# Electroencephalogram Detection for Insomnia Patients: A Preliminary Study

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**Abstract.** Measurement of insomnia is currently generally carried out by medical practitioners by looking at the patient's condition accompanied by symptoms that refer to insomnia. In contrast, minimal quantitative measurements were found. This study proposes an alternative measurement with the acquisition of brainwave activity through electroencephalogram (EEG) in identifying sleep disorders. Insomnia is a common sleep disorder that can make it difficult to fall asleep difficult to stay asleep, or cause waking up too early and not being able to go back to sleep. Insomnia not only weakens energy levels and moods, but also a person's health, performance, and quality of life. This sleep disorder appears due to several factors, such as anxiety, stress, depression, bipolar disorder, or trauma. Photic stimulation is given as an attempt to find a person's body's response to light. Late adolescents with insomnia symptoms with an age range of 17-25 years were included as respondents, had previously been given a simulation test related to the treatment of sleep disorders, and identified severe, moderate, and mild insomnia. Acquisition using Narosky Mindwave Mobile 2 with the electrode in forehead position, Fp1. This study compares several types of insomnia data acquisition from previous studies and obtains patterns of insomniacs based on photic stimulation.

**Key words:** Electroencephalogram; Insomnia; Photic Stimulation; Sleep Disorder.

## INTRODUCTION

Sleep disorders occur when a person cannot sleep properly and perfectly. Poor sleep quality can affect activities the next day. Insomnia is an inadequate perception of the quality and quantity of sleep and is the most common complaint of sleep disorder. Insomnia is the most common sleep disorder. Every year it is estimated that about 20%-50% of adults report a sleep disorder and about 17% experience a serious sleep disorder. The prevalence of sleep disorders in the elderly is quite high, which is around 67% (Susanti, 2015). Sleep disorders in the form of insomnia generally use biological benchmarks which will later be diagnosed by a health expert, both a doctor and other health workers. Quantitatively, measuring brainwaves with EEG has the potential to help diagnose insomnia by measuring brainwaves in someone who has symptoms of insomnia.

Electroencephalogram (EEG) is a medical device known as a procedure to measure electrical signals from the scalp that are generated by monitoring the activity of neurons in the brain (Azmy & Safri, 2013). EEG signal is a bioelectrical signal originating from the surface of the human skin, usually, the signal is very complex and is used as a source of information from the brain. The EEG signal is in the form of an electric wave with a relatively small size, making it difficult to observe directly (Karmila et al., 2016). The form of the EEG signal is used to diagnose and monitor brain disorders, which of course vary from person to person depending on the factors that influence it. Factors in the occurrence of abnormalities in the brain such as emotional state, mental state, age, activity, and health. EEG is very commonly used to diagnose epilepsy it is also used to detect and analyze coma and damage to the brain. Moreover, EEG also has the potential to detect sleep disorders in the form of insomnia in someone who has sleep disorders.

Photic Stimulation is a method used to identify a person's sensitivity to light stimuli. Intermittent photic stimulation (IPS) is used as one of the activation methods in electroencephalography (EEG) (Kasteleijn-Nolst Trenité et al., 2012). This method can help to establish a very effective diagnosis to understand whether a person is sensitive to light or not. The results were obtained from the combination of EEG with Photic Stimulation, in the form of brainwave patterns. This brainwave pattern is obtained when a person blinks in response to a flash of light placed in front

of the person. Brainwaves are generated by the activity of neurons in the human brain, these neurons produce electrical signals as carriers of sensory and motor information.

Every human being born into the world is endowed with a brain. The intelligence of each human being is not determined by the size of the brain they have, but is determined by the processes that take place in each person's life so that each person has a share in the development of his own brain (Rifqiawan, 2016). The brain is a very complex organ with specific and different parts and functions (Lusiawati, 2017). The human brain can also produce fluctuating (up and down) electrical waves called brainwaves (Mardhiyah, 2021). The human brain will receive messages and information that comes according to the frequency of brainwaves. The simple explanation is that brainwaves are like radio or television. The basic principle of the two electronic devices is the existence of a channel or signal that can transmit messages through radio waves (Mardhiyah, 2021). Waves in the human brain can be measured in two ways, namely amplitude and frequency. Amplitude is a scalar measurement of electrical impulse power with units of Microvolts ($\mu$V). Medium frequency is the speed of the rate of electrical emission measured in units of Hertz (Hz).(Saminan, 2020).The waves produced by the human brain when carrying out an activity have a frequency range of 0.5 Hz to 50 Hz.

Sleep is a condition of an organism that is resting regularly, repeatedly, and reversible in a state where the threshold of stimulation to external stimuli is higher than the state of wakefulness. Sleep disturbance itself is a condition where a person cannot sleep properly and perfectly. Sleep disorders are characterized by disturbances in the amount, quality, and timing of sleep in a person. Sleep disorders are divided into two, namely dyssomnias and parasomnias. Dyssomnia is characterized by disturbances in the amount, quality, and timing of sleep. Parasomnias are associated with sleep behaviors or physiological events associated with sleep, specific sleep stages, or sleep-wake shifts. Dyssomnias consist of primary insomnia, primary hypersomnia, narcolepsy, sleep-related respiratory disorders, circadian rhythmic sleep disorders, and unclassified dyssomnias. Among the authors, the most common sleep disorder is primary insomnia. Primary insomnia is a person who experiences sleep problems that are not directly related to a health condition or other problem (Indrawati, 2018).

Insomnia comes from the words in which means not and Somnus which means sleep, so insomnia means not sleeping or sleep disturbances. Insomnia is a condition characterized by a disturbance in the amount, quality or time of sleep in an individual (Nurdin et al., 2018). Generally, a person takes 8 hours to sleep in one day. The portion of 8 hours of sleep serves so that humans can keep their bodies in a fit condition. Because sleeping too little or too long (not according to the position) can cause disturbances in a person. But it doesn't mean that someone who has the right amount of sleep can always be in a fit or healthy condition. The negative impact is decreased activity, decreased mood, and health problems. On the other hand, the positive impact of insomnia is the achievement of the desired target, which is accompanied by good use of time or on time to do something (Rizqiea & Hartati, 2012). To find out whether a person has insomnia or not, without a scale measurement, a screening test can be carried out regarding the sleep pattern he experienced a few days ago. ISI (Insomnia Severity Index) is a questionnaire that can help doctors in determining the diagnosis of insomnia. The Insomnia Severity Index has seven questions. Seven answers are added up to get a total score. Electroencephalogram

The electroencephalogram is an instrument created by Hans Berger, of the University of Jena in Australia, in 1924. EEG is a bioelectric signal that is often used for bioelectrical purposes originating from the brain (Yulianto et al., 2013). Electroencephalogram is also part of biomedical studies, especially neuro- science related to brain activity that produces electromagnetic signals and is related to the physical function of the human body. One of the resulting goals of the biomedical field is to generate authentication and identification of individuals. In another study conducted by Hans Berger, he found that irregular electrical potentials originating in the human brain are about 50 to 100 V (Immadudin & Habibie, 2013). In this case, EEG is used to detect brainwave patterns in patients who experience sleep disorders such as insomnia. The tool that will be used is called Neurosky Mindwave Mobile 2. Neurosky Mindwave Mobile 2used to measure the user's EEG signal and has several types of output data obtained when the user thinks or concentrates on a particular thing (Olam et al., 2014).

**Stimulation**

Stimulation is the encouragement of development or the cause of activity generally. In

this study, to get the specific brainwave of patients with insomnia, so the brain should be given stimulant success photic stimulation. Photic stimulation is one of the activation methods in electroencephalography which is usually used in epilepsy patients (Kasteleijn-Nolst Trenité et al., 2012). Photic Stimulation is done to identify a person's sensitivity to light stimuli. This method can help to establish a very effective diagnosis to understand whether a person is sensitive to light or not. The results were obtained from the combination of EEG with Photic Stimulation, in the form of brainwave patterns. This brainwave pattern is obtained when a person blinks in response to a flash of light placed in front of the person.

**METHODS**

Many studies and research on feature extraction from EEG signals and discussions related to sleep disorders This review is based on literature research conducted in January 2022 through Google Scholar and several other web journals. The most recent article used is from 2021. The combination keywords used are: "Electroencephalogram", "Sleep Disorders", "Insomnia", "Photic Stimulation", "Beta EEG Signal", "EEG Stimulation". written in English in which the article is used and selected as the basis of conditions. A total of approximately 54 articles were selected and then screened. While screening this article, some articles were then excluded. The articles were excluded because they did not meet the criteria to answer questions for this review. Five other articles were added in the drafting phase to deepen the test.

Screening tests were also carried out to find out the surrounding conditions and the required respondent's capacity. The screening test was given by filling in personal data, as well as answering some basic questions related to sleep patterns in the last few days. These questions are of course based on the ISI, which is adapted to the existing case studies. That way, testing for sleep disorders in the form of insomnia can be another alternative in diagnosing insomnia, which is generally qualitative, into quantitative. See table 2 of the ISI Assessment Guidelines.

After the screening test was carried out by looking at the guidelines on the ISI, measurements and recordings of brain wave patterns were performed using an EEG device. The waves produced by the brain when carrying out activities can be divided into 5 types of EEG signal patterns, namely Alpha, Beta, Theta, Delta, and Gamma (Azhari, 2015). Table 1. and Figure 1. show Neural Oscillation.

Equation 1 show guidelines for scoring or interpretation from the seven questions in Table 2.

$$\sum x_0 + x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7$$

The total score is obtained from the sum of the scores from the first question to the seventh question. Then, the results are adjusted to the insomnia category in Table 3.

**RESULTS AND DISCUSSION**

Many studies and research on feature extraction from EEG signals and discussions related to sleep disorders in the form of insomnia have been carried out. EEG has several advantages including having a relatively high temporal resolution up to a thousandth of a second, quite practical and there is no significant medical risk. But behind the advantages, there are disadvantages of EEG, namely it lacks high spatial resolution. So, when you want to get high spatial resolution, this EEG tool must be combined with other imaging methods. Not only EEG, insomnia also has advantages and disadvantages. Insomnia has a positive side, namely the achievement of the desired target accompanied by the use of the right time to do something (Rizqiea & Hartati, 2012). For the negative side of insomnia in the form of decreased activity, health problems, and decreased mood. Several related studies will be discussed in this chapter.

The research was conducted by Olam et al (2014) , Dalu Setiaji, and Deddy Susilo who discussed the Implementation of the NeuroSky Mindwave Mobile Headset for Wirelessly Controlling Wheeled Robots. The application of this method is to control the robot with the waves detected in it. The percentage of successful testing of robot control in the labyrinth is obtained. EEG here is the method of choice because it can display various kinds of waves which can later be used to detect the robot. Not much different from the research by Murat (2010) on EEG Analysis for Brainwave Balancing Index (BBI). With the EEG method using Mobilab together with gold electrodes, using a bipolar connection (2 channels), can form a brainwave signal with the BBI system. On the other hand, there was also a discussion about the EEG-Based Automatic Sleep Stage Classification by Tzimourta et.al. (2018).

**Table 1**. Neural Oscillation (Azhari, 2015)

| Wave Type | Frequency | Mental Condition |
|---|---|---|
| Delta | 0.5 – 4 Hz | The state of deep sleep without dreaming (Deep Sleep). Rest phase for the body. |
| Theta | 4 – 8 Hz | Meditation, intuition, and fantasy states. |
| Alpha | 8 – 15 Hz | State of relaxation and wakefulness. |
| Beta | 15 – 32 Hz | Conditions of focus, thinking, and concentration. Productivity phase for the body. |
| Gamma | 32 – 50 Hz | Conditions of high mental activity such as fear, panic, high concentration. |
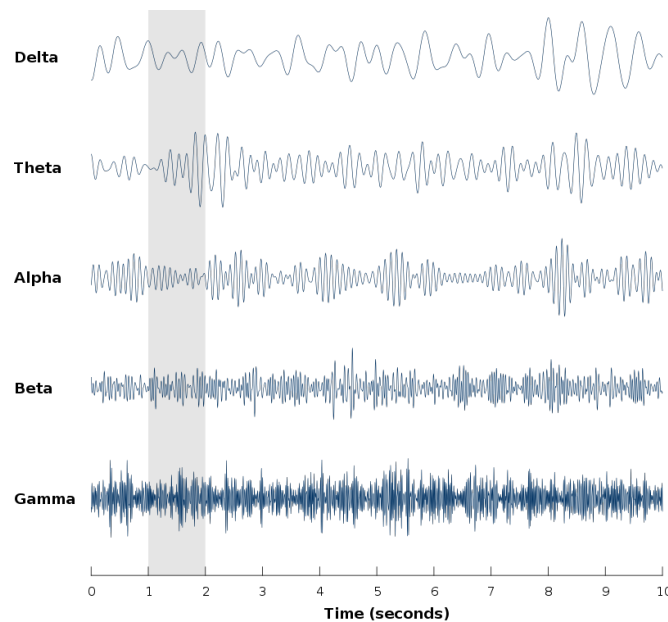


**Figure 1.** EEG Brainwave

With EEG, which is a cost-effective and usually non-invasive method, it can be used to monitor and record electrical signals and voltage fluctuations from neurons in the brain, which have proven to be accurate at scale.

Research conducted by (Ahmad Azhari, et.al., 2019) discusses related Neural Network Classification of Brainwave Alpha Signals in Cognitive Activities. The application of this method is distinguished signals from each individual based on the characteristics of the alpha signal from the brainwaves produced by each individual. The Neural Network method is used with a back propagation algorithm where the learning process is carried out during data training and normalization will be matched using a normalized Euclidean distance. Euclidean distance is applied to show the degree of similarity. While the EEG signal was obtained from the participants by applying hypnotherapy first. The goal is to get certain cognitive activity and focus out of the brain. This study presents the results of alpha signal representation with stable conditions to deepen meditation. By attaching a picture related to brainwave oscillations according to Figure 2.

In Figure 4, each wave represents the activity of the human brain. Each wave Gamma, Beta, Alpha, Theta, and Delta waves. Understanding the distribution of wave patterns according to brain activity, it can be concluded that patients with insomnia sleep disorders fall into the research category on beta brainwave patterns. Signal beta has a wave frequency that is between 13-30 Hz with a voltage amplitude of between 10-20. These waves are generated when a person is in a state of thinking or doing daily activities(Azhari, 2015).

Next is the research conducted by Jianfeng Hu, Jianliang Min who discussed Automatic Detection related to driver fatigue based on EEG signals using a gradient boosting decision tree model. The application of this method is the classification of a

**Table 2.** Seven Question of ISI

| Question | Answer Options | | | | |
|---|---|---|---|---|---|
| | *Option 1 (Score 0)* | *Option 2 (Score 1)* | *Option 3 (Score 2)* | *Option 4 (Score 3)* | *Option 5 (Score 4)* |
| Is it difficult for you to fall asleep? | No | Not really difficult | Somewhat difficult | Difficult | Very difficult |
| Is it difficult for you to stay asleep? | No | Not really difficult | Somewhat difficult | Difficult | Very difficult |
| Is it difficult for you to wake up in the morning? | No | Not really difficult | Somewhat difficult | Difficult | Very difficult |
| How satisfied/dissatisfied are you with your sleep pattern in the past two weeks? | Very satisfied | Satisfied | Somewhat satisfied | Dissatisfied | Very dissatisfied |
| Is your current sleep problem noticeable to others? | Not at all noticeable | Not really noticeable | Somewhat | Noticeable | Very much noticeable |
| Are you worried/ distressed about your current sleep problem? | No | Not really worried | Somewhat | Worried | Very worried |
| How much does you current sleep problem impacts your quality of life in terms of fatigue, mood, concentration, and memory? | Not at all | Not too much | Somewhat | Much | Very Much |

driver's fatigue condition by calculating the Gradient Boosting Decision Tree (GBDT) parameter, from the use of 3 classifications, namely KNN, SVM, and Neural Network. With this method, the classification results are obtained based on the results of the calculation of the GBDT parameter to detect the weakness of a driver reaching the highest level of success with only one channel (Hu & Min, 2018). In this study, respondents were asked to drive with a total trial duration of 40 – 120 minutes. Starting with first adapting to the simulation software, then the respondent can immediately drive at a monotonous tempo continuously until he feels tired. EEG signal recording is taken under normal circumstances starting from the last 5 minutes before the driver feels tired by complying with the subjective fatigue scale (Jo et al., 2014). After recording the EEG signal in the last 5 minutes, the researcher also used Electrooculography (EOG).

EOG is one of the most useful signals that help to successfully communicate with the environment using eye movements (Kaur, 2021).

In terms of insomnia, a discussion by Riya Mirchandaney, Raul Barete, and Lauren D. Asarnow regarding Moderators of Cognitive Behavioural Treatment for Insomnia on Depression and Anxiety Outcomes admits that insomnia is closely related to depression and anxiety. However, the analysis was carried out by looking at the symptoms of insomnia clearly by looking at the diagnostic criteria related to insomnia. There is a CBT-I method as a therapeutic agent for insomnia sufferers. However, this qualitative measurement is not very accurate. Therefore, in this study, we offer a scalable/quantitative measurement. In contrast to the research by Garnis Swanenghyun, dr. Astuti, Sp. S(K), and dr. Abdul Ghofir, Sp. S(K) regarding the validity and reliability of the

**Table 3.** Total Score Categories

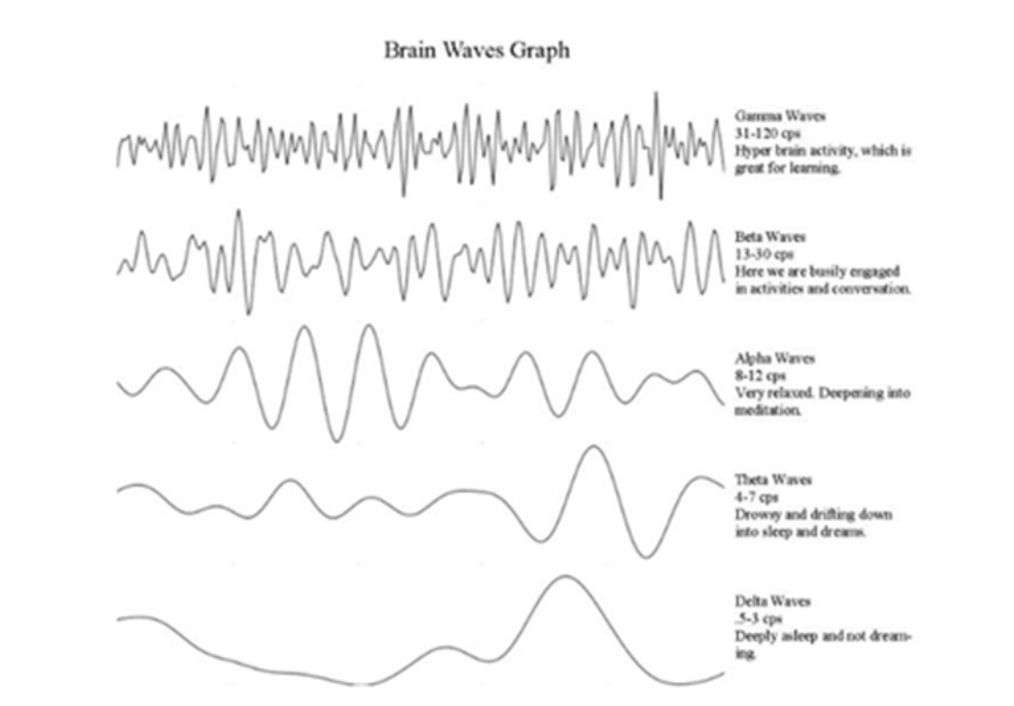| Total score | Identification |
|---|---|
| 0 – 7 | No clinically significant insomnia |
| 8 – 14 | Subthreshold insomnia |
| 15 – 21 | Clinical insomnia (moderate severity) |
| 22 – 28 | Clinical insomnia (severe) |

**Figure 2.** Brainwave Oscillation (Azhari et al., 2019)

Indonesian version of the insomnia severity index (ISI-INA) on street youth in Yogyakarta. The study used the ISI method to be the initial benchmark for insomnia patients. Evidenced by the results of high validity in the study. This method will later be applied in this research.

Further research was conducted by Susanti (2015) who discussed the factors that influence the incidence of insomnia at the Neurology Polyclinic of DR. M. Djamil Hospital, Padang. A trial was conducted on 100 patients most were women (51%), and 38% of the sample had insomnia. In this study, the results showed that depressed patients experienced more insomnia than patients without depression, and this was significantly different after being tested with chi-square (p=0.00) (Susanti, 2015). In the logistic regression test, it was found that people with depression had a 9 times greater risk of experiencing insomnia than individuals without depression. This is in accordance with the literature which states that the most common cause of insomnia found by doctors is depression and 80% of insomnia occurs in patients with depression and chronic pain. The conclusion of this study is that insomnia is not related to gender, age, education, economic status, and family history of insomnia. However, the main factor triggering insomnia is depression.

Subsequent research was conducted by Patchouli PI Warni Sayekti and Lucia Y. Hendrati with a discussion on the risk analysis of depression, sleep hygiene levels, and chronic diseases with the incidence of insomnia in the elderly. This study was conducted on 40 elderly people by dividing them into 2 populations, namely 20 case populations and 20 control populations. The variables studied were depression, chronic disease, sleep hygiene, and insomnia. Most of the elderly suffer from early insomnia with severe symptoms of Difficulty Initiating Sleep. Early Morning Awakening is the least common symptom experienced by the elderly. Depression (OR = 22,667), chronic disease (OR = 6,926) and sleep hygiene (OR = 11,000) showed a significant relationship with insomnia. Depression shows a risk factor for sleep disorders whereas patients suffering from depression show 22 (N. Sayekti, 2018).

The latest research was conducted by Har (2018) with the title The Effect of Murottal Al-Quran Listening Therapy on Insomnia Levels in Nursing Students at UIN Syarif Hidayatullah Jakarta. This research was conducted on 12 students of the nursing science study program at UIN Syarif Hidayatullah Jakarta. Data collection was carried out in May 2018 on the campus of the Faculty of Health Sciences UIN Syarif Hidayatullah Jakarta.

**Figure 3.** The use of Electroencephalogram and simulation

The results of these tests can be concluded that the majority of insomnia is caused by PSIK students of UIN Syarif Hidayatullah Jakarta. And testing murottal therapy is less effective on the level of insomnia after the intervention (Har, 2018). However, EEG can be used as a measure of sleep complexity at the 5 stages of sleep from the study.

Based on the research that has been described, brainwave patterns can be grouped into 5 parts, namely delta waves, theta waves, alpha waves, beta waves, and gamma waves. The presence of activity during the EEG process will affect the pattern of brainwaves that are formed. EEG is considered capable of being used as an alternative in detecting sleep disorders such as insomnia.

Insomnia also has a relationship with brain performance, which is dominated by depression, according to the research described. In this study, the detection of sleep disturbances that focused on sleep disorders in the form of insomnia entered the Beta signal pattern. Detection of insomnia sleep disturbances enters the Beta signal pattern because Beta waves are designed to help detect human mind when someone is thinking, concentrating, and in a focused state. The brainwave pattern in the Beta signal is the result of the data acquisition process in this study. This data acquisition is the stage of taking and collecting data samples that are used to obtain information by generating data in a study (Pamiela & Azhari, 2021). Figure 4. shows comparative research.
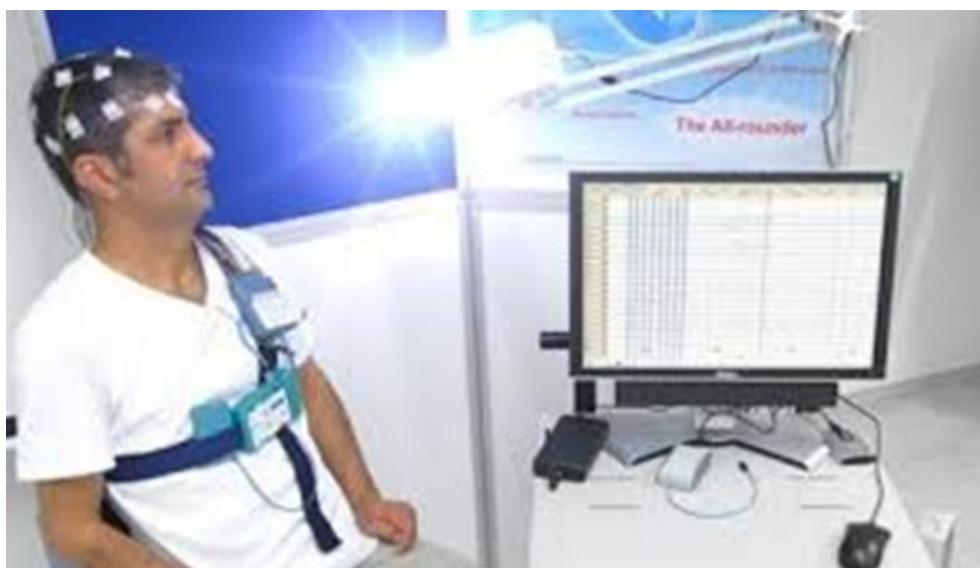


**Figure 4.** Photic stimulation

This study compared several types of insomnia and obtained EEG data from previous studies. The research from Figure 4 shows that several types of qualitative measurements are widely used, but the level of accuracy is still lacking. Meanwhile, in this study, pay attention to the level of accuracy in quantitative testing. Including an EEG measuring instrument that is considered to have a high level of accuracy. The advantages of the NeuroSky Mindwave Mobile headset are in accordance with the first research statement from table 4. That way, the advantages of the method offered are a high level of accuracy and also the effectiveness of a good bang time. While the drawback is that it is still minimally used, especially EEG measurements for diagnosing insomnia. Therefore, this study has a good opportunity by considering various existing methods and previous supporting theories, to be able to assist in detecting sleep disorders in the form of insomnia accurately with quantitative measurements. Figure 3. show EEG device in the form of Neurosky Mindwave Mobile 2 and simulation of use.

Considering that EEG requires additional stimulation to be able to help see brain wave patterns, photic stimulation is present as the right stimulation to accompany EEG in the detection of insomnia diagnoses. Figure 4. shows an illustration of photic stimulation.

## CONCLUSION

Previous research on insomnia, which involved the use of photic stimulation, showed that data acquisition methods mostly used qualitative, measurement by conducting a direct review of insomnia by asking about related symptoms that occur in insomnia. Using the standard insomnia severity scale to help analyze the level of insomnia. In the successful comparison, it is concluded that it provides an opportunity for data acquisition methods using quantitative, using biometrics, one of which is EEG. Acquisition using EEG can process brain wave patterns, both for an alpha, beta, gamma, theta, and delta signals. Measurements involving measuring instruments are still very minimal to analyze sleep disorders, especially insomnia. This quantitative research offers faster performance, time efficiency, and higher accuracy. By comparing several types of insomnia data acquisition from previous studies, the pattern of insomnia sufferers can be obtained easily using EEG and photic stimulation. Considering the research gap between qualitative and quantitative diagnosis of insomnia sleep

disorders, quantitative scale measurements can be used as another alternative in obtaining brain wave patterns of insomniacs, so as to assist the process of diagnosing insomnia precisely and accurately.

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