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THE EFFECTIVENESS OF ELECTROENCEPHALOGRAPHY (EEG), A BRAIN-COMPUTER INTERFACE (BCI) PLATFORM FOR CLINICAL PURPOSES

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April, 2022

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In Partial Fulfillment of the Requirements
in Practical Research 2

By

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APPROVAL SHEET

In partial fulfillment of the requirements in Practical Research 2, this study entitled **THE EFFECTIVENESS OF ELECTROENCEPHALOGRAPHY (EEG), A BRAIN-COMPUTER INTERFACE (BCI) PLATFORM FOR CLINICAL PURPOSES,** prepared and submitted by Katrina Angela Lee, Ferdinand Manteza Jr., Lovely Hans Agape, John Michael Rosaroso and Francis Dave Brina is hereby recommended for oral examination, approval and acceptance.

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Approved by the panel of examiners, after the presentation of the study with the grade of passed.

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Accepted in partial fulfillment of the requirements in Practical Research 2.

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The Researchers

ABSTRACT

This study assessed the effectiveness of Electroencephalography, a Brain-Computer Interface Platform, for clinical purposes, specifically in perceiving brain activities. The results of this study identified the different Electroencephalography types, their impacts and their level of effectiveness. The study used quantitative content analysis approach. Research articles and project reports were gathered from trusted online publications and scholarly engines that talked about Electroencephalography. The study found out that the identified Electroencephalogram types imply that EEG can be a great endeavor and an effective technology in perceiving brain activities and various brain disorders. Aside from its portrayed success and safeness, the study also discovered that Electroencephalograms are practical and intensive since it covers a wide range in neuroscience field. However, Electroencephalograms may be laborious making it costly and lavish, in order for the efficient utilization of the said device. Hence, Electroencephalograms are said to be cost-effective as they portray the favorable impacts. The study concluded that Electroencephalograms through its types, and its portrayed impacts are emphatically effective. Thus, professionals under the supervision of the device should present a thorough explanation towards patients that would utilize the certain device for perceiving brain activities for a more effective technology utilization.

Keywords: Electroencephalography, Brain-Computer Interface, Electromechanical Systems

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INTRODUCTION

Background of the Study

Modern day technology started emerging during the twentieth century and has made a substantial change in the society. At a later date, these technologies had evolved at such a prompt pace and eventually became new and advanced innovations. One of these new technologies is Electroencephalography, specifically used for the human brain (Duggal, 2021). The human brain is made up of millions of neurons that play an essential part in directing the behavior of the human body. These neurons will serve as data carriers between the human body and the brain. Understanding cognitive behavior of the brain can be accomplished through examining brain signals or visuals with the use of technology (Kumar & Bhuvaneswari, 2012). Electroencephalography (EEG) has been used to detect problems in the electrical activity of the brain that is associated with certain brain cognition, brain function, and disorders or malfunctions. It is a test that uses small metal discs (electrodes) connected to the scalp to detect electrical activity in the brain (Blocka, Lee & Yetman, 2021).

There has been a study on the application of EEG in developing countries such as Nigeria. In a hospital in Ilorin, the capital of the Nigerian state of Kwara, 142 (or 92.2 percent) of 154 patients had complete records and were analyzed. The vast majority of the patients, 84.5 percent, were under the age of 30. As the result from the breakdown of the data, 96 (67.6%) of the patients had normal EEG records, while 46 (32.4%) had aberrant EEG records. A generalized seizure was accounted for 43.5% of instances, whereas focal seizure accounted for 34.8%. Eighty percent of the tentative diagnoses were for different seizure disorders (Abiodun, Ajiboye & Ogbebor, 2017). Electroencephalography, meanwhile, is a technology employed by the Chinese to record electrical impulses in the brain. Chinese corporations are mining data directly from workers' brains by embedding wireless sensors in headgears, according to a study. The study is chock-full of interesting lines about businesses using technology to track their employees' emotions, but the reality is that these hats are unlikely to be effective (Chen, 2018). In the United States of America, a group of researchers gathered 180 signals from the brain from developing individuals using an EEG amplifier and a 63-channel EEG cap attached to the scalp in accordance with the international 10/10 system (Sase & Kitajo, 2021).

Regardless of the innumerable uses of EEG, in 2014, it was recorded through the systematic analysis of the Global Burden of Diseases study that one of the most burdensome diseases in the United States of America are neurological disorders, specifically stroke, Alzheimer’s disease and other dementia and migraine (Chin & Vora, 2014). Moreover, the burden of individual neurological disorders varied from moderate to wide range by states, and the absolute numbers of incident, prevalent and fatal cases, and disability-adjusted life-years of neurological disorders across all US states increased from 1990 to 2017 (Feigin & Vos, 2020).

On the other hand, EEG at one of the hospitals of Manila can offer much more services like EEG Asleep, EEG Awake (Sleep deprived EEG), Video Epilepsy and Neonatal EEG with video monitoring (Manila Doctors Hospital, 2018). Also, in one of the hospitals in Davao City, Electroencephalography is used for examining patients in hospital and is interpreted by an interpreter certified by the American board of clinical

Neurophysiology (Davao Doctors Hospital, 2016). Unfortunately, limited information was elucidated, due to the scars of sources – hospitals that offer EEG services.

Despite the demand of Electroencephalograms in inputting brain activities and abnormalities, over the last 25 years, the number of persons affected by, dying from, or remaining incapacitated as a result of neurological illnesses has risen internationally. Due to the rise in neurologic illnesses and the ever-evolving era of technology, brain computer interfaces have become progressively prevalent. However, there is a clear lack of strong research that specifically examines the efficiency of the electroencephalograms invented, usually only focusing on the usage of the said type. Relative to this, the researchers wanted to assess the effectiveness of Electroencephalogram (EEG), a brain-computer interface platform, for perceiving brain activities.

Statement of the Problem

This study aimed to assess the effectiveness of Electroencephalography as brain-computer interface platform for humans especially with a wide range of clinical disorders.

In particular, the following questions were addressed:

1. What are the frequently utilized Electroencephalography tests in perceiving brain activities?
2. What are the effects of Electroencephalogram types in perceiving brain activities?
3. What is the level of effectivity of Electroencephalography in perceiving brain activities?

Review of Related Literature

This portion covers a variety of literature and studies that are related to the present study. Hence, studies regarding the importance of brain-computer interfaces, specifically Electroencephalography, are then discussed. Further, status, impact and challenges of Electroencephalography in perceiving brain activities are addressed in this section.

Brain-Computer Interface and its Developments

The human brain has been said to be the most daunting human organ compared to a high-performance and sophisticated machine where none has succeeded in recreating and simulating its entire structure until now. Then, brain-computer interfaces (BCIs) that are non-invasive version, based on electroencephalography, recently began a very rapid advancement in medicine and information technology and their combination (Sterniuk, et al.. 2021). Brain-machine interfaces (BCIs) collect, interpret brain impulses and translate them into commands related to the performer's outputs. Natural neuromuscular production channels are not used by BCIs. The primary purpose of the BCI is for individuals with neuromuscular conditions, such as amyotrophic lateral sclerosis, brain paralysis, stroke, or spinal cord injury, to replace or return helpful function. Researchers have used electroencephalographic, intracortical, electrocorticographic and other brain impulses to monitor, cursors, robotic arms, prosthetics, wheelchairs, and other instruments based on initial demonstrations of electroencephalographic and neuro-based interface control. Interfaces with brain processors can also prove useful for post-stroke therapy and other conditions (Shih, Krusienik & Wolaw, 2012).

Invasive and non-invasive devices may be distinguished from BCIs. Normally, data that are transmitted in real time represents for any kind of BCI shared information from brain to computer or for some other interface that is part of BCI scheme. Any brain function needs to be directly or indirectly measured for this reason. Direct connection means measurement of electrical activity the brain generates (e.g., EEG), while indirect connection can be performed through: blood oxygen measurements, functional resonance imaging (FMRI), functional infrared spectroscopy (FNIRS), etc. (Sterniuk, et al., 2021). In the 1960s, the first human BCI study was performed. Via electroencephalography (EEG) method, subjects were provided with the ability to control a slide machine, which also measures brain waves as demonstrated in the research. While this study was the start of a full research emphasis, the BCI name was still not adopted at that time. In the 1970s the word brain-computer interface was born (Brainmab, 2018).

In addition, the invention and electrical activity of Hans Berger on 1924 in human brain research was very similar to the development of brain-computer interfaces. The evolution of electroencephalography is recognized by Berger, who marked a significant accomplishment for humans and helped researchers document human brain activity. This was a significant discovery in human brain mapping that enabled brain disorders to be identified. Berger was influenced by the observation by Canton of electrical signals in animal brains in 1875. The EEG neurofeedback has been used for many decades as one of the first popular applications of brain-computer interface technology (Brain Vision UK, 2014). As BCIs continued to develop, it became very popular in neurorehabilitation of sensory and motor disabilities, neuro-communication, cognitive state evaluation, etc. in the present time. In addition, this technology is top to trend in terms of new innovations and is studied by many.

Significance of Perceiving Brain Activities

The brain is challenging to study not only because of its inherent complexity: billions of neurons, hundreds or thousands of different types of neurons, trillions of connections. The brain also operates on a variety of scales, both physically and in terms of time (Chirimuuta, 2018). Every second of the day, the brain is buzzing with activity. Neurons send information over a tiny distance between them, causing electrical messages to propagate across enormous networks and causing your brain to perform what it does. If that signaling pathway fails for whatever reason, it might result in difficulties such as brain abnormalities or diseases (O'Connell, 2015).

Because many critical activities rely on the brain's ability to sense the dynamically changing environment, neuronal systems must detect and process external stimuli accurately under a wide range of operational conditions. Indeed, a recurring theme in research is that overall neural activity in every given condition is important for understanding brain function, from rest to activation. Future research should investigate whether the same phenomena occur in the cerebral cortex, which has a very different neural composition than the olfactory bulb. Despite the fact that both awake humans and anesthetized animals exhibit this phenomenon, how anesthetics (which are used to vary the baseline) affects various brain regions should be studied more specifically, because anesthesia directly affects thalamic structures that innervate the cerebral cortex but not the olfactory bulb (Hyder & Rothman, 2011).

To summarize, neuroscientists must come down on the side of baseline neuronal activity (or energy) and account for it in absolute terms using methods such as EEG monitoring and others in order to perceive better quantitative neuroimaging of brain function. However, whether total neuronal activity (or energy) during job or the difference from rest is more important for understanding brain function is a critical subject (Li, Gong, & Xu, 2011).

The study of Ozdemir et al. (2014) showed that Electroencephalogram under the sleep deprived test can increase the probability of detecting epileptiform discharge. In addition, the researchers stated that Electroencephalograms has been used for differential diagnosis of mental disorders making it one of the successful types of Brain-Computer Interfaces ever invented. The study of Hsu and Wang (2013) also supported this impact as they stated that EEGs are the most effective power indexes for the visual fatigue measure.

Meanwhile, the study of Hsu and Wang (2013) focused on the evaluation of EEG's effectiveness in measuring visual fatigue and the results showed the safeness of EEG with the affirmation that EEGs are effective for measuring visual fatigue, may it be in short and long durations. Studies of Odzemir, et al. (2014), Hsu and Wang (2013), and Holler, et al. (2017) revealed that Electroencephalograms are extensive. However, in the study of Odzemir, et al. (2014), it was stated that Electroencephalograms are the most important diagnostic tool for diseases. In the second study that supports the impact, it was shown that EEGs are used as the ultimate test in the differential diagnosis between brain disorders associated with the intermittent or paroxysmal disturbances that resemble epileptic seizures. In addition to the above mentioned, it was found out in the study of Holler, et al.

(2017) that the measures of interaction of the EEG are at the forefront of current neuroscientific research, making electroencephalography extensive.

On the other hand, it has been said by Vance et al. (2014) that Electroencephalograms can be used to track the electrical activity of the brain over time. It has also become practical in a way that these are used to determine the frequency of ictal events and other disorders in the brain. For instance, in seizure, it was confirmed by the study that EEGs are useful for determining the degree of alteration of consciousness. Electroencephalograms time requirement may be short-term or long term, but most of the EEG requires less time. This impact is supported by the study of Estraneo et al. (2016) stating that Standard EEG recording is done meticulously and usually lasts an hour. The patient may be asked to do a sleep-deprived EEG, which requires them to have only 4 hours of sleep. Abnormal brain waves may appear when the body is stressed or fatigued. This exam usually takes 2 to 3 hours.

Benefits of Electroencephalography in Perceiving Brain Activities

An electroencephalogram (EEG) is a noninvasive test that can be used to track the electrical activity of the brain over time (Vance, Anderson, Kirwan, & Eargle, 2014). There are roughly 86 billion neurons in the human brain (Voytek, 2013). The EEG records the sum of the electrical activity coming from neurons, as well as the changes in activity over time, by inserting electrodes around the scalp. It changes in action potentials and postsynaptic potentials, which are generated by a variety of causes, cause energy variations. EEGs are helpful in medicine because they can detect areas of brain injury. They can also be utilized to aid in the diagnosis of epilepsy patients (Beres, 2017).

Electroencephalography (EEG) is the most important diagnostic tool for investigating patients with clinically-suspected epilepsy. EEG abnormalities, which are seen as spikes, or sharp waves, spike and slow-wave complexes, polyspike, and slow-wave complexes, indicate epileptic seizures that are related to present psychiatric disorders (Putz & Riedl, 2015). But in contrast to the previous findings, Hrishikesan (2018) said that certain limitations of an EEG's ability to monitor brain waves much below the higher levels of the brain is one of its limitations. They also have low signal-to-noise ratios and cannot be used to pinpoint medication and neurotransmitter locations in the brain. It is hard to figure out where in the brain the electrical activity is coming from.

EEGs are effective in that they are far simpler and more efficient to operate than other brain imaging technologies like fMRIs and PET scans. Although, the imaging they provide is less detailed, they show the total of all action potentials in a general area of the brain, depending on where the electrode is put. As a result, pinpointing the particular spot where activity is generated is more difficult (Gable, Paul, Pourtois, & Burgdorf, 2021).

Current Status of Electroencephalography

The emerging field of affective computing focuses on enhancing computers' ability to understand and appropriately respond to people's affective states in human-computer interactions, and has revealed significant potential for a wide spectrum of applications. Recently, the electroencephalography (EEG) based affective computing has gained increasing interest for its good balance between mechanistic exploration and real-world practical application (Hu, Chen, Wang, & Zhang, 2019).

EEGs have expanded and made significant scientific advancements, and these are now one of the most effective functional tools for mapping the human brain. Most technology literates are aware that is a painless test that examines the electrical activity of the brain by connecting electrodes to the head and recording electrical activity (Cinel, Valeriani & Poli). It is capable of detecting abnormal brain waves following head injuries, diseases, seizures, strokes, or brain tumors. BCI-EGG applications have been investigated in a variety of domains, including communication, robotics, and mobility control, as well as neuro-prosthetics (College of Engineering, Carnegie Mellon University, 2020).

In 2020, it has been found that EEG, particularly continuous EEG, may play a predictive role in Covid19. COVID-19 central nervous system (CNS) signs were discovered early in the epidemic. Researchers in China observed neurologic signs and symptoms in up to 25% of patients very early on. Neurologic manifestations documented to date are diverse and can affect the nervous system in a variety of ways. Encephalopathy, stroke, anosmia/dysgeusia, dizziness, headache, Guillen-Barre Syndrome, Miller Fisher Syndrome, skeletal muscle injury/myalgia, seizures, and acute hemorrhagic necrotizing encephalopathy have all been reported. A range of epileptic phenotypes, including new-onset seizure, convulsive seizure, myoclonic seizures, status epilepticus, and new-onset refractory status epilepticus, have also been described (NORSE) (Dougherty, 2020).

Today, the electroencephalography (EEG) devices market is poised to grow by USD 444.18 million during 2021-2025, progressing at a CAGR of over 9%. The market is driven by the increasing prevalence of neurological disorders, growing demand for EEG procedures, and increasing initiatives and support from governments and healthcare organizations. However, the substitute products hinder the growth of the market.

Conversely, growth potential in developing nation is expected to serve as a lucrative opportunity for the Global EEG market during the forecast period (Data Bridge Market Research, 2021).

Challenges Faced by Electroencephalography in Perceiving Brain Activities

Changes in brain activity may be detected with an EEG, which can be used to diagnose brain illnesses and uncover possible treatments. It is also used to confirm brain death in those who are in comas, as well as continuous EEG to determine the appropriate amount of anesthesia. This sounds excellent, however there have been multiple incidences of EEG misunderstanding, like the result in epilepsy misdiagnosis (Benbadis, 2013).

Many patients with non-epileptic diseases, such as syncope and PNES, receive the mistaken diagnosis of epilepsy, which is perpetuated by the misinterpretation of benign EEG patterns, (Winesett & Benbadis, 2011). Previous EEGs that were regarded as epileptiform in one-third of the patients later revealed to have PNES contributed to the misdiagnosis (Jing, et al., 2020). The majority of the misread patterns were simple variations of highly contoured background rhythms or fragmented alpha wave activity (Stafstrom & Carmant, 2015).

Misreading EEGs has a slew of negative repercussions. For starters, it may make it more difficult to get the right diagnosis. It is tough to erase a diagnosis after it has been 'tagged' on a patient. It necessitates collecting the original EEG and reinterpreting it, and the longer the PNES diagnosis takes, the worse the prognosis (Amin & Benbadis, 2019). One cause is the widespread belief that phase reversals, a sharp activity that points toward each other, are harmful. Second, straining too hard to discover an abnormality because the patient had a seizure, fear of missing an abnormality, or just inexperience in interpreting EEGs are all reasons why this is not true; it only signals localization of a negative discharge, much of which is normal events (Frau & Benbadis, 2011).

Electroencephalography can be labor-intensive according to Stern and Engel (2012). Its processes put a heavy burden on neurologists and it usually affects their performance. The methods of Electroencephalograms are laborious as it requires a specialized technical and clinical expertise to place the electrodes unto the sculp, guarantee patient safety in the recording unit and for the inputting ang interpretation of the data obtained. Also, Electroencephalograms as costly are verified by the current study of Plos One (2021) where in a high model order is recommended for a more reliable outcome. As an EEG system is straightforward and its cost is driven up significantly due to the materials (electronics, amplifiers and electrodes), professional assistance, and other diagnosis conditions are required. But despite that, it is cost-effective in many circumstances (reliability, success, and safeness). Electroencephalograms may have portrayed favorable impacts but its difficulties more to as challenges are also present. This impact is supported by the study of Jing et al. (2020) that several patients receive the mistaken diagnosis of epilepsy, which is perpetuated by the misinterpretation of benign EEG patterns.

Processes and Methods of Electroencephalography (EEG)

For ergonomic investigations, brain monitoring should be reliable, sensitive, unobtrusive, and cost-effective, with a high temporal resolution. All of these characteristics are met by the EEG approach, which also holds promise for successful capacity in more difficult real-world situations (Sawyer, Karwowski, Xanthopoulis, & Hancock 2017). Five well-known methods and types are furtherly discussed in the next paragraphs.

The first method is the Fast Fourier Transform (FFT) method. In this method, the EEG data are analyzed using mathematical tools. Power spectral density (PSD) estimation is used to determine the characteristics of the acquired EEG signal to be analyzed. In order to calculate the PSD, nonparametric methods estimate the autocorrelation sequence, which is then Fourier transformed to obtain the PSD. Another method is Welch's method, which has been around for a long time. A modified periodogram is created by applying the data sequence to the windowing of the data (Al-Fahoum & Al-Fraihat, 2014).

This is followed by the Wavelet Transform (WT) method. A Wavelet Transform (WT) is a spectral estimation technique that can express any general function as an infinite series of wavelets, which is the best way to extract features from raw EEG data due to the nonstationary nature of EEG signals. Due to WT's ability to use variable-sized windows, it provides a more flexible way to represent a signal's time-frequency. WT long time windows are used to get a finer low-frequency resolution, while short time windows are used to get high-frequency information (Oliveira, Reversat, & Reynoso, 2019).

Another method used is Eigenvectors. When artifacts dominate measurements, these methods are used to calculate the frequency and power of signals. Even artifact-corrupted signals can be correlated using these methods because of the Eigen decomposition capability. Eigenvector methods can be found in a variety of forms, including Pisarenko's Method; MUSIC Method; and the minimum-norm method (Dawkins, 2020). Pisarenko's method is used to evaluate power spectral density (PSD) and is among the available eigenvector approaches (Gutierrez, 2019). MUSIC method eliminates false zero difficulties by using the spectra's average equivalent to the artifact subspace of all eigenvectors (Awang, Paulraj, & Yaacob, 2012). Lastly, to generate a desired noise subspace vector from either the noise or signal subspace eigenvectors, the minimum-norm method creates bogus zeros in the unit circle to differentiate them from genuine zeros. Minimal-norm technique selects a linear combination of all noise subspace eigenvectors (Al-Fahoum & Al-Fraihat, 2014).

The fourth method is the Time-Frequency Distributions, these approaches require noiseless signals. As a result, a relatively limited preprocessing stage is required to remove all types of artifacts. Because time-frequency approaches deal with the stationary principle, the preprocessing module must include a windowing procedure (Shao, et al., 2019). The last method is the autoregressive method. Using a parametric approach, autoregressive (AR) approaches assess the EEG's power spectrum density (PSD). As a result, unlike nonparametric approaches, AR methods do not suffer from spectral leakage and hence provide superior frequency resolution. PSD estimation is accomplished by determining the coefficients, or parameters, of the linear system in question (Glen, 2015).

A total of five of the most popular frequency domain and time-frequency domain methods were examined. There are advantages and disadvantages to each method that make it suitable for certain types of signals. For some EEG signals, frequency domain methods may not be as effective as they could be. However, time-frequency methods may not provide as much information on EEG analysis as frequency domain methods do. When discussing the performance of an analyzing method, it is crucial to specify the type of signal to be analyzed. As a result, the optimal method for each application may vary.

Standard Electroencephalography Test can complement behavioral diagnosis of disorders of consciousness. This is done usually in clinics and lasts for at least an hour or three. Standardized EEG electrode placements are critical for clinical and research purposes. This guideline's goal is to update and expand the unified terminology and uniform positioning for EEG scalp electrodes. The electrode placements were determined using 20% and 10% of standardized measurements taken from anatomical landmarks on the head, respectively (Estraneo, et al., 2016).

A sleep-deprived-EEG method is necessary, which involves keeping the patient awake for all or part of the preceding night and recording EEG for a longer amount of time. In such cases, EEG during sleep deprivation can improve the likelihood of identifying epileptiform discharges. Sleep-deprived EEG may also be effective in detecting endogenous electrophysiological abnormalities. As a result, in the psychiatry clinic, this method has been employed for differential diagnosis of mental diseases (Ozdemir, Aydin, Milanlioglu, & Yilmaz, 2014).

The ultimate test in the differential diagnosis of epilepsy and other illnesses associated with intermittent or paroxysmal abnormalities that resemble epileptic episodes is Video Electroencephalogram Monitoring. VEM is very beneficial for separating focal seizures from generalized seizures based on ictal EEG characteristics. It is critical to differentiate between the various epileptic causes of temporary loss of consciousness, which can be a standard absence seizure, an atypical absence seizure, or a focal seizure marked exclusively by reduced consciousness (Stern & Engel, 2012).

To sum up, EEG was created in purpose of providing an effective neurologic tool to detect brain disorders and illness. Most notably, EEG's development in the medical field has been significant. It was able to map the brain and record brain waves to detect potential seizures and spikes that could signal brain injuries, disorders or diseases. Most of the data mentioned above imply that Electroencephalography is beneficial in the clinical field.

Some data presented have also explained the problems and issues dealt by the device. Relative to this, the researches yearn for assessing the effectiveness of Electroencephalography through identifying its types and these type's portrayed impacts.

Theoretical Framework

In the 1920's, a German psychiatrist, Hans Berger, demonstrated that human brains generated electric currents. He added that these currents reflected brain activity and could be measured on the sculp using electrodes. Through this he presented the idea of Electroencephalography. EEG proved to be a critical neuroscience tool for understanding or diagnosing neuro-pathologies, particularly the study of cognitive functions and their neurological correlates. The idea of Berger that the measuring of brain activity through the use of electrodes could be used as a communication medium or information carrier within a brain and a computer and vice versa also quickly arose with the idea that development of Electroencephalograms should be continued and evaluated over time (Lotte, Nam, & Nijholt, 2017).

In this, the effectiveness of Electroencephalography in perceiving brain activities is the one being focused. The types of Electroencephalography variable amount to the concept of Berger's theory regarding Electroencephalography's developments. Thus, if such types are evaluated and have impacted the usage and development of Electroencephalograms over time, this may result in a more commendatory effect with regard to the communication medium or information carrier within a brain and a computer.

Conceptual Framework

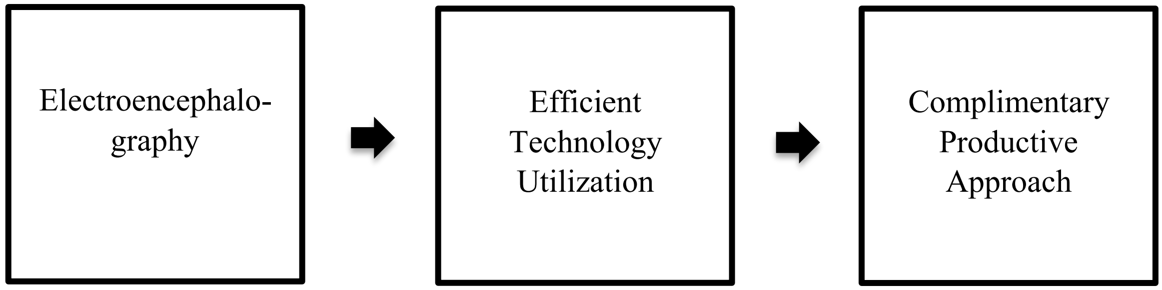

Figure1. Conceptual Framework

Shown in figure 1 is the conceptual framework of this study. Electroencephalography and its identified types were assessed and evaluated, through its given portrayed impacts. With the impacts identified and with the result of Electroencephalography's level of effectiveness, a more efficient utilization of the said technology was suggested resulting in a complimentary productive approach within the technology, the medical/clinical field and also with the public.

Significance of the Study

The findings of this study will redound to the benefit of society considering that electroencephalography plays an important role in science and technology today. Aside from it is timely, this study can be a significant endeavor in evaluating the efficiency of electroencephalogram types and other sort of brain-computer interface technologies. This study will be beneficial to the following: medical practitioners as they will be the first hand in promoting the technology to their patients and also people dealing with conditions of the brain including inflammation, injury, as well as psychiatric disorders, epilepsy, and seizures. Groups dealing with neurological diseases can also analyze this type of Electroencephalography's safeness and could possibly decide to what sort of

Electroencephalogram should they utilize in the future. This study will also concern patients who are suffering from brain disorders whom not yet diagnosed. The study will also be a benefit to medical schools in the country, especially those departments that deal with neuroscience and technology for they can advertise Electroencephalography (which is not that well known in local communities) to aspiring doctors and that they can appreciate, use, and even develop such technology. Government agencies and other organizations like the Department of Health and Department of Science and Technology (DOST) will also benefit from the study as they can be the lead advocates in educating the general public about Electroencephalography and its effectiveness.

Moreover, this will be beneficial to technology developers especially those who are concerned with brain-computer interface platforms specifically Electroencephalography. This will serve as a guide in identifying as to which component is better for any technological development for Electroencephalograms, and lastly, this study would serve as references for future researchers as they conduct similar or comparative study that may involve Electroencephalography types and other sort of brain-computer interface platforms.

Scope and Limitations

The study is focused on assessing the effectiveness of Electroencephalography, as brain-computer interface platform, in perceiving brain activities. The study will focus on the most common and frequently utilized types of Electroencephalograms. Other types of Electroencephalograms may be partially included but deeper information about these types were not examined further. This study is only to determine the effectiveness and efficiency of Electroencephalogram. Hence, other aspects not related to Electroencephalogram types were not included.

The sample used in analyzing was limited in the past 10 years backwards, from 2021 to 2011. Any study and other information that range in 2010 and below are not mentioned. The types of articles gathered were research articles and project reports from the internet, chosen from reliable and verified sources. These came from scholarly engines (google scholar, science gov, etc.), conference proceedings publications (PubMed National Library of Medicine-NCBI, Institute of Electrical and Electronics Engineers-IEEE etc.) for research articles. Only certain and important parts of the research articles gathered were used by the researchers as sample for the study. These parts are; Abstract, Results, Discussion, and Conclusion.

Definition of Terms

Throughout the course of the study, the researcher utilized scientific terminologies and instruments. To strengthen the rationality and value of this study, the following terms were operationally defined:

Brain-Computer Interface	- are hybrid entities where nerve cells establish a close physical interaction allowing the transfer of information in one or both computer directions.
Electroencephalogram (EEG)	- is a test that detects electrical activity in the brain using small, metal discs (electrodes) attached to the scalp.
Electromechanical	- are integrated mechanical elements, sensors, actuators, and

Systems electronics that are fabricated using microfabrication technology similar to that used for integrated circuits.

Theme **-** the result of classifying, categorizing, and evaluating sets of related words or concepts within the text samples under examination.

Coding - is the process by which researchers categorize and analyze words, phrases, and concepts within a collection of article samples indicated in the scope of the study using the set coding standards.

Chapter 2

METHODS

In this section, the research methods are discussed. This explains the research design, ethical considerations and data analysis including the sampling frame, unit of analysis, and coding and procedure scheme.

Research Design

Quantitative content analysis in particular is a research method that is opposed to the qualitative content analysis (Coe & Scacco, 2017). In conducting this research method, general research process of quantitative inquiries should be followed. Hence, the most important part is the construction of the coding and procedure scheme, sampling frame, and a thorough instruction for identifying and classifying the units of analysis (Quantitative Methods, 2014).

This study made use of quantitative content analysis research design, whereas the study's primary concern is interpreting and comprehending. The researchers focused on counting and measuring, which are often in the form of word frequencies based on established coding standards. The researchers addressed the research questions by coding and analyzing texts from the gathered research articles related to the effectiveness of Electroencephalogram (EEG), a brain-computer interface platform, for perceiving brain activities.

Ethical Considerations

Ethical consideration is an ethical component in conducting research. Given the importance of the ethics for the conduct of research, many have used these codes relating to research ethics. These codes are: the welfare of research subjects, privacy rights, confidentiality, anonymity, avoidance of subterfuge about the study's intent, accountability, truthful contact, and avoidance of false information and data findings. It is important to adhere ethical norms in research for it promotes the aims of the research itself (Resnik, 2020).

In this regard, the researchers secured such characteristics by not naming the authors of the articles gathered. This is to ensure the anonymity and confidentiality of the authors of the studies involved in data analysis. The researchers considered all authors' privacy, ensuring that none of the authors' names or the identities of other people involved in the research were revealed and their identity hidden in the answered coding sheets. Furthermore, any firms referenced in the texts were not identified. The researchers instead used aliases or code names. Thus, the researchers acquired these ethical norms mentioned while gathering different mediums used as samples from different authors.

Sampling Frame

The sampling frame is used as a sampling basis and generally is any collection, material or system which delimits, defines, and allows access to the research elements (CROS, 2019). The researchers made use of the random sampling technique wherein each sample has an equal probability of being chosen without any biases. Through-out the study, the researchers gathered 5 to 10 researches or articles used as basis for assessing the effectiveness of Electroencephalogram (EEG), as brain-computer interface platform, for perceiving brain activities, which came from reliable online media sources like google scholar engine and science direct. These studies were all about Electroencephalography (EEG). The samples covered the time period from 2011 to present. This time frame was selected because between these years, Electroencephalography started to gain more attention, wherein studies and researches about EEG became relevant and 10-year period is sufficient to assess the effectiveness of Electroencephalogram (EEG), a brain-computer interface platform, for perceiving brain activities.

Unit of Analysis

The unit of analysis is one of the most important concepts in content analysis type of research. This refers to the primary entity that researchers are analyzing throughout the study. The various forms of unit analysis that may be used in a study include the following: individuals, groups of people, objects such as photographs, newspapers and books, geographical unit based on parameters such as cities or countries and social parameters (Trochim, 2020).

In this study, the unit of analysis are the research samples about Electroencephalography (EEG), its impacts and types in perceiving brain activities that were found online. Only certain and important parts of the research articles gathered were used by the researchers as samples for the study. These parts are; Abstract, Results, Discussion, and Conclusion. The researchers analyzed the research samples in order to get the ideas each sample brings. Coding sheet with separate classifications was utilized in evaluating the fundamental thoughts about each example. In addition, frequency table was made to distinguish the frequencies of words among the samples that are connected to depicting the effectiveness of Electroencephalography (EEG), a brain-computer interface platform, for perceiving brain activities. This further assisted the researchers with interpreting the fundamental thoughts about each research sample.

Coding and Procedure Scheme

As the researchers reviewed the research samples, the research questions made by the researchers were considered for the identification of what will be answered, thus, related topics about the questions were considered. As samples, five to ten research publications and project reports were employed in this study. The codes were key words or phrases. Codes with similar situations or concepts were grouped to form a theme. The frequency column was filled with the number of recognized codes that comprised each theme. The researchers used a coding sheet with word frequency tables in order to code and analyze each of the chosen research samples. The researchers assigned words and phrases and were then categorized in a segment of the data by topic as to what research question they relate to. Refer to the sample table below.

Table 1. Sample Coding Sheet 1

Sample No.	EEG Type	Significant Words/Phrases	Theme	Frequency
Sample 1	Standard EEG	- briefly done - instant process	Less time requirement	2
		- expensive - high-priced	Costly	2
		- Many people inquire - a lot where satisfied	Success rate	2
Sample 2	Sleep Deprived EEG	- Expensive	Costly	1
		- secure process and results	Safeness	1

Samples that were collected were well analyzed and coded through a coding sheet. Sample numbers were simply filled corresponding to what sample number is being analyzed and coded. On the next columns, significant words and phrases were identified and were classified based on their themes. Thus, the EEG Types column answered the research question number 1.

To address research question no. 2, the themes from the codes formed the basis for determining perceived challenges and impacts. The frequencies of themes with the same notion that were present in other samples were summed up to acquire the overall frequency of the theme. Another table was made while using the formula, Total Frequency/Total Number of Codes x 100%. Percentages of each theme were solved and identified.

Table 2. Sample Coding Sheet 2

Theme	**Total Frequency**	**Percentage**
Less time requirement	2	$\frac{2}{8}$ (100%) = **0.25%**
Costly	3	$\frac{3}{8}$ (100%) = **0.375%**
Success rate	2	$\frac{2}{8}$ (100%) = **0.25%**
Safeness	1	$\frac{1}{8}$ (100%) = **0.125%**
TOTAL	**8**	**100 %**

The obtained percentages were used to answer research question number three concerning the effectiveness of the themes identified. The portrayed effects of Electroencephalography were amongst the subjects. Each topic has a percentage that corresponds to the amount of effectiveness. The researchers formed assumptions after coding and obtaining quantitative data.

Chapter 3

RESULTS AND DISCUSSION

This section includes the presentation of the outcomes of the data collection. Discussions on the study's research questions are also included. This chapter addresses the analysis, and interpretation of data in relation to the researchers' data gathering results. This section contains visual representations and tables for better comprehension of what is being presented.

Research Problem #1: What are the frequently utilized Electroencephalography tests in perceiving brain activities?

Table 3. Identified Electroencephalography Tests

Identified EGG Types	Classification	Frequency
Standard Electroencephalogram Test	Most Popular and the Most Constantly Used Tests by the field.	1
Sleep Deprived Electroencephalogram Test		1
Video Electroencephalogram Monitoring Test		1
EEG Beta, EEG Alpha	Other Types	1

The types of Electroencephalograms most commonly used in perceiving brain activity are listed in the table above. The researchers discovered these in the combined published research and project reports that were evaluated. The researchers discovered three commonly used forms of Electroencephalograms, namely: Standard Electroencephalography Test, Sleep Deprived Electroencephalogram Test, and Video Electroencephalogram Monitoring Test. Other types of Electroencephalography were identified which are the Electroencephalography Beta and Electroencephalogram Alpha. The three most popular and the most constantly used tests in the field of EEG were identified as the 6 studies and researches gathered mentioned and discussed the said types thoroughly, having frequencies of 1.

Standard Electroencephalography Tests, complement behavioral diagnosis of disorders by increasing the chance of capturing seizure-like discharges through photic simulation. However, Sleep Deprived Electroencephalogram Test optimizes conditions by evoking epileptiform abnormalities in the brain caused by lack of sleep. To treat depression and sleep disorders, Video Electroencephalogram Monitoring Test records and monitors the brain activity for accurate results and determines the area the seizure came from. Meanwhile, EEG Alpha filters out distracting sensory information and used as a treatment for Schizophrenia, Depression, Stress, as it boosts and balances out hormones. Lastly, EEG Beta boosts hormones that make people stay active and focused. They stimulate the brain by promoting concentration towards intellectual activities and alertness.

Research Problem #2: What are the impacts of Electroencephalogram types in perceiving brain activities?

Table 4. Present Impacts of Electroencephalogram types

EEG Test Type	Impacts	Frequency
Standard Electroencephalogram Test	Less time requirement, Costly, Successful, Safe	4
Sleep Deprived Electroencephalogram Test	Extensive, Successful, Difficulties	5
Video Electroencephalogram Monitoring Test	Costly, Laborious, Practical, Extensive, Successful, Safe	9
Other Types	Extensive, Safe, Successful, Costly, Laborious	10

After analyzing many study articles and other reliable data from the internet about Electroencephalography, the table above illustrates the identified present impacts of Electroencephalogram types. Each form of EEG has its own set of impacts. The common elements throughout the categorizations include success rate, extensiveness, and safety impact. Meanwhile, the Video Electroencephalogram Monitoring Test has the most reported effects wherein it portrayed the impacts such as costly, laborious, practical, extensive, successful and safe. The standard EEG test, on the other hand, and other EEG variants have had less documented impacts. Overall, each category's impacts are satisfactory due to its simple yet productive approach.

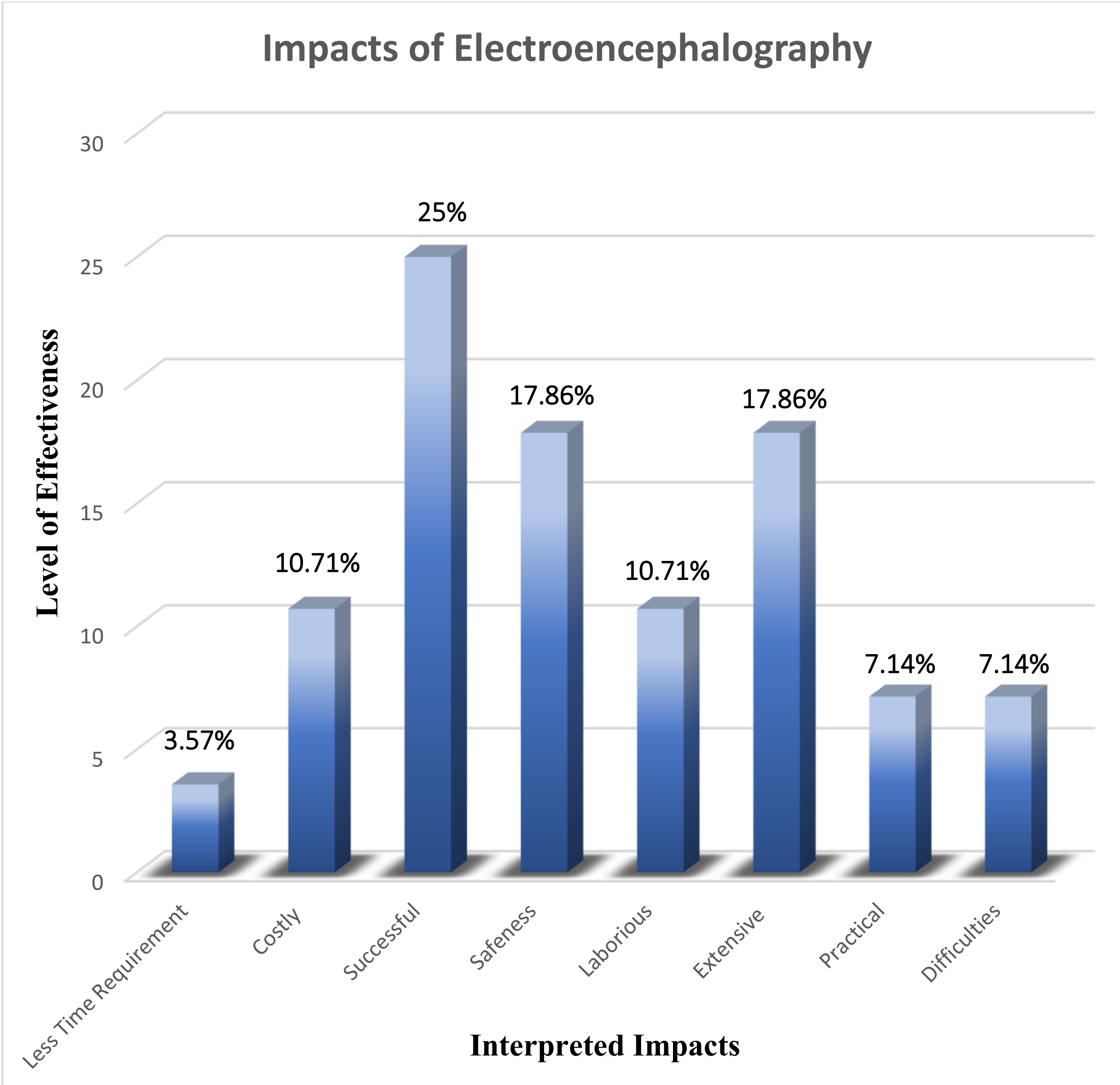

Figure 2. Level of Effectiveness of Electroencephalography's Impacts

The graph summarizes the level of each interpreted impacts of the Electroencephalography in perceiving brain activities. The success impact clearly has the highest level among the other impacts with a percentage rate of 25%. This was followed by the Electroencephalogram's safeness and extensiveness with both a percentage of 17.86%. This was followed by both impacts dealing with the cost and the labor. Costly and laborious impacts garnered a percent rate of 10.71%. Furthermore, practicality and difficulties impact ranked 4th with the percentage of 7.14%. And with the lowest percent rate of 3.57%, the less time requirement impact had the least part and ranked last among the 8 portrayed impacts.

The researchers came up with the graph showing the percentage rates of each impact through making a frequency table. In the frequency table, the total frequency of each impact from the 6 samples gathered and used were summed up. The total frequency of the impacts was: low time requirement was 1, costly was 3, successful was 7, safeness was 5, laborious was 3, extensive was 5, practical was 2 and issues got 2. To get the percent rate, the frequency of each impact was divided by the total number of frequencies which was 28. The answer was divided into a hundred percent to get the final answer or percent rate, with the formula $\frac{Impact\ frequncy}{Total\ No.of\ Frequencies}\ (100\%)$. The percent rate of each impact must be in a total of 100% when summed up for the solution to be as accurate.

Research Problem #3: What is the level of effectiveness of Electroencephalography in perceiving brain activities?

Table 5. Level of effectiveness of Electroencephalogram

Classification of Portrayed Impacts	Frequency	Percent Rate
Positive Impacts	5	62.5 %
Negative Impacts	3	37.5 %

The table shows the level of effectiveness through its portrayed impacts. In the table, the identified impacts were classified into two: positive impacts and negative impacts. Positive impacts have a frequency of 5 which was identified through the impacts:

less time requirement, successful, safe, extensive, and practical, while the negative impacts have the frequency of 3 and was identified through the impacts: costly, laborious, and issues. To get the percent rate, the frequency of the classified impacts was divided by the total number of impact frequencies which was 8. The answer was divided by a hundred percent to get the final answer or percent rate, with the formula $\frac{Impact\ frequncy}{Total\ No.of\ Impacts}$ (100%). The digits in the table clearly manifest that Electroencephalography through its identified types and portrayed impacts are effective.

Chapter 4

CONCLUSION AND RECOMMENDATIONS

This section outlines the researchers' findings and recommendations in relation to the results provided in Chapter 3.

Conclusion

Based on the finding about the effectiveness of Electroencephalography, a Brain-Computer Interface platform, in perceiving brain activities, the researchers came up with the following conclusions:

The identified Electroencephalogram types imply that EEG can be a great endeavor and an effective technology in perceiving brain activities and various brain disorders like Seizures and Epilepsy. Standard Electroencephalography test, Sleep Deprived Electroencephalography test, Video EEG Monitoring and other types of Electroencephalography as classified in chapter 3 portrayed exemplary impact and productive approach, which make these technologies efficient and beneficial to groups involved in the measurement of brain activities, particularly patients and medical professionals.

Based on the identified impacts, Electroencephalography has been proven successful and has contributed to the success rate of technologies ever invented for neuroscience. This has been taken into serious consideration, which is a good thing, specifically that the world is confronting risks in terms of technological success as well as its backslide. These resulted in Electroencephalography's adorned safeness and responsible use throughout the entire domain that utilizes Electroencephalograms in perceiving brain activities. In addition, Standard Electroencephalogram test, Sleep Deprived

Electroencephalogram test, Video EEG Monitoring and such types of Electroencephalography have become extremely informative in a way that these are utilized in numerous differential diagnoses and caters a wide scope of current neuroscientific research. This impact made the groups involved more knowledgeable of the processes, methods and some techniques in the usage of Electroencephalography. Another beneficial impact to consider is the time requirement in using Electroencephalography types. Knowing that these technologies are used to measure and perceive brain activity through putting electrodes unto the scalp, this has been expected to take some time but in actuality it does require less time period.

Regardless of the favorable portrayed impacts mentioned, unenthusiastic impacts where also identified. Electroencephalograms may be costly and lavish, in order for the efficient utilization of the said device. However, despite this, Electroencephalograms are said to be cost-effective as it portrays the favorable impacts mentioned above such as successful, safe and reliable over all. Moreover, some issues and difficulties faced by Electroencephalography are also identified. The common issue was the misdiagnosis of patients. This may have been resulted in the lack of knowledge of the medical professionals who handled the patients but nonetheless, Electroencephalograms are well grounded.

Lastly, based on the delineated results, the researchers concluded that Electroencephalograms, in general, are effective. The garnered positive impacts and its portrayed negative impacts form the gathered research samples made a significant contribution in assessing the effectiveness of Electroencephalography. As the impacts were weighed through a systematical and mathematical method, its portrayed positive impacts became more remarkable making the researchers conclude that Electroencephalograms are structured and effective.

Recommendations

The researchers sought to recommend the following interpreted findings:

Primarily, groups involved with Electroencephalography as a Brain-Computer Interface platform shall put into consideration the type, processes, methods, and techniques of Electroencephalograms before dealing with such technologies. Furthermore, professionals under the supervision of the device shall present a thorough explanation to patients who would utilize the certain device for perceiving brain activities. The explanation shall include the following prospects: Success rate, safeness, time requirement, reliability, safeness and repercussions or after effects.

Secondly, government sectors, organizations, medical schools and the general public shall review the study and look up to the essence of Electroencephalography. This is to spread awareness and understanding about the technology which could be a great help for everyone especially those who have concerns with neurological diseases, diagnosed or not.

This study only focused on the assessment of the effectiveness of Electroencephalography, a Brain-Computer Interface platform, in perceiving brain activities. Thus, it did not cover the detailed contributing factors that affect the level of effectiveness of each portrayed impact. Hence, future researchers can study the factors affecting each specific portrayed impact. This can provide more detailed information about what are those entities needed to significantly increase the level of effectiveness for each positive impact which can still be done through content analysis methodology.

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Appendix 1: Samples

SAMPLE #1

Abstract

This [redacted] study assessed the ability of standard EEG in distinguishing vegetative state (VS) from minimally conscious state plus (MCS+) or MCS minus (MCS−), and to correlate EEG features with aetiology and level of responsiveness assessed by Coma Recovery Scale-Revised (CRS-R).

Results

All patients, but one, showed abnormal background activity. EEG abnormalities were more severe in VS than in MCS+ or MCS−, and in anoxic than other aetiologies. MCS+ patients with normal or Mildly Abnormal background activity showed higher scores on CRS-R than patients with moderate to severe EEG abnormalities. Reactivity to IPS, and acoustic stimuli was significantly more frequent in MCS+ and MCS− than in VS patients.

Conclusions

EEG features differ between VS and MCS− or MCS+ patients and can provide evidence of relative sparing of thalamocortical connections in MCS+ patients. In anoxic patients EEG organization is more severely impaired and provides less discriminative diagnostic information. Standard EEG recording is done in the office and usually lasts an hour. You may be asked to do a sleep-deprived EEG, which requires you to have only 4 hours of sleep. Abnormal brain waves may appear when the body is stressed or fatigued. This exam usually takes 2 to 3 hours. You will be given specific instructions regarding food, drink, and medications that may need to be avoided. consider that they have around 30 electrodes each, the cost is driven up significantly.

Highlights

•Standard EEG can complement behavioral diagnosis of disorders of consciousness.

•EEG activity and reactivity differ in vegetative and minimally conscious state.

•In anoxic patients EEG features are more severely impaired and less discriminative.

SAMPLE #2

Abstract

Epilepsy is a brain disorder characterized by recurrent and unpredictable seizures. It is associated with an increased risk of developing mental disorders. Electroencephalography (EEG) is the most important diagnostic tool for this disease; however, a normal EEG cannot exclude the diagnosis of epileptic seizures, so EEG performed under sleep deprivation was performed in two case examples treated in the

psychiatry clinic, in order to prove that sleep deprivation may increase epileptiform discharges.

Epilepsy is associated with an increased risk for development of psychiatric disorder.4 Furthermore, some psychiatric disturbances, such as mood, anxiety, psychotic, and dissociative states, are directly caused by epileptic conditions. The mood changes include an abnormally elevated or depressed mood. Psychotic disorders involve hallucinations, delusions, or disorganized speech and behavior. It is often difficult to describe the clinical features and to obtain a correct diagnosis in these cases.

Electroencephalography (EEG) is the most important diagnostic tool for investigating patients with clinically-suspected epilepsy. EEG abnormalities, which are seen as spikes, or sharp waves, spike and slow-wave complexes, polyspike, and slow-wave complexes, indicate epileptic seizures that are related to present psychiatric disorders. However, the initial routine EEG sometimes cannot detect epileptiform activity. EEG under sleep-deprivation can increase the probability of detecting epileptiform discharges in such patients. A sleep-deprived-EEG procedure is required, keeping the patient awake for all or part of the previous night, with a longer period of EEG recording. In this study, two cases showing normal routine EEG but epileptiform discharges in sleep-deprived EEG conditions are presented.

Discussion

The causes of mental disorders are generally complex interactions and combination of biological, psychological, and social factors. There are many medical conditions, such as neurological disorders, infectious diseases, or endocrine problems that may induce psychiatric symptoms. Therefore, patients with psychiatric disorders require careful evaluation. Clinicians must be able to distinguish between organic and primary mental disorders for an appropriate treatment plan. Sometimes, accurate diagnosis may require advanced diagnostic methods.

Neurological diseases, especially epileptic seizures, can often cause symptoms of mental disorders such as depression, psychosis, or anxiety. It is known that psychiatric manifestations of epilepsy may occur in both idiopathic cases and patients with seizures after a traumatic brain injury, as demonstrated in the above presented cases. Psychiatric presentation of epileptic conditions is an important cause of misdiagnosis and, thus, the delay of proper treatment. Clinically suspicious signs and routine EEG can assist in the differential diagnosis. Psychiatric manifestation of epileptic seizures include inattention, confusion, mood changes, bizarre behavior (inappropriate laughing, singing), and psychotic states.

A routine EEG should be performed to support the diagnosis of epilepsy, but a normal EEG does not exclude the possibility of epilepsy. If a routine EEG has been normal or has shown abnormal features that are not clear enough to make a definitive diagnosis, a sleep-deprivation EEG might help to determine the presence of epileptiform abnormalities. Moreover, routine EEG has low sensitivity for detection of epileptiform activity in deep structures, such as the limbic structures, hippocampus, and cingulate gyrus, which have an association with psychiatric disorders.

The majority of the evidence supports the idea that sleep deprivation activates interictal epileptiform discharges. However, how sleep deprivation might activate epileptic regions is unclear. [redacted] reported that sleep deprivation affects behavioral and membrane excitability in hippocampal neurons, causes a lower membrane input resistance in CA1 pyramidal neurons, decreasing action potentials in response to depolarizing current, and also inhibiting long-term potentiation in both CA1 pyramidal neurons and dentate granule cells.

In conclusion, sleep-deprived EEG may be also useful for revealing organic electrophysiological dysfunction. Therefore, this method has been used for the differential diagnosis of mental disorders in the psychiatry clinic.

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SAMPLE #3

VEM can be expensive and labor-intensive, but it is cost-effective in many circumstances. Its use should be limited to diagnostic problems that cannot be resolved easily in the routine EEG laboratory.

Differential Diagnosis

VEM is often used as the ultimate test in the differential diagnosis between epilepsy and other disorders associated with intermittent or paroxysmal disturbances that resemble epileptic seizures. A definitive diagnosis is made easily when habitual events are shown to consist of clinical behaviors characteristic of epilepsy and are associated with well-defined ictal EEG discharges, or when other etiologies can be clearly demonstrated (e.g., cardiac arrhythmias or sleep disturbances). Often, however, the events in question occur without obvious EEG or other electrophysiologic changes. In this case, a diagnosis usually is reached with reasonable confidence based on features of the ictal behavior in association with other clinical and laboratory information.

Focal seizures without amnesia or alteration of consciousness (traditionally called simple partial seizures) usually have no EEG correlates that can be recorded with extracranial electrodes. Consequently, seizures without impaired consciousness are diagnosed most often by characteristic behavioral features and, at times, elevated serum prolactin levels, rather than by the occurrence of ictal EEG discharges. Myoclonic jerks may also have no EEG correlates but usually can be diagnosed on the basis of characteristic motor signs. Many other nonepileptic disorders can be recognized readily by clinical examination during the habitual event, by review of video recordings, or both. In most of these situations, however, the results of VEM merely confirm the clinical impression derived from historical and other information, and are not diagnostic in themselves.

The most difficult, and most important, differential diagnosis for which VEM is used is the distinction between epileptic seizures and psychogenic nonepileptic seizures. Because, by definition, psychogenic nonepileptic seizures have no abnormal EEG correlates, this diagnosis is usually one of exclusion. Certain features may distinguish them from epileptic seizures. These include: gradual onset, eye closure, waxing and waning motor activity, uncoordinated nonsynchronous thrashing or undulation of the limbs, quivering, pelvic thrusting, side-to-side head movements, opisthotonic posturing, weeping, screaming and talking throughout the ictal episode, prolongation for many minutes or even hours, abrupt termination without postictal confusion, evidence of some recall during the ictal event, and features that are not stereotyped but differ from one episode to another. Any of these symptoms, however, can be epileptic phenomena, and differential diagnosis between nonepileptic psychogenic seizures and complex partial seizures is particularly difficult. Furthermore, nonepileptic psychogenic seizures may be associated with autonomic changes (e.g., pupillary dilatation, depressed corneal reflexes, Babinski responses, cardiorespiratory changes, and urinary and fecal incontinence) as well as self-injury induced by falling or biting the lips and tongue. Consequently, a definitive diagnosis cannot be made solely on the basis of ictal clinical features observed during VEM; other positive evidence (e.g., secondary gain) is necessary.

A conclusion that an ictal event captured by VEM is nonepileptic and psychogenic does not, in itself, rule out the existence of an epileptic condition, because some patients with epilepsy also have nonepileptic psychogenic seizures. When the two phenomena coexist, it should be possible to obtain a history of more than one seizure type and to use VEM to record examples of each type to determine which are nonepileptic and which are epileptic. Based on this information, the patient and family can be instructed to record these events separately to determine the effects of antiepileptic and psychiatric interventions on each independently.

Nonepileptic psychogenic seizures, which are involuntary and as disabling as epileptic events, need to be distinguished from malingering, which is voluntary simulation, and from factitious disorder, which is self-induction of epileptic attacks for the purpose of gaining patient status.This differential diagnosis sometimes can be accomplished by data obtained during VEM, but usually it depends on historical information.

Characterization and Classification

Patients with known epileptic seizures that do not respond to antiepileptic medication may be undergoing treatment for the wrong type of epilepsy. In this situation, VEM can provide crucial information that characterizes the epileptic events so that the physician can make a seizure diagnosis and, when possible, a diagnosis of a specific epilepsy syndrome. Seizure type usually determines the most appropriate antiepileptic drugs and whether a patient might be a candidate for surgical intervention. A specific epilepsy syndrome is often associated with a known prognosis, which is helpful information for the patient and physician.

VEM is particularly useful for distinguishing focal from generalized seizures on the basis of characteristic ictal EEG features. It is important to distinguish the different epileptic causes of brief loss of consciousness, which can be a typical absence seizure, an atypical absence seizure, or a focal seizure characterized by impaired consciousness only. It may be impossible to distinguish between atypical absences resulting from bilateral or diffuse brain damage and focal seizures originating primarily from frontal lobe lesions with secondary bilateral synchrony.

VEM is also useful for determining the degree of alteration of consciousness during focal seizures, particularly when trained personnel are available to examine the patient during the ictal event. Although this information usually has no direct therapeutic relevance, because all focal seizures are treated with the same medications, a definitive diagnosis can at times have medicolegal implications (e.g., a patient without alteration of consciousness might be allowed to drive), and it is important for counseling patients regarding activities of daily living. Documentation of the degree of disability during and after the seizure can be important in the decision about whether surgical treatment is warranted. More detailed tests (e.g., reaction time tasks) during ictal events can be used to identify subtle disturbances of function for the same purposes.

Determination of Frequency and Temporal Pattern of Seizures

When patients are known to have epileptic seizures of a specific type, but it is unclear how often these seizures are occurring, VEM can be used to determine the frequency of ictal events. Patients with seizures that involve relatively brief lapses of consciousness may not be aware of each ictal event; therefore they depend on observers to know whether therapeutic interventions have resulted in benefit. In these situations, VEM is a more accurate way of documenting seizure frequency before and after treatment. Unexplained deterioration in mental function can be caused by unrecognized brief daytime seizures or more severe nocturnal events. Knowledge about the occurrence and frequency of such ictal events is important for medicolegal reasons, for counseling patients regarding the activities of daily living, and for deciding whether surgical intervention is warranted.

VEM can reveal when seizures are most likely to occur. At times, this information is useful for identifying specific precipitating factors that might be avoided.21 Combining VEM with serum drug level assessments can help to determine whether seizures occur because serum levels are subtherapeutic at specific times of the day, and it can aid in suggesting more effective drug dosing schedules.

Localization of the Epileptogenic Region

The most common use of VEM is for localization of a discrete epileptogenic region in patients with drug-resistant epilepsy who are candidates for surgical therapy. Consideration for surgical therapy is essentially the only situation in which detailed information about localization is of clinical value. This localization includes not only identification of an area that can be removed when localized resection is contemplated, but also demonstration that no such well-defined epileptogenic region exists in patients who are candidates for nonlocalized therapeutic surgical procedures such as hemispherectomy and corpus callosum section.

VEM is capable of revealing clinical signs and symptoms of habitual ictal events that have localizing value; however, these clinical behaviors may result from propagation to distant cortical areas and can never be considered definitive evidence of an epileptogenic region. Consequently, identification of the area to be surgically resected usually requires clear demonstration of the site of electrographic ictal onset. Reliable localization of an epileptogenic region can often be determined with scalp EEG recordings, in association with a variety of other confirmatory tests; but at times VEM with intracerebral, epidural, or subdural recordings is necessary. A variety of electrode types are used for this purpose, including depth, strip, grid, and foramen ovale electrodes. The performance of intracranial VEM requires specialized technical and clinical expertise to place electrodes, to guarantee patient safety in the recording unit, and to interpret the EEG data obtained.

In large part as a result of technical advances in VEM, approximately twice as many patients underwent surgical treatment for medically refractory epilepsy in 1991 as did so in 1985. For some surgical procedures (e.g., standard anterior temporal lobectomy), 70 to 90 percent of patients with medically refractory focal seizures with dyscognitive features can expect to become seizure-free, whereas almost all of the remainder experience worthwhile improvement. The results of VEM techniques are also used increasingly to guide extratemporal cortical resections with beneficial results, and patients with secondary generalized epilepsies who would not have been considered surgical candidates only a few years ago are now benefiting from large multilobar resections and, to a much lesser extent, corpus callosum sections.

SAMPLE #4

Abstract

Electroencephalography (EEG) is widely used in cognitive and behavioral research. This study evaluates the effectiveness of using the EEG power index to measure visual fatigue. Three common visual fatigue measures, critical-flicker fusion (CFF), near-point accommodation (NPA), and subjective eye-fatigue rating, were used for comparison. The study participants were 20 men with a mean age of 20.4 yr. (SD = 1.5). The experimental task was a car-racing video game.

Result and Discussion

Results indicated that the EEG power indices were valid as a visual fatigue measure and the sensitivity of the objective measures (CFF and EEG power index) was higher than the subjective measure. The EEG beta and EEG alpha were effective for measuring visual fatigue in short- and long-duration tasks, respectively. EEG beta/alpha were the most effective power indexes for the visual fatigue measure.

SAMPLE #5

Abstract

Measures of interaction (connectivity) of the EEG are at the forefront of current neuroscientific research. Unfortunately, test-retest reliability can be very low, depending on the measure and its estimation, the EEG-frequency of interest, the length of the signal, and the population under investigation. In addition, artifacts can hamper the continuity of the EEG signal, and in some clinical situations it is impractical to exclude artifacts. We aimed to examine factors that moderate test-retest reliability of measures of interaction. The study involved 40 patients with a range of neurological diseases and memory impairments (age median: 60; range 21–76; 40% female; 22 mild cognitive impairment, 5 subjective cognitive complaints, 13 temporal lobe epilepsy), and 20 healthy controls (age median: 61.5; range 23–74; 70% female). We calculated 14 measures of interaction based on the multivariate autoregressive model from two EEG-recordings separated by 2 weeks. We characterized test-retest reliability by correlating the measures between the two EEG-recordings for variations of data length, data discontinuity, artifact exclusion, model order, and frequency over all combinations of channels and all frequencies, individually for each subject, yielding a correlation coefficient for each participant. Excluding artifacts had strong effects on reliability of some measures, such as classical, real valued coherence (~0.1 before, ~0.9 after artifact exclusion). Full frequency directed transfer function was highly reliable and robust against artifacts. Variation of data length decreased reliability in relation to poor adjustment of model order and signal length. Variation of discontinuity had no effect, but reliabilities were different between model orders, frequency ranges, and patient groups depending on the measure. Pathology did not interact with variation of signal length or discontinuity. Our results emphasize the importance of documenting reliability, which may vary considerably between measures of interaction. We recommend careful selection of measures of interaction in accordance with the properties of the data. When only short data segments are available and when the signal length varies strongly across subjects after exclusion of artifacts, reliability becomes an issue. Finally, measures which show high reliability irrespective of the presence of artifacts could be extremely useful in clinical situations when exclusion of artifacts is impractical.

Conclusion

In this study we could demonstrate that in addition to the choice of the measure, signal length affects reliability of measures of interaction, while discontinuity of the signal has no effect. Exclusion of artifacts is relevant for reliability of most non-directed measures such as coherence, but not for most directed measures such as direct, full frequency, or classical directed transfer function. Similarly, differences between reliability within frequency ranges is moderated by the choice of the measure. As shown previously, reliabilities differ between patients with different neurological conditions, but these differences do not interact with discontinuity or signal length, nor with artifact exclusion. Model order is relevant for most measures within the examined range of model orders. Choosing a high model order is recommendable, but the design should be limited by calculating the ratio between available samples and to-be estimated parameters is highly recommended. We suggest that the future of brain network research should be guided by a paradigm shift in order to fight the reproducibility crisis. Scientists should argue the choice of measures of interaction to be used for a specific study by considering the factors that affect reliability.

SAMPLE #6

Abstract

Simultaneously recorded electroencephalography and functional magnetic resonance imaging (EEG-fMRI) is highly informative yet technically challenging. Until recently, there has been little information about EEG data quality and safety when used with newer multi-band (MB) fMRI sequences. Here, we measure the relative heating of a MB protocol compared with a standard single-band (SB) protocol considered to be safe. We also evaluated EEG quality recorded concurrently with the MB protocol on humans.

Results

The heating induced by the MB sequence was lower than that of the SB sequence by a factor of 0.73 ± 0.38. This is consistent with an expected heating ratio of 0.64, calculated from the square of the ratio of B1+RMS values of the sequences. In the resting state EEG data, gradient and cardioballistic artifacts were successfully removed using traditional template subtraction. All subjects showed an individual alpha peak in the spectrogram with a posterior topography characteristic of eyes-closed EEG. The success of artifact rejection for the MB sequence was comparable to that in traditional SB sequences.

Conclusions

Our study shows that B1+RMS is a useful indication of the relative heating of fMRI protocols. This observation indicates that simultaneous EEG-fMRI recordings using this MB sequence can be safe in terms of RF-related heating, and that EEG data recorded using this sequence is of acceptable quality after traditional artifact removal techniques.

Appendix 2. Coding Draft

Sample No.	EEG Type	Significant Words/Phrases	Theme
Sample 1	Standard Electroencephalogram Test	- Lasts for an hour to 3 hours	Less Time Requirement
		- Cost is driven up	Costly
		- Complement behavioral diagnosis of disorders of consciousness	Successful
		- Differ in vegetative and minimally conscious state	Safe
Sample 2	Sleep Deprived Electroencephalogram Test	- Most important diagnostic tool	Extensive
		- Increase the probability of detecting epileptiform discharge - Used for the differential diagnosis of mental disorders	Successful
		- affects behavioral and membrane excitability in hippocampal neurons - Decreases action potentials	Issues
Sample 3	Video Electroencephalogram Monitoring Test	- Expensive	Costly
		- Labor-intensive - Requires specialized technical and clinical expertise to place electrodes	Laborious
		- Ultimate test in the differential diagnosis	Extensive
		- Provide crucial information that characterizes the epileptic events - Can reveal when seizures are most likely to occur	Successful
		- Distinguishes focal from generalized seizures - More accurate way of documenting seizure frequency before and after treatment	Safe

		- Used for determining the degree of alteration of consciousness during focal seizures - Used to determine the frequency of ictal events.	Practical
Sample 4	Other Types	- Widely used	Extensive
		- Effective for measuring visual fatigue in short and long duration tasks	Safe
		- Most effective power indexes for the visual fatigue measure	Successful
Sample 5	Other Types	- At the forefront of current neuroscientific research	Extensive
		- Careful selection of measures of interaction	Safe
		- High model order	Costly
Sample 6	Other Types	- Highly informative	Extensive
		- Technically challenging	Laborious
		- Considered to be safe	Safe
		- Successful	Successful

Appendix 3. Coding 1

Sample No.	EEG Type	Codes	Theme	Frequency
Sample 1	Standard Electroencephalogram Test	- Lasts for an hour to 3 hours	Less Time Requirement	1
		- Cost is driven up	Costly	1
		- Complement behavioral diagnosis of disorders of consciousness	Successful	1
		- Differ in vegetative and minimally conscious state	Safe	1
Sample 2	Sleep Deprived Electroencephalogram Test	- Most important diagnostic tool	Extensive	1
		- Increase the probability of detecting epileptiform discharge - Used for the differential diagnosis of mental disorders	Successful	2
		- affects behavioral and membrane excitability in hippocampal neurons - Decreases action potentials	Issues	2
Sample 3	Video Electroencephalogram Monitoring Test	- Expensive	Costly	1
		- Labor-intensive - Requires specialized technical and clinical expertise to place electrodes	Laborious	2
		- Ultimate test in the differential diagnosis	Extensive	1

		- Provide crucial information that characterizes the epileptic events - Can reveal when seizures are most likely to occur	Successful	2
		- Distinguishes focal from generalized seizures - More accurate way of documenting seizure frequency before and after treatment	Safe	2
		- Used for determining the degree of alteration of consciousness during focal seizures - Used to determine the frequency of ictal events.	Practical	2
Sample 4	Other Types	- Widely used	Extensive	1
		- Effective for measuring visual fatigue in short and long duration tasks	Safe	1
		- Most effective power indexes for the visual fatigue measure	Successful	1
Sample 5	Other Types	- At the forefront of current neuroscientific research	Extensive	1
		- Careful selection of measures of interaction	Safe	1

		- High model order	Costly	1
Sample 6	Other Types	- Highly informative	Extensive	1
		- Technically challenging	Laborious	1
		- Considered to be safe	Safe	1
		- Successful	Successful	1

Appendix 4a: Frequency/ Percent Rate 1

Theme	Total Frequency	Percentage
Less time requirement	**1**	$\frac{1}{28}$ (100%) = **3.57%**
Costly	1+1+1 = **3**	$\frac{3}{28}$ (100%) = **10.71%**
Successful	1+2+2+1+1 = **7**	$\frac{7}{28}$ (100%) = **25%**
Safeness	1+2+1+1+1 = **5**	$\frac{5}{28}$ (100%) = **17.86%**
Laborious	2+1 = **3**	$\frac{3}{28}$ (100%) = **10.71%**
Extensive	1+1+1+1+1 = **5**	$\frac{5}{28}$ (100%) = **17.86%**
Practical	**2**	$\frac{2}{28}$ (100%) = **7.14%**
Issues	**2**	$\frac{2}{28}$ (100%) = **7.14%**
TOTAL = 8	**28**	**100 %**

Appendix 4b: Frequency Precent Rate 2

Theme	Total Frequency	Percentage
Positive Impacts	**5**	$\frac{5}{8}(100\%) = \mathbf{62.5\%}$
Negative Impacts	**3**	$\frac{3}{8}(100\%) = \mathbf{37.5\%}$
TOTAL	**8**	**100%**

Appendix 5: Editor's Certificate

Holy Cross College of Calinan
Davao- Bukidnon Highway, Calinan Poblacion, Davao City
RESEARCH AND PUBLICATION OFFICE

CERTIFICATION

This is to certify that the research paper of **Katrina Angela S. Lee**, **Ferdinand M. Manteza Jr.**, **Lovely Hans M. Agape**, **John Micheal O. Rosaroso**, and **Francis Dave O. Brina** entitled **The Effectiveness of Electroencephalography (EEG), A Brain-Computer Interface (BCI) Platform for Clinical Purposes** has undergone the editing process and been approved by the undersigned.

This certification is issued upon the request by the researcher on July 26, 2022.

Rizalito H. Paga PhD
Editor

CURRICULUM VITAE

Name:	Katrina Angela S. Lee
Age:	18 years old
Date of Birth:	May 31, 2003
Place of Birth:	Davao City
Civil Status:	Single
Citizenship:	Filipino
Religion:	Roman Catholic
Sex:	Female
Father:	Edwin V. Lee **Occupation:** Government Employee
Mother:	Mary Ann Theresa S. Lee **Occupation:** House Wife

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Holy Cross College of Calinan	2016

CURRICULUM VITAE

Name: Lovely Hans Agape

Age: 17 years old

Date of Birth: January 20, 2004

Place of Birth: Pingaping, Surigao del Norte

Civil Status: Single

Citizenship: Filipino

Religion: Roman Catholic

Sex: Female

Father: Oscar M. Agape **Occupation:** Secondary School Teacher

Mother: Leizl M. Agape (Deceased) **Occupation:** N/A

EDUCATIONAL ATTAINMENT

	School	**Year Graduated**
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Lower Tamugan National High School	2020
Elementary	Lower Tamugan National High School	2016

CURRICULUM VITAE

Name:	Ferdinand M. Manteza Jr.		
Age:	18 years old		
Date of Birth:	September 30, 2003		
Place of Birth:	Davao City		
Civil Status:	Single		
Citizenship:	Filipino		
Religion:	Roman Catholic		
Sex:	Male		
Father:	Ferdinand E. Manteza	**Occupation:**	OFW
Mother:	Alice M. Manteza	**Occupation:**	House Wife

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Holy Cross College of Calinan	2016

CURRICULUM VITAE

Name:	Francis Dave O. Brina
Age:	18 years old
Date of Birth:	May 26, 2003
Place of Birth:	Davao City
Civil Status:	Single
Citizenship:	Filipino
Religion:	Roman Catholic
Sex:	Male
Father:	Patricio S. Brina Jr. **Occupation:** Government Employee
Mother:	Doris O. Brina **Occupation:** Government Employee

EDUCATIONAL ATTAINMENT

	School	**Year Graduated**
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Calinan Central Elementary School	2016

CURRICULUM VITAE

Name:	John Michael B. Rosaroso		
Age:	17 years old		
Date of Birth:	June 11, 2004		
Place of Birth:	Davao City		
Civil Status:	Single		
Citizenship:	Filipino		
Religion:	Roman Catholic		
Sex:	Male		
Father:	Dennis G. Rosaroso	**Occupation:**	Businessman
Mother:	Maybelen B. Rosaroso	**Occupation:**	House Wife

EDUCATIONAL ATTAINMENT

	School	Year Graduated
Senior High School	Holy Cross College of Calinan	2022
Junior High School	Holy Cross College of Calinan	2020
Elementary	Holy Cross College of Calinan	2016