

Brain Wave Frequency Measurement in Gamma Wave Range for Accurate and Early Detection of Depression

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Abstract

The Global System of Mobile Communication (GSM) which debuted in Nigeria in August 2001 was greeted with much celebration as the country finally joined the League of the GSM nations, though after less economically buoyant African countries such as Botswana, Mozambique, Uganda and Tanzania. Fourteen years after the introduction, Issues and challenges has been raised on why subscribers are being ripped of their money and short changed with epileptic services. This arises from the myriad of problems ranging from congestion to the poor network delivery. This paper discusses the evolution of GSM services in Nigeria, the range of services available and the issues involved in its operation in the last fourteen years. Not forgetting the benefit it has brought to the Nigerian economy. Suggestions are also made on how Nigeria can reap more benefits of the GSM communication.

1. Introduction

According to the World Health Organization factsheet published in April 2016, there is one suicide committed every 40 seconds which averages for 2,160 suicides per day and over 8,00,000 suicides every year. Moreover, suicide is the third leading cause of death in the world for those aged 15-44 years. Research has consistently shown a strong link between suicide and a mental illness called depression, with 90% of the people who die by suicide having an existing mental illness[1]. It is depression that causes people to commit suicide 95% of the times. We tend to lose about 3% of our population each year to depression.

This establishes a thorough background of how severe this disease is and how it is taking our own species away from us. We are losing our workforce and human resources to a mental illness. Often called the "cold" of the brain, depression – like any other disease – has its own symptoms, causes, diagnosis, treatments, and complications.

We are well aware of the treatments, yet we lose 2,160 humans to suicide every day. One of the major causes of this is late diagnosis. Depression turns severe over time – minor depression turns into psychotic depression. People often overlook the symptoms of minor depression, considering their feelings to be a mere sign of slight sadness. Sometimes this feeling of "slight sadness" persists over a long duration of time and turns into a major depression. The earlier depression is diagnosed, the easier it is for effective treatment.

This work focuses on the same – the timely and accurate diagnosis of depression. The project establishes a relation between brainwaves and depression, and the introduction of

an idea of a device which uses the concept of brainwaves waves to diagnose depression. The work of this project is divided into two main themes, one being the co-relation of brainwaves with depression; the other being the proposal of a device based on the brainwaves which can be used to diagnose the same. It is important to know some basic concepts that are used, before beginning with the core concepts of the project. The section 2 and 3 thoroughly explains the various concepts, both basic and core, and helps in the easy and proper understanding of the topic.

This project is inspired by the recent rise in teenage suicides among high school students. Many online forums have shown teenagers venting out their feelings as being misunderstood in school and feeling low since they feel as if their sadness doesn't matter. Due to high school stress and various other factors, majority of the This project is inspired by the recent rise in teenage suicides among high school students. Many online forums have shown teenagers venting out their feelings as being misunderstood in school and feeling low

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since they feel as if their sadness doesn't matter. Due to high school stress and various other factors, majority of the teenagers get depressed, some come out of the disease with help of their parents or the school counselors, but some others are unable to do so and their depression prolongs into their adult life. The device which this project suggests can be used to solve this problem. Among students from Grade 9-12 in 2013, 17.03% of the students seriously considered attempting suicide.

2. State of Depression

To begin with, depression – as a word in general – is synonymous to "low". Geographically it means a "low" lying area, financially it means a "low" stock of monetary fund, and medically it means the "low" of the mind. Sadness, grief and guiltiness are all normal human emotions. One experiences those feelings from time to time; they usually go away within a single or a short span of days. But, depression is something more. It is a period of overwhelming sadness. Depression, as defined by the American Psychiatric Association on their official webpage www.psychiatry.org is:

"Depression (Major Depressive Disorder) is a common and serious medical illness that negatively affects how one feels, thinks and acts, and interferes with the everyday life of a person for weeks or more." Untreated depression can cause complications which further put the individual's life at risk. Studies show that teenagers are more prone to depression than any other age group; this is due to the hormonal changes that occur in the body during puberty [2]. When it comes to gender, studies show that women are more likely to be diagnosed with depression than men.

3. Symptoms and Statistics of Depression

Often called the "cold" of the brain, depression like any other disease has its own symptoms. Feelings of sadness or emptiness that don't go away within a few weeks may be a sign of depression. Some other emotional symptoms may include:

- (i) Extreme irritability over minor things.
- (ii) Anxiety and restlessness.
- (iii) Anger management issues.
- (iv) Loss of interest in favourite activities.
- (v) Fixation on the past or the things that have gone wrong.
- (vi) Thoughts of death and suicide.

Although the presence of these symptoms is used as a tool in diagnosis of depression, they sometimes might be misleading as they might be only temporarily present i.e. when the person is feeling low only for that certain period of time[4]. Yet males take their own lives at nearly 4 times the rate of females and represent 77.9% of all suicides. According to the World Health Organization, 350 million people suffer from depression worldwide. This is about 5% of the human population. It is depression that causes people to commit suicide 95% of the times. Percentage of people who

experience depression in various countries: Germany - 9.9%, Israel - 10.2%, United States - 19.2%, France- 21%, and India- 9%

4. Waves and Brain Activity

All our thoughts, emotions and even behaviors are caused due to the communication between neurons in our brains. The brain is made up of millions of neurons. These neurons use electric impulses to communicate with each other. This activity results in the formation of waves in the brain. These waves are, logically, called brainwaves. Brainwaves are produced by synchronized electrical pulses from masses of neurons communicating with each other [7,8]. It is important to know that all living Homo sapiens display five different types of electrical patterns or “brainwaves” across the cortex, i.e. the brainwaves from the brain can be divided into five categories [3]. Each of these five types of brainwaves have a purpose and helps to serve us in optimal mental functioning. Our brain’s capability to transition through various brainwave frequencies plays an important role in determining our stress management, concentration, and even our sleep quality. Even if one of the five types of brainwaves is overproduced or under produced in our brain, it can cause problems.

These five types of brainwaves are categorized into these groups on the basis of their frequencies (ranging from 0 Hz – 300 Hz). It is important to know that all the five types of brainwaves are being produced all the time. What distinguishes “Wave A” from “Wave B” is the difference in frequency. The five brain waves in decreasing order of their frequency are: Gamma, Beta, Alpha, Theta and Delta [5,9]. The frequency diagrams for various waveforms is shown in fig. 1.

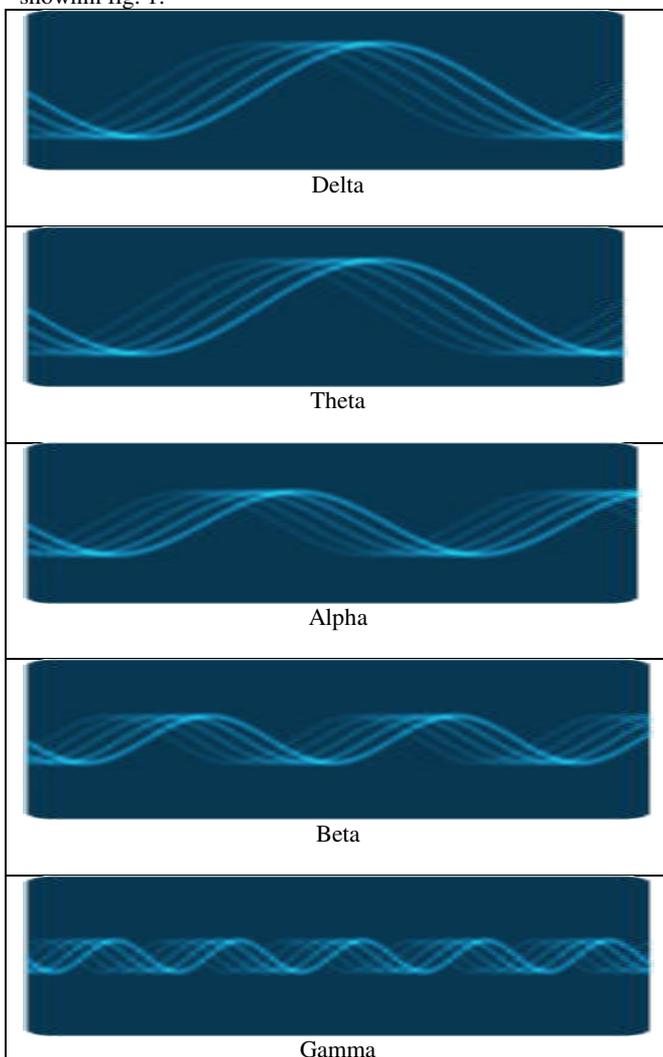


Fig 1: Waveform Diagrams for various frequency bands

Even though all the five types are produced throughout the day, one particular brainwave will be dominant over the rest four depending upon the state of mind and consciousness. The Table 1 thoroughly explains the emission cause, range, purpose, effect due various amounts of each of the waves. We observe that depression is witnessed when a person’s brainwaves exist in the lower region of the gamma wave band i.e. around 25 Hz. Hence, to diagnose depression we only need to focus on the gamma waves, therefore a deeper understanding of the gamma waves is important for the thorough understanding of the project as a whole.

4.1 Brain Function and Gamma Waves

One must not confuse Gamma Waves with Gamma Rays. Gamma Rays are the EM Waves which are emitted from fusion, fission, alpha decay or gamma decay of the atomic nucleus. They are produced in the sun, to cite an example.

They have the highest frequency in the Electromagnetic Spectrum. Gamma brain waves are a frequency pattern of brain activity that measures between 25 and 100 Hz, with around 40 Hz being typical in humans.

The similarity between Gamma Rays and Gamma Waves is that their frequency is the highest in Electromagnetic Spectrum and Brainwave Spectrum respectively, accompanied with a low amplitude. The gamma wave originates in the thalamus and moves from the back of the brain to the front and back again 40 times per second – not only that, but the entire brain is influenced by the gamma wave. Everyone has gamma brainwave activity, but the amount of gamma waves produced varies. Low amounts of gamma brainwave activity have been linked to depression, as the table suggests and high amount of gamma waves are related to peace.

According to neuroscientists, higher gamma activity is linked to higher focus. People with high gamma activity are naturally happier, calmer and more at peace. This is nature’s best anti-depressant. Being the highest of all four brainwaves, increased production of gamma brainwaves can help boost your energy levels, enabling peak performance, physically and mentally. In depression, a person’s focus is majorly affected. They are not able to concentrate easily due to the disease. If the gamma activity is very low, the focus of the person will be very low thus indicating depression. Since more gamma activity means a happier person, the lack of gamma activity would mean lack of happiness. It would directly mean that the “nature’s anti-depressant” is not working the way it was supposed to thus indicating depression.

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Table 1: Brain wave frequency ranges and the symptoms of patient

Gamma Waves	Frequency Range:	25 Hz - 100 Hz
	Average Frequency:	40 Hz
	Too Much Amount:	ADHD, Extreme Anxiety Disorder
	Too Little Amount :	Depression
Beta Waves	Frequency Range:	12 Hz - 25 Hz
	Average Frequency:	20 Hz
	Too Much:	DEPRESSION
	Too Little:	Poor Cognition
Alpha Waves	Frequency Range:	8 Hz - 12 Hz
	Average Frequency:	10 Hz (and around)
	Too Much:	Maladaptive Daydreaming
	Too Little:	Poor Cognition
Theta Waves	Frequency Range:	4 Hz - 8 Hz
	Average Frequency:	6 Hz (and around)
	Too Much:	Inattentiveness
	Too Little:	Poor emotional awareness
Delta Waves	Frequency Range:	0 Hz - 4 Hz
	Average Frequency:	2 Hz (and around)
	Too Much:	Inability to think
	Too Little:	Inability to sleep

A depressed person, usually, is seen as a bit more lethargic as compared to a average mentally healthy person given the same circumstances. This means that it would be right to conclude that a person having very low energy levels showing the symptoms of frequently tiredness or extremely lazy would probably be in a depressed state. So we can conclude from the neuroscience researches as well as from the data provided above that if we wish to diagnose depression we have to detect a brainwave which lies in the interval 20 to 30 Hz, since that would relate us to the lower range of the gamma waves, the range where depression is diagnosed. The various sections of human brain are shown in fig. 2.

Parts of the Human Brain

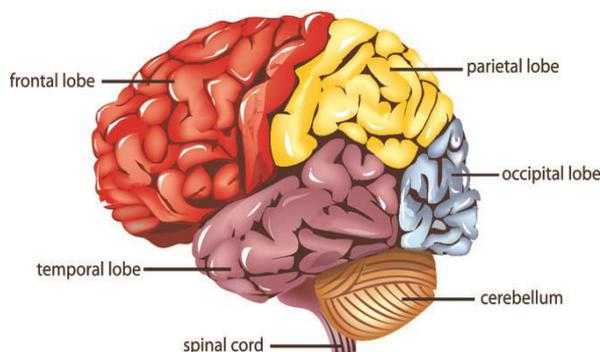


Fig.2: Parts of human brain

5. Diagnosis of Depression

In today's time, the trend of going to WebMD and taking a depression quiz is up for the diagnosis of depression and in the psychiatrists office it's more or less the "questionnaire" method of diagnosis [6]. What is one of the major drawbacks with such type of a method of diagnosis is that it is not the most reliable form. It does not analyze the person scientifically for depression, but takes their current mood into perspective and attempts to diagnose the disease. The depression questionnaires usually have questions such as "in the past few months have you been—"or "has the past week been difficult etc.". These questions refer to the past but the answers are dependent on the person's current mood. If a person is feeling low while they are attempting the questionnaire then they tend to project their past worse than it was, or if they are feeling happy then they might tell that everything was okay in the past. There is a problem with both these scenarios – the problem being that the person's current mood serves as an obstacle in the accurate diagnosis of depression[10]. The brainwaves, however, do not do this. A depressed person will show low gamma wave activity no matter what their current mood is.

5.1 Proposed Device for detection of depression

The development of a device which detects only the frequencies ranging from 20 Hz to 30 Hz would be exactly fitting for the accurate and timely detection of depression.

The first part of the project was correlating brainwaves with depression. That part has already been explained in the above sections. The following section explains the second part of the project i.e. the development of the device. If the device detects frequencies ranging from 20 Hz to 30 Hz we will be able to say that it is a tool which will help in the diagnosis of one of the deadliest illness—Depression. The device indicates the presence of a brainwave having frequency ranging from 20 Hz to 30 Hz only. If a frequency of, for example, 45 Hz is given to the device, and then the device would show no activity. The indication of the presence of a brainwave in 20-30 Hz interval can be done by lighting of a bulb whenever such a wave is detected. Perhaps one of the most important concepts to know in this is that a brainwave is not a normal wave. The term "wave" can be highly misleading to many people as it suggests a system of waves which are originating in the brain and travelling elsewhere. This, however, is not the case. What happens in the brain is that the millions of neurons fire electricity through the brain over extremely, extremely short spans. What we call a wave is the graphical representation of these electrical impulses plotted along the time axis. So when we say that a wave of 22 Hz is being produced by the brain, what we mean to say is that in 1 second, 22 electrical impulses are travelling into the electrodes attached to the scalp.

5.2 Working of proposed depression detection device

About 20 small electrodes are attached to the head with washable glue. Electrode: a conductor that carries current; can be used for diagnostic testing to receive and record electrical activity of nerves. The device contains 2 parts; a transmitter and a receiver. The transmitter is connected to the electrodes which are attached to the scalp, where as the receiver stands alone, wirelessly. At any given period of time, the brain is always sending out electrical impulses into the electrodes. The electrodes act as a mediator for sending these electrical impulses to the transmitter. So, the electrical impulses initiate in the brain and travel all the way to the transmitter through electrodes.

The transmitter captures the impulse, encodes it and sends it wirelessly to the receiver using a carrier frequency. It sends the impulse as soon as the electrode supplies it with impulse. Many such impulses are sent over a period of time. The impulses reach the receiver in a wave form. The receiver decodes the impulses and determines if the frequency of these impulses lies within the desirable range of 20 Hz to 30 Hz. If the frequency does come out to

be within the desirable range, then a bulb attached to the receiver starts glowing. If the frequency is outside the range, then the receiver's bulb shows no activity.

This device can also be used in schools to analyse students who are lagging behind in academics. It has been noted that a person suffering from depression loses their intellectual ability which in turn affects their studies. Teachers in school usually take a student's poor performance as laziness – but it can be much more, it could be an indication of depression. If this device is introduced in school, we would be able to diagnose students with depression and treat them accordingly for their better performance instead of labelling them lazy.

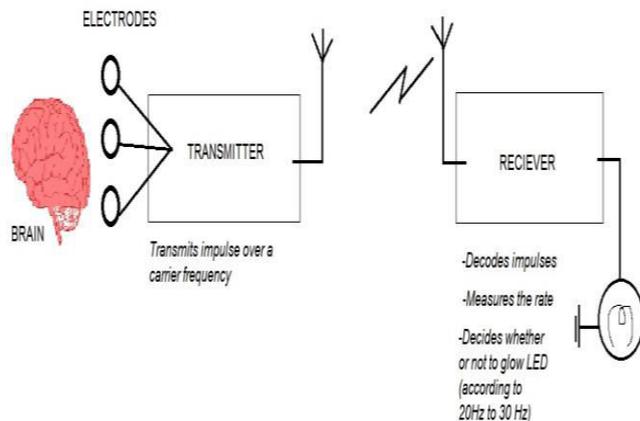


Fig. 3: Block diagram of proposed device

6. Treatment methods of depression

The cure for depression, however not a technical part of the project, but one of the most necessary part is explained in this section. Some of the treatment methods are :

- (i) Anti-depressant medication is available in the market. These usually have some side-effects but they are effective for curing depression. Antidepressants primarily work on brain chemicals known as neurotransmitters, such as serotonin, norepinephrine and dopamine. These chemicals are involved in regulating mood.
- (ii) Regular exercise. Exercise enhances the actions of endorphins, which improve natural immunity and reduce the perception of pain.
- (iii) Listening to alpha waves regularly is found to have reduced depression according to recent studies. Alpha Wave recordings are openly available on the internet and can be used for various purposes such as boosting creativity.
- (iv) Psychiatric help. There are several therapy sessions as well as counseling available in the outside world. Depression, even in the most severe cases, can be effectively treated with professional help. Up to 80% of those treated for depression show an improvement in their symptoms generally within 4 to 6 weeks of beginning a professional help treatment. The earlier a treatment begins, the more effective it is. A depressed person might be reluctant to seek help at first, they can be held back by stigma that is associated with depression in certain societies. The society, too, must rise above the illogically produced stigmas and help those in need. The patients often feel that help is of no use, but that is not true. Therapy sessions, behavioral therapy, medication as well as exercise have been scientifically proven to improve a depressed person's state of mind. No matter how hopeless a person might feel, one thing that they must not ever forget is that- There is always help.

7. Conclusions

There is a tremendous rise in cases of depression worldwide. We are losing our efficient workforce and human resources to this mental illness. Often called the "cold" of the brain, depression like any other disease has its own symptoms, causes, diagnosis, treatments

and complications. We're well aware of the treatments, yet the treatment methods are not effective sometimes. One of the major reasons of the failure of treatments is the late diagnosis of depression. The earlier depression is diagnosed, the easier and effective the treatment is. Late diagnosis usually happens when people are unsure of their feelings and take their sadness for simply just a bummer. Currently, questionnaires are often used for diagnosis of depression, which is not a very reliable method. The method proposed in this project is based on the idea of brainwaves. The millions of neurons in our brain send electric current over short spans of time. This activity results in the formation of waves namely Delta, Theta, Alpha, Beta and Gamma waves. Considering symptoms of depression such as focus levels, laziness, lack of natural anti-depressants this project comes to the conclusion that lower gamma wave activity in the brain indicates depression. Gamma waves range from 25 Hz to 100 Hz. A lower gamma activity would be having brainwaves emitted in the range from 20 Hz to 30 Hz. A proposal for a device is also laid down in the project. The device uses electrodes, a transmitter and a receiver for detecting whether the impulses sent by the brain are in the 20 Hz to 30 Hz range, thus indicating depression accordingly.

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