

# **An Improvised Methodology for the Extraction and Analysis of EEG Signals in the Diagnosis of ADHD Syndrome**

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**ABSTRACT:** A common mental disorder that begins in childhood and can continue through adolescence and adulthood is Attention Deficit Hyperactivity disorder(ADHD). Epilepsy, sleep disorders, coma, encephalopathy, and brain death are diagnosed using EEG. The first-line method of diagnosis for tumours, stroke and other focal brain disorders is EEG. This paper is presented to predict the probable region of brain that shows abnormality due to ADHD syndrome. EEG data of five normal and ADHD affected subjects (children) of age group 4-17 years has been collected following a protocol which contains 3 events-Eyes Blinking, Left hand movement and right hand movement. The segmented data is subjected to extract features like, energy that corresponds to Alpha, Beta, Delta and Theta frequency ranges and amplitude levels at different electrode positions. Single map analysis is also performed and distance measure is done for comparative analysis between the normal and ADHD affected subject- Manhattan distance .For improvised classification Euclidian distance is implemented. This paper work concludes that the posterior region of the brain, covering electrode positions O1, O2, T3 and T4 could be considered to predict the abnormality during eye blinking activity. Anterior portion of the brain, covering pre-frontal regions and frontal region of the brain, with electrode positions FP1 and FP2 could be used to predict the abnormality.

**KEYWORDS:** Attention Deficit Hyperactivity Disorder (ADHD), Electroencephalography (EEG), Distance Measure.

## **I. INTRODUCTION**

Attention Deficit Hyperactivity Disorder (ADHD) can be described as a neurological condition characterized with problems such as inattention and hyperactivity-impulsivity which are developed inconsistent with the age of the child. It is noticed that ADHD is a function of developmental failure in the brain circuitry that monitors inhibition and self-control and not a disorder of attention as had long been assumed. Loss of self-regulation pairs other important brain functions such as crucial for maintaining attention and the the ability to defer immediate rewards for later gain .Excessive motor activity is also a behaviour of children with ADHD.. The high energy level and subsequent behaviour are manifestation of the disorder and require specific interventions. Children with ADHD exhibit a range of symptoms and levels of severity. Many children with ADHD have seen observed to have at least average intelligence and have a range of personality characteristics and individual strengths.

It affects children and teens and it continue into adulthood. One of most commonly diagnosed mental disorder of children is ADHD. Children with ADHD are prone to be hyperactive and find it difficult to control their impulses and they may have trouble paying attention. These behavioural characteristic interfere with school and home life. ADHD is more commonly seen in boys than girls It's usually noticed during the preliminary school years, when a child begins to face problems paying

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attention .Adults with ADHD may have difficulty in managing time, being organized, setting aims, and holding down a job. They may also face problems in relationships, in having self-esteem, and addiction.

## II. RELATEDWORK

1. Attention deficit disorder with or without hyperactivity (ADHD) is characterized by the prevalence rate of 69% among school age children within United States and persists in adolescence in 70% and in adulthood in 40-60%. children with ADHD displayed increased theta power, slight elevations in frontal alpha power, and diffuse decreases in beta mean frequency according to the largest study of EEG.[2]
2. Children with ADHD have typically found increased theta activity, increased posterior delta, decreased alpha and beta and an increase in the theta/beta ratio compared to normal children according to the EEG studies.. This study has also investigated the presence of EEG subtypes of children with the combined type of ADHD. Results have indicated the presence of 3 distinct EEG-defined clusters of children, characterized by increased slow wave activity and deficiencies of fast wave, increased high amplitude theta with deficiencies of beta activity, and a beta-excess group.[3]
3. The first method used to study brain processes in children with attention deficit hyperactivity disorder (ADHD) are the electrophysiological measures. According to the conclusion depicted by the Early reviews of studies of electrophysiological measures collected on hyperactive or ADHD children the disorder is most likely associated with problems of under reactivity to stimulation and task demands with less evidence supporting resting under arousal in the disorder. EEG findings in children, adolescents, and adults with ADHD have increased slow-wave activity in frontal regions, suggesting cortical hypo arousal, especially in the ADHD Combined subtype.EEG measures discriminate well between children with and without ADHD according to several reports of the researchers.[1]

## III.TYPES SYMPTOMS AND CAUSES OF ADHD

### A. TYPES OF ADHD

When it comes to ADHD, no one diagnosis or treatment fits all since everyone is different. According to The American Psychiatric Association identification there are three types. Each type has different symptoms, and treatments are based on those symptoms.

1. Inattentive type
2. Hyperactive type
3. Combined type

### B. SYMPTOMS OF ADHD

- Not paying attention to the given detail and making careless mistakes
- Difficulty in following directions and finishing tasks.
- Forgetting about daily activities and faces problems in organizing daily tasks.
- Getting up often when being seated
- Running or climbing at inappropriate times

### C. CAUSES OF ADHD

- Low birth weight.
- Brain damage either in the womb or in the first few years of life.
- Consumption of alcohol, smoking or misusing drugs while pregnant.

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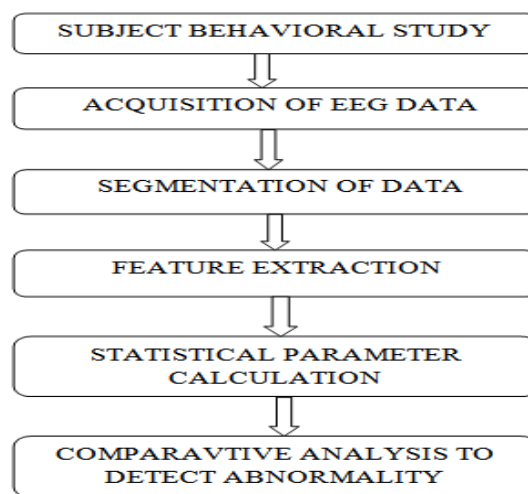
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- Exposure to high levels of toxic lead at a young age.
- Prematurity birth (before the 37th week of pregnancy).

## IV. METHODOLOGY



### A. Subject behavioural study

Subject means the child who has been considered for the studies in this paper. So, here 5 normal and 5 ADHD children were identified and considered for the research. An interview was conducted to the parents/ guardians of ADHD subjects and doctors/teachers as a part of this work. Subjects of age group 4-17 were chosen for this study.

### B. Acquisition of EEG data

According to International standard 10-20 electrode system EEG signals of selected ADHD and normal subjects were obtained using Brain Tech traveller portable EEG device with 24 channels digital EEG machine having A/D conversion of 16 bits sampling frequency of 256 Hz.

Here, 10-20 denotes the placement of electrodes in a particular manner as shown in figure.

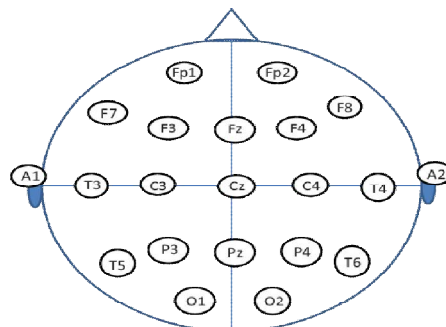


Figure 1: International 10-20 electrode system

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Electrodes are placed on the scalp in special positions. These positions are identified by using the International 10/20 System. This relies on taking measurements between certain fixed points on the head. The electrodes are then placed at points that are 10% and 20% of these distances. Each electrode site is labelled with a letter and a number. The letter refers to the area of brain underlying the electrode e.g. F - Frontal lobe and T - Temporal lobe. Even numbers denote the right side of the head and odd numbers the left side of the head.

## C. Protocol used

To understand the thinking of a person few activities are to be performed by the subjects during data acquisition. the electrical activity in subjects brain is changed by these activities which can help the doctor to make a diagnosis. It's helpful to keep as still as possible during the test, because any movement can also change the electrical activity in your brain. This can affect readings. The protocols used are as follows

- Eyes blinking
- Left hand movement
- Right hand movement

The markers were inserted by noting down the timings. While the children are performing these activities the timings were noted down and accordingly the markers were inserted. We requested the subjects to blink their eyes for few seconds with varying time record length. This helps us to study the alpha wave activity. The timings for each event in eyes blinking are 5second. The second protocol is left and right hand movement. In this protocol we made the subjects whose data we were collecting to watch a slide show. This slide show consisted of aspects such as colours, numbers, and animals which are identifiable by both normal and abnormal subjects. The left hand and Right hand movement was conducted for around 5 seconds. We studied the delta, theta, alpha and beta waves behaviour.

## D. Segmentation of data

The process of taking the data i.e., EEG signal and segmenting it so that it can be easy to analyze the brain activities is called as data segmentation.

## E. Feature extraction

The parameters such as mean, SD and variance were calculated for different EEG signals such as frequency bands and energy.

## F. Statistical parameter calculation

Statistical parameter can be defined as important component of any statistical analysis. Any numerical quantity that characterizes a given set of data or some aspect of it is known as a parameter which means that it tells something about the whole data.

The different types of parameters that have been calculated are:

- a) Mean
- b) Variance
- c) Standard deviation
- d) Amplitude levels

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## V. EXPERIMENTAL RESULTS

### A. Single map analysis

Comparative analysis of EEG signals between the ADHD and Normal subjects yields the following results:

EVENTS	NORMAL SUBJECTS	ADHD SUBJECTS
EYE BLINKING	<ul style="list-style-type: none"> <li>• Lower amplitude level.</li> <li>• Lower SD compared to ADHD subjects.</li> <li>• Higher SD in both P3 and T3.</li> </ul>	<ul style="list-style-type: none"> <li>• Higher amplitude level</li> <li>• Higher SD is observed in FP1 and P3.</li> </ul>
LEFT HAND MOVEMENT	<ul style="list-style-type: none"> <li>• Lower amplitude level.</li> <li>• SD is relatively lower than the ADHD subjects.</li> <li>• SD is higher in P3.</li> </ul>	<ul style="list-style-type: none"> <li>• Higher amplitude level.</li> <li>• Higher SD is observed in O2 and P4 positions.</li> </ul>
RIGHT HAND MOVEMENT	<ul style="list-style-type: none"> <li>• Higher amplitude level is seen in temporal region.</li> </ul>	<ul style="list-style-type: none"> <li>• Higher amplitude is seen in occipital region.</li> </ul>

Table 1 : Comparison analysis of single map

The amplitude levels are measured for each event as per the protocol used in single map analysis. The unit for the measured amplitude levels is in micro volts ( $\mu V$ ). These amplitude levels indicate the brain activities. Varies from person to person. It may be positive or negative values.

Eye blinking:

Electrode position	Normal subjects	ADHD subjects
FP1	19-45	35-130
FP2	17-91	35-121
O1	19-22	28-69
O2	19-22	28-69
P3	29-91	35-114
P4	29-37	33-47
T3	23-45	24-49
T4	21-34	26-51

Table 2: Standard deviation for eye blinking even

The table 2 provides the range of Standard deviation for ADHD and normal subjects for electrode positions FP1, FP2, O1, O2, P3, P4, T3 & T4 for eyes blinking position. As observed in the table, lower SD values are observed for normal subjects when compare to ADHD.

### B. ENERGY CALCULATION

Here we calculate the energy and find the range analysis. This is performed for every event and for 8 selected electrode positions. 1st row is for delta band, 2nd for theta, 3rd for alpha and fourth for beta.

Normal Kids:  
Eyes Blinking:

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Frequency/ electrode	FP1	FP2	O1	O2	P3	P4	T3	T4
Delta	2-210	5-685	126-196	168-755	2-813	450-507	322-507	169-607
Theta	2-19	16-119	32-54	54-113	61-146	61-174	50-264	29-103
Alpha	17-296	11-202	52-59	22-250	72-442	31-560	62-365	35-220
Beta	26-47	24-37	35-46	40-57	55-70	39-56	67-146	48-64
Gamma	22-52	20-29	25-29	20-45	32-53	27-52	39-58	40-58

Table 2: Energy calculation for Normal subjects in eye blinking activity

In normal subjects, they have higher alpha activity in P4 position, i.e. right side of the brain which is responsible for cognitive processing. A considerably good alpha activity is seen in the T4 position which indicates that normal subject think or memorize during eyes blink event.

ADHD kids:  
Eye Blinking:

Frequency/ electrode	FP1	FP2	O1	O2	P3	P4	T3	T4
Delta	2-100	2-673	2-497	7-441	2-334	233-565	2-233	2-309
Theta	93-308	116-328	105-348	144-516	68-291	67-313	66-277	35-197
Alpha	2-164	2-197	3-150	2-232	38-200	223-500	50-123	20-88
Beta	116-285	126-285	267-475	377-571	235-471	281-481	186-387	205-486
Gamma	3-10	4-9	3-8	13-30	18-49	20-32	24-47	31-53

Table 3: Energy calculation for Normal subjects in eye blinking activity

During eyes blink event, ADHD subjects showed beta activity in most of the electrodes. They even showed theta activity at electrode position F2, O2, P3, and T4, P4. They have less alpha and gamma activity, which should have been more if they were normal kids. Similarly for left hand movement, In normal subjects, they have higher theta activity in T4 position, i.e. right side of the brain which is responsible for learning ability and sensory interpretation. A considerably good alpha activity is seen in the P4 position which indicates that normal subject have good sensory reception during left hand movement. During left hand movement, ADHD subjects showed alpha activity in most of the electrodes. They even showed alpha activity at electrode position FP1, O1, P3, and T4, P4. They have less gamma activity, which should have been more if they were normal kids.

## VI.CONCLUSION

This paper work included 5 ADHD and 5 normal subjects. The work includes two types of evaluation 1. Behavioural evaluation, 2. Educational evaluation. In the behavioural evaluation, subjects' parents and teachers of ADHD subjects were interviewed and questioned to obtain the child's previous medical history, social behaviour, symptoms of disorder and so on. which showed that the disease may be hereditary, the ADHD child was under medication, had improved in day-to-day activities after training, and mainly, the root cause for the syndrome was quoted to be due to the severe epilepsy and fever within the age 1 year (as informed by doctors) and partially due to the improper growth of brain.

MATLAB software is used for the calculation of parameters such as mean, energy and standard deviation . which is used for the comparative analysis between ADHD affected and normal subjects. Several analysis performed indicate that, ADHD affected subjects show increased neuronal activities in the eyes blink position, whereas normally, healthy subjects tend to suppress their neuronal activity. Generally, alpha is higher in electrode positions P3 and P4 and beta waves are high in case of a ADHD subject in the electrode position O2 and T4 for eyes blinking event .Here , the ADHD cases show very low alpha in the region T4 and O1 and Higher beta power levels in position O2 and T4.



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