stress presents itself differently in different age, gender, and cultural contexts may result in more inclusive and successful therapies that enhance societal well-being. EEG-based technologies have the potential to be very useful in measuring employee stress and increasing workplace productivity in professional settings. Businesses might minimize burnout, optimize workloads, and create a more supportive, healthy environment by monitoring stress responses. By detecting stressors unique to particular job types or work situations, these tools may also help employers address the underlying causes of employee stress.

To sum up, these upcoming advancements that will come from the basis of your current project have the potential to significantly improve our knowledge of stress, its impacts, and coping mechanisms. We can create a society that is more resilient to stress by combining EEG technology with individualized strategies, therapeutic interventions, and more extensive research. These developments have enormous potential to enhance mental health and cognitive function, benefiting people from all walks of life, including professionals and students.

5.3 Market Potential

There is a lot of market potential for creating an EEG-based paradigm that uses MATLAB and NeuroSky to monitor stress-inducing states in college students.Researchers, mental health professionals, and educational institutions can benefit from this solution due to the rising awareness of mental health issues among students as well as the affordability and availability of consumer-grade EEG equipment like NeuroSky. Cognitive research, early stress detection, and customized educational interventions are some examples of how the paradigm is applied. MATLAB's powerful analytics are incorporated to ensure scalability and customisation, despite the requirement to address concerns like device accuracy and data protection. Some possibilities to generate revenue include licensing the program to academics and academic institutions, integrating it with EEG equipment, and providing training services. Because of the growing need for affordable, evidence-based mental health solutions, this project has a lot of potential in both the academic and commercial sectors.

5.4 Future works

A solid basis for future research and improvements is established by the creation of an EEG-based paradigm to monitor stress-inducing conditions in college students using NeuroSky and MATLAB. The following could be included in future development for this project:

I. A bigger and more varied sample of participants, such as students from different age groups, academic fields, and cultural backgrounds, to increase the generalizability of the results.

II. Putting in place a real-time feedback system that tracks and shows participants' stress levels while they work on tasks could offer quick insights and assist participants in immediately implementing stress-reduction strategies.

III. The robustness of the system can be increased by integrating machine learning algorithms to categorize EEG signals and more accurately forecast stress levels. Additionally, these models can assist in spotting subtle stress-related patterns that conventional analysis can miss.

IV. A more thorough evaluation of stress reactions may be possible by combining EEG data with additional physiological signals, such as heart rate variability (HRV), galvanic skin response (GSR), or eye-tracking data.

V. Building on the project's results, future research can concentrate on creating individualized stress-reduction strategies, including biofeedback training or relaxation methods catered to each person's unique EEG patterns.

VI. Stress monitoring can become more widely available and useful for daily usage by broadening the paradigm to incorporate wearable EEG devices and mobile applications. VII. To further understand context-specific stress triggers, future research can examine stress responses in a wider variety of cognitive tasks or real-life situations, like academic exams, public speaking, or collaborative exercises.

VII. Longitudinal studies that track changes in stress patterns over time may offer important new perspectives on the long-term effects of academic demands and interventions on mental health.

VIII. Using this paradigm in academic contexts in collaboration with colleges and universities may have useful uses, like detecting students who may face stress-related difficulties and enhancing student support services.

IX. Cooperation, replication, and additional developments in stress and cognitive research can be promoted by establishing an open-source repository of the EEG analysis pipeline and stress-inducing task designs.

The project can develop into a flexible tool for comprehending and controlling stress by addressing these future directions, which will benefit the larger domains of education, neuroscience, and mental health.

APPENDIX

Appendix A

Appendix A Gantt Chart PSM 1

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Confirmation project’s title	PSM Briefing and The Registration						Mid TermBreak							
Introduction (Chapter 1)														
Project progress														
Update Logbook														
Research journals (Literature review)														
Methodology (Chapter 3)														
Preliminary result analysis														
Full report progress														
Presentation PSM 1														

Appendix B

Appendix A Gantt Chart PSM 2

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Development Feature extraction								Mid TermBreak						
Model testing														
Performance evaluation														
Update Logbook														
Result and Discussion (Chapter 4)														
Testing and Validation														
Result analysis														
Presentation PSM 2														
Submission of final report														

Appendix C

Coding for show EEG Data Alpha waves and Beta waves

```
clc;
clear;
% Load the EEG data
filePath = 'C:\Users\User\Downloads\DATASET\RECOVERED DATA\SUBJECT_3.xlsx'; %
Update this path
data = readtable(filePath, 'Sheet', 'BETA'); % Replace 'MEDITATION' with your
sheet name

% Display the variable names to check the columns
disp(data.Properties.VariableNames);

% Replace 'EEG_Signal' with the actual name of the EEG signal column
beta_signal_column_name = 'MEDITATE'; % Update this with the correct column name
alpha_signal_column_name = 'ALPHA1'; % Update this with the correct column name

% Ensure the BETA EEG signal is numeric
if ismember(beta_signal_column_name, data.Properties.VariableNames)
    if iscell(data.(beta_signal_column_name))
        eeg_signal1 = cell2mat(data.(beta_signal_column_name)); % Convert cell
array to numeric array if necessary
    else
        eeg_signal1 = data.(beta_signal_column_name); % Directly use if already
numeric
    end
else
    error('EEG signal1 column does not exist in the data.');
end

% Ensure the ALPHA EEG signal is numeric
if ismember(alpha_signal_column_name, data.Properties.VariableNames)
    if iscell(data.(alpha_signal_column_name))
        eeg_signal2 = cell2mat(data.(alpha_signal_column_name)); % Convert cell
array to numeric array if necessary
    else
        eeg_signal2 = data.(alpha_signal_column_name); % Directly use if already
numeric
    end
else
    error('EEG signal2 column does not exist in the data.');
end


% Preprocess the data (e.g., filtering)
sampling_rate = 250; % Sampling frequency
window_size = 1;  % Window size in seconds
overlap = 0.5;    % Overlap in seconds (optional)
num_samples = size(eeg_signal1, 1); % Total number of samples
window_samples = window_size * sampling_rate; % Samples per window
overlap_samples = overlap * sampling_rate;     % Overlap samples
step_size = 25;

% Display information for debugging
disp(['Total number of samples: ', num2str(num_samples)]);
disp(['Window size (samples): ', num2str(window_samples)]);
```

```
disp(['Overlap (samples): ', num2str(overlap_samples)]);
disp(['Step size (samples): ', num2str(step_size)]);
disp(['Length of EEG Signal 1: ', num2str(length(eeg_signal1))]);
disp(['Length of EEG Signal 2: ', num2str(length(eeg_signal2))]);

figure;
subplot(2,1,1);
plot (eeg_signal1);
xlabel('Time(s)'); % Label for x-axis
ylabel('Amplitude'); % Label for y-axis
title('Beta EEG Signal'); % Title for the plot
hold on;
subplot(2,1,2)
plot (eeg_signal2);
xlabel('Time(s)'); % Label for x-axis
ylabel('Amplitude'); % Label for y-axis
title('Alpha EEG Signal'); % Title for the plot
hold on;
grid on;


% Initialize results
stress_detection = []; % To store stress detection results
time_vector = [];       % To store time for each window
alpha_power_values = []; % To store alpha power
beta_power_values = []; % To store beta power

% Sliding window analysis
% Iterate through the EEG signal with sliding windows


for start_idx = 1:step_size:250

    end_idx = 280;

    disp(['Start Index: ', num2str(start_idx), ', End Index: ',
num2str(end_idx)]);

    % Extract windows for beta and alpha signals
    eeg_window1 = eeg_signal1(start_idx:end_idx);  % Beta signal
    eeg_window2 = eeg_signal2(start_idx:end_idx);  % Alpha signal

    % FFT for the window
    n_fft = 256;  % Zero-padding length
    Y1 = fft(eeg_window1, n_fft);  % FFT for the beta signal
    Y2 = fft(eeg_window2, n_fft);  % FFT for the alpha signal
    f = (0:n_fft-1) * (sampling_rate / n_fft);  % Frequency vector

    % Compute the beta and alpha power spectra
    power_spectrum1 = abs(Y1).^2 / n_fft;  % Power spectral density (magnitude
squared)
    power_spectrum2 = abs(Y2).^2 / n_fft;  % Power spectral density (magnitude
squared)

    % Compute alpha and beta power
    alpha_range = (f >= 8 & f <= 13);  % Alpha band (8-13 Hz)
    beta_range = (f >= 13 & f <= 30);  % Beta band (13-30 Hz)
    alpha_power = sum(power_spectrum2(alpha_range));
    beta_power = sum(power_spectrum1(beta_range));
```

```
    % Store alpha and beta power values for plotting later
    alpha_power_values = [alpha_power_values, alpha_power];
    beta_power_values = [beta_power_values, beta_power];

    % Alpha-to-beta ratio
    alpha_beta_ratio = alpha_power / beta_power;
    disp(['Window ', num2str(start_idx), ': Alpha-to-Beta Ratio = ',
num2str(alpha_beta_ratio)]);

    % Classify stress (example threshold)
    if alpha_beta_ratio < 1  % Adjust threshold based on your data
        stress_detection = [stress_detection, 1]; % Stress detected
    else
        stress_detection = [stress_detection, 0];  % No stress
    end

    % Store the midpoint time of the window
    window_midpoint = (start_idx + end_idx) / (2 * sampling_rate);
    time_vector = [time_vector, window_midpoint];
end


% Plot the stress detection results

% % Plot the power spectra
figure;
subplot(2, 1, 1);
plot(f, power_spectrum1, 'b'); % Beta power spectrum
title('Power Spectral Density of EEG Signal (Beta Wave)');
xlabel('Frequency (Hz)');
ylabel('Power');
xlim([0 50]);  % Zoom into lower frequencies for better visualization
grid on;
hold on;
fill([13 13 30 30], [0 max(power_spectrum1) max(power_spectrum1) 0], 'b',
'FaceAlpha', 0.2, 'EdgeColor', 'none');
legend('Power Spectrum','Beta Band');

subplot(2, 1, 2);
plot(f, power_spectrum2, 'r'); % Alpha power spectrum
title('Power Spectral Density of EEG Signal (Alpha Wave)');
xlabel('Frequency (Hz)');
ylabel('Power');
xlim([0 50]);  % Zoom into lower frequencies for better visualization
grid on;

hold on;
fill([8 8 13 13], [0 max(power_spectrum2) max(power_spectrum2) 0], 'r',
'FaceAlpha', 0.2, 'EdgeColor', 'none');
legend('Power Spectrum', 'Alpha Band');


if ~isempty(stress_detection)
    figure;
    plot(time_vector, stress_detection, 'LineWidth', 2, 'Color', 'b');
    xlabel('Time (s)', 'FontSize', 12);
    ylabel('Stress Detection', 'FontSize', 12);
    title('Stress Detection Over Time', 'FontSize', 14);
    ylim([-0.2, 1.2]);  % Binary output (0 = no stress, 1 = stress)
```

```
    yticks([0, 1]);
    yticklabels({'No Stress', 'Stress'});
    grid on;
else
    disp('No stress detection results to plot.');
end
```

Appendix D

Coding for show Theta/Beta ratio

```
% Load EEG data from Excel
eeg_data = readtable('C:\Users\User\Downloads\Calculate Theta Beta.xlsx'); % Load
the data
eeg_signal = eeg_data{:, 1}; % Assuming the EEG signal is in the first column
fs = 256; % Sampling frequency in Hz

% Bandpass filter for theta (4-8 Hz)
theta_band = bandpass(eeg_signal, [4 8], fs);

% Bandpass filter for beta (13-30 Hz)
beta_band = bandpass(eeg_signal, [13 30], fs);

% Compute power in each band
theta_power = bandpower(theta_band, fs, [4 8]);
beta_power = bandpower(beta_band, fs, [13 30]);

% Calculate the theta/beta ratio
theta_beta_ratio = theta_power / beta_power;

% Display the result
disp(['Theta/Beta Ratio: ', num2str(theta_beta_ratio)]);

% Plotting
figure;

% Data for plotting
data = [theta_power, beta_power, theta_beta_ratio];
labels = {'Theta Power', 'Beta Power', 'Theta/Beta Ratio'};

% Create bar graph
bar(data);
set(gca, 'XTickLabel', labels);
ylabel('Power / Ratio');
title('Theta and Beta Power with Theta/Beta Ratio');
grid on;

% Adding data labels on top of the bars
for i = 1:length(data)
    text(i, data(i), num2str(data(i), '%.2f'), 'HorizontalAlignment', 'center',
'VerticalAlignment', 'bottom');
end
```

Appendix C

Consent Form

NEUOROSKY EXPERIMENT CONSENT FORM

STEP 1: PATIENT INFORMATION

I, _______________(Patient's Name) of, ______________________________(address), _________________________(city), hereby give my consent to the following Experiment: Do the stroop color task with using Neurosky Brainwave kit.

STEP 2: MEDICAL PROVIDER INFORMATION

I hereby give consent to Nur Najwa Widad Binti Zainal, Matric No. B082110073, of JTK, FTKEK UTeM , to administer the above- mentioned experiment.

STEP 3: EMERGENCY CONTACT

Contact Name: **Relationship:**

Phone Number:

STEP 4: CONSENT AND DISCLAIMERS

I understand that there are risks associated with any experiment and that the experimenter has explained these risks to me. These may include but are not limited to. I acknowledge that no guarantees or assurances have been made to me concerning the results of this experiment.

STEP 5: SIGNATURES

By signing below, the Subject and Experimenter acknowledge that they have read and agreed to the terms of this Medical Consent Form.

PATIENT SIGNATURE: DATE:

MEDICAL PROVIDER SIGNATURE: DATE:

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