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Implementation of EEG signals and P-300 Component to estimate Mild Cognitive Impairment (MCI)

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Abstract*: *Aim: The aim is to estimate the parameters of MCI by evaluating the EEG and P-300 component of subjects. The controlled healthy and MCI patients selected for this analysis. The aim is to reveal the worsening cognition in the patients and diagnose the disease at an early stage. Method: EEG recording & P-300 measurement of 30 subjects is performed. Considering all the possibilities and artefacts 1024-point Quantitative EEG selected to perform the analysis. Results: The parameters of EEG and P-300 analysis revealed the difference between Controlled healthy and MCI group patients. Power, relative power, symmetry, coherence, phase cross spectrum, correlation were differentiated using QEEG analysis. Conclusion: The study on MCI patients discovered that the mass posterior sluggish rhythm of frequency bands dropped the alpha and beta behavior whereas the occipital movement of the alpha and beta band in the usual aging is increasing. The P-300 component used to classify MCI and Controlled healthy people.

Index Terms*: *EEG, MCI (Mild Cognitive Impairment), Power Spectrum, P-300, Statistical Analysis

I. INTRODUCTION

The experimental arrangement of the Mild Cognitive Impairment (MCI) is related to the memory mutilation which cannot be compared to the definition of dementia. The MCI can be called as pre-stage of dementia and Alzheimer's disease (AD). MCI is the alteration between normal ageing and dementia. According to the research studies of 'Semeion Research center of Sciences of Communication', Rome, Italy the conversion rate of patients from MCI to AD is 6 to 40% and from normal aging (Controlled Healthy) to AD ranges from only 0.18% to 3.9% [2]. Pointing to this reason, the patients or persons suffering from MCI are considered for analysis. In order to plan the favorable remedial solution, it is necessary to make an early diagnosis of MCI in elderly patients which may result into developed AD [1-4].

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To reveal the analysis of MCI, AD and other neurological disorders, EEG analysis with all its frequency rhythms used for classifying the patients and providing correct solutions to minimize the effects of neurological disorders. Neurophysiology, and in particular electroencephalography (EEG), provides the appropriate means in the biomarkers study of dementias [4, 24].

The Fig.1 shows the curve of worsening cognition with respect to time. Time can be in months, days or years. It shows three major cases control healthy class i.e. normal humans, Mild cognitive impairment i.e. normal people suffering from memory loss that means person may or may not suffer from dementia. The threshold value shows that below which there is Age Related Cognitive Impairment (ARCI),

means old age person may or may not suffer from dementia. The moderate value shows that the person may suffer from early stage dementia which can be detected and cured. But in severe case Alzheimer disease (AD) can occur. AD is a progressive disease which can be reverted back and cannot be cured.

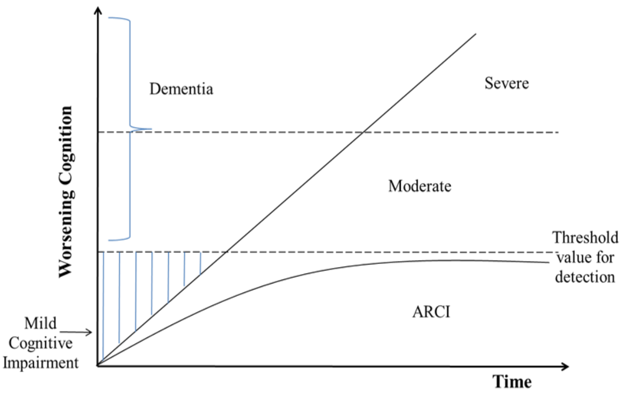

Fig 1. Classification of patients

The features of Control healthy and MCI patients are considered for analysis.

The curve of worsening cognition with respect to time is shown in Fig. 1. It shows three major cases control healthy class i.e. normal humans, Mild cognitive impairment i.e. normal people suffering from memory loss that means person may or may not suffer from dementia. The threshold value shows that below which there is ARCI, means old age person may or may not suffer from dementia. The moderate value shows that the person may suffer from early stage dementia which can be detected and cured. But in severe case Alzheimer disease (AD) can occur.

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Therefore, for early diagnosis of dementia (MCI) it is necessary to perform the laboratory tests, mental state examinations, functional magnetic resonance imaging (fMRI) etc. But these techniques are costly and require experience clinicians.

The evaluation time of these techniques is very long. Hence, effectiveness of the early diagnosis of the disease may worsen if proper analysis tool is not used.

To overcome these limitations, appropriate neurophysiologic techniques like EEG and MEG that are appropriate to detain the macroscopic spatial temporal dynamics of the electromagnetic fields of the brain are used. Also, quantitative electroencephalography (qEEG) is used as a tool for assisting physicians to choose exact amount of EEG data for analysis [1, 4]. This is required since EEG is recorded for many hours or also overnight i.e. sleep EEG. Since the EEG signal replicate practical alteration in the cerebral cortex, it can be used to analyze neuronal degeneration and practical impairment before actual tissue loss can be detected by fMRI [1-4, 15, 19].

By comparing the Z-score values, statistical analysis of EEG signals and QEEG; MCI patients and normal aged controlled healthy person can be differentiated. The different EEG rhythms, different states and brain regions gives the appropriate knowledge of MCI.

Zhu B. et.al. has described the Lempel-Zev degree analysis technique which is used to calculate the EEG parameters of MCI patients. The brain functional characteristics and symptoms are investigated in this paper [1].

The EEG analysis performed during meditation process is explained in the paper. The SPECT scan technique can used to differentiate between the patients practicing meditation and those who do not [2].

The multiple EEG biomarkers for predicting progression of Alzheimer's disease at MCI stage explained by authors shows the results of large database of neurosciences. The neurophysiological toolbox utility is also shown by analysing MCI patients [3].

The early detection of MCI using QEEG technique considering the EEG rhythms is covered by Norsiah Fouzan. The power spectral density approach is carried out to show the difference between MCI and healthy [4].

Andras Howarth et.al critically reviews the EEG as a biomarker of Alzheimer's disease. The dynamical systems theory (DST) are surveyed and also sleep studies are performed. The synaptic neurotransmission as a potential biomarker also enlightened [6].

Irene Sturm et.al. evaluated EEG recordings of nine samples who submissively listened to stimuli from various sound categories around simple tone series which examined multivariate analysis. EEG outcrop was then employed to determine the Cortico-Acoustic Correlation (CACor), a measure of management between EEG signal and stimulus [7].

In [19], EEG spectral analysis is carried out of the subjects during MUSLIM prayer. In this technique stress is also considered in addition to the cognition. The cognition is compared before and after performing the Muslim methodology of the prayer. The statistical analysis of EEG with ANOVA explains how these techniques can be used in biomedical engineering.

The solution approaches used in analysis of EEG are shown in Table-I.

II. METHODOLOGY

This part explains the technique of EEG recording, database used for analysis, various EEG frequency bands, and QEEG analysis.

A. Database used

EEG capturing carried in a special guard room of Shantiniketan hospital, Nagpur. EEG signals were recorded as per the international standard of '10-20 electrode system' from 24 channels using RMS-24 India machine with 1024 points sampling frequency for bipolar montages as shown in Figure-2 and 3. These electrodes are FP1-F7, F7-T3, T3-T5, T5-O1, FZ-CZ, CZ-PZ, FP2-F4, F4-C4, C4-P4, P4-O2, FP1-F3, F3-C3, C3-P3, P3-O1, FP2-F8, F8-T4, T4-T6, T6-O2 [16, 18].

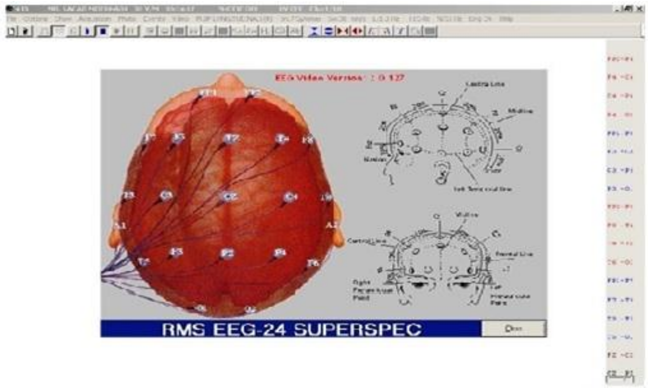

Fig. 2. Placement of Electrodes

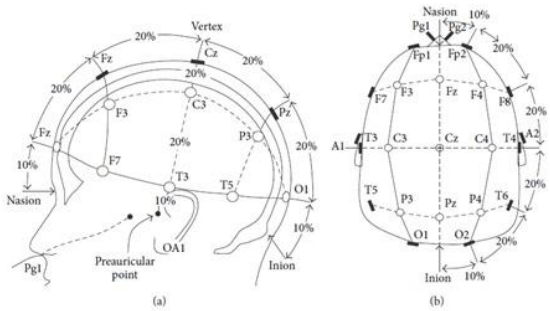

Fig. 3. The 10–20 EEG electrodes assignment system (a) and (b) 3-dimensional view [

Electroencephalography accounts electrical movement of brain and brain impression using electrodes placed on the scalp. Computing electrical actions from the brain is useful since it imitates how the many dissimilar neurons in the brain network communicate with each other via electrical impulses.

The standard 10-20 electrode placement system and its three-dimensional view which clearly shows the practical electrode placement on the scalp after applying the gel as shown in Fig. 2 and 3.

The mini state mental examination was also carried out to properly differentiate between controlled healthy and MCI patients. The cognition and dementia patients were not considered i.e. only two groups were formed controlled healthy and MCI.

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Table I: Solution Approaches used in analysis of EEG

Authors	Methods of EEG analysis	Hardware/ Software used	Technique Adopted	Remarks (Data used)
Christopher Dooley et.al, 2016	Meditative practices, Transcendental Meditation, EEG as frequency bandwidths	Biomedical software for Endocrine and Immune systems	Baseline SPECT scans	Transcendental Meditation, Buddhist Mantra chanting on some users
Zhu B. et.al, 2017	2048-point EEG analysis	Mat tab	Lempel-Zev Degree	50 MCI patients Considered for statistical analysis
Pilar Garcés, et.al, 2014	Peak Fitting EEG analysis	Max filter software (version 2.2.)	signal space separation technique with movement compensation	27 patients with a MCI control group and 24 control healthy
Raymundo Cassani et.al, 2014	Spectral estimation	Wavelet analysis and Independent component analysis	Automatic Artifact removal algorithms	59 members were employed from the Behavioral and Cognitive Neurology Unit
Roberta Lizio et.al, 2011	EEG rhythms analysis	Low-resolution electromagnetic tomography algorithm (LORETA)	Source reconstruction of EEG scalp signals	Database not specified
Alida A. Gouw et.al, 2016	EEG rhythms	EEGLAB	MEG analysis, time frequency analysis	Database of three patients with Dementia
Amjed S. Al-Fahoum, 2014	FFT and Wavelet analysis	MATLAB	MUSIC , Nonparametric methods of EEG signals	Comparisons of nonparametric methods of EEG
Sheshav Somani, et.al	P-300 wave event related potential	P-300 analysis ERP software	-	Different stimuli like finger lifting, a unique music during analysis
Diego Alfonso Rojas et.al	EEG signals though speech processing	EMOTIV, EEGLAB	FFT, Analysis of variance (ANOVA)	Three subjects in stress free environment
J.Sateesh Kumar et.al	EEG rhythms	MATLAB	-	Characterization of EEG with respect to human states
Hazem Doufesh	Measuring of alpha, beta, theta, delta waves	MP150 EEG acquisition system (BIOPAC Systems Inc., California, USA).	Statistical analysis, ANOVA	9 subjects/ samples

A. EG Frequency Bands

To deal with EEG signals and to extract useful information and features that help in early dementia diagnosis, an EEG signal is illustrated in conditions of its rhythm's activity in the stated work. Medical EEG wave forms amplitude that is typically between 10 and 100 μv and at a frequency range of 1Hz to 100Hz. EEG is categorized into the following five rhythms according to their frequency bands as follows:

Delta : 1–3 Hz (20 μv to 200μv)
Theta : 4 – 7 Hz (5 μv to 10μv)
Alpha : 8 – 12 Hz (20 μv to 200μv) Beta : 13 – 25 Hz (5 μv to 10μv)
Gamma : 30Hz – 100Hz

B. Statistical terms related to QEEG

1. Z Score

Z score is calculated as the divergence between mean values of the samples taken (all patients) and the patient's entity score i.e. spectral values of all electrodes divided by the standard deviation of the all samples.

$$Z = \frac{\bar{x} - x}{\sigma^2} \quad (1)$$

Z score provides the data analysis of QEEG; whether there is an increase or decrease of theta, Delta or alpha activity for particular sets of electrodes. For e.g. excessive theta activity at Fz. The absolute power, relative power, coherence, frequency etc. are analyzed calculating the Z scores.

2. **Multivariate Analysis**

In this analysis, the groups of electrodes are formed according to the clinical or research convenience.

For e.g. Left Lateral – F7, T3, T5; Right Central – T4, C4 and so on. Depending on this several variables like mean, cumulative frequency etc. are obtained.

The multivariate analysis, Positive, negative and Zero Z -scores are obtained.

3. **Absolute power**

The definite power in the EEG of the patient and is the data which is measured in microvolt square.

4. **Frequency Ratios**

The values of alpha, theta, delta, beta etc.

5. **Relative Power**

The power percentage in any group of frequency contrasted to total power in EEG database of the patients.

6. **Coherence**

Interhemispheric and Intrahemispheric coherence measures the degree of similarity of EEG signals between two regions.

7. **Mean Frequency**

The average of EEG frequency within the frequency bands.

C. Statistical terms related to QEEG

As per the doctor's certification, standard alpha frequency less than 8 Hz is an abnormal frequency; condition is that patient must be fully alert. Alpha frequency occurs in posterior region of the brain. The lowering of alpha frequency cannot specify the disorder but can be considered in many cognition disorders. Therefore, Z score analysis is performed for all EEG electrodes. The occipital region of alpha (Oz-O2) with high value of alpha band is used for analysis in the current study. When the EEG signal is expressed in terms of frequency in coordination with various frequency bands, frequency components are obtained using period analysis. Power spectral density (PSD) demonstrate the might of dissimilarity i.e. energy as a function of frequency. The power spectral density is computed b performing the Fast Fourier transform (FFT) analysis using autocorrelation function and then transforming it into corresponding digital value of EEG [12-14]. Considering these details, QEEG calculates different brainwaves from different electrode positions of 10-20 electrode placement system. QEEG determined the electrical impulse signal in μV^2. This is proportional to the power of the signal on the specific electrodes on the scalp for detecting the electrical impulses. As per the analysis carried out, alpha and beta waves are outweighed and a fast component of EEG.

D. EEG Signal Acquisition

The EEG of the patients has been recorded in a specialized clinical unit state with the 10–20 system of the international federation, which is adopted by the American EEG Society, while resting with eyes comfortably closed, as shown in Fig.3.

EEG device encloses a lowpass, high pass, and notch filters. The usual frequency values for lowpass filter (LPF) (i.e., 3 dB) are 0.15, 0.28, 1.7, and 5.4 Hz, and the upper cutoff frequency values are, 15, 30, 70, or 300Hz. Typically, the frequency for EEG recording for MCI range is from 0.3Hz to 70Hz, and the notch filter is 50Hz or 60Hz. The sampling frequency is selected as 128Hz, 173Hz, or even 256Hz, 1024 and it is selected based on the application with a 12bit or 16bit A/D converter digitalizing the signal to be more correct [16,17,33].

- 24 electrodes (according to the 10-20 International System for electrode assignment)
- The subjects i.e. patients are to be classified under Control Healthy (CT) and MCI
- Sampling frequency of 256 and 1024 samples per second on (RMS-EEG 24 channel), with sweep time of 30 mm/s and SNR 7.5 µV/mm is taken.
- 300 seconds signal duration is taken into picture.

Table II. EEG Analysis sample details

Clinical Condition	No. of Subjects			Mean Age (In Years)	
	Female	Male	Total	Female	Male
CT	3	7	12	66.45	68
MCI	7	5	18	69	70

Table-II shows the samples collected i.e. the number of patients those undergone EEG analysis. The eyes closed analysis was carried out for entire work since eyes closed provide artefact free data.

E. Event Related Potential

P300 ERP randomness in usual subjects is a complicated factor in scientific event-related possible studies because it restricts analytical applicability. The present study is conducted to decide whether classification of P300 (P3A and P3B) mechanism using source examination methods can decrease discrepancy in P300 parameters. The EEG of some patients suffering from MCI is coming out be normal after some time/ days. The mild cognitive impairment, dementia parameters should not change with respect to time, therefore, a technique is to be employed for same. Hence P-300 will be carried out and compared with EEG.P-300 is an event related potential module obtained in the procedure of result making. It is consider being an event managed potential, as its incidence not only relates to the physical attributes of a stimulus, but to a person's reaction to it. This process is carried out on RMS-24 channel EEG machine with P-300 stimulus installed as shown in Fig.4 [18].

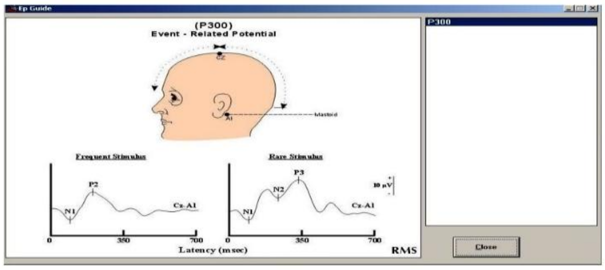

Fig. 4. P-300 Electrode Placement

RMS 24 channel machine with P-300 test and electrode placement with proper stimulus applied. Also showing the graphs of frequent stimulus and rare stimulus.

When the brain identifies a person or a sound, it produces a scrupulous type of electric wave which is called a P-300. Sensors are placed to the head of a person with hearing aids and are seated before a computer. The sensor monitors a electrical action in the brain and register P-300 waves which are created only if the subject has some association with the stimulus. Therefore, P-300 is an event related potential whereas EEG is not. This test is done to classify the patients into normal, MCI (mild cognitive impairment) and established dementia.

In this analysis statistical analysis of EEG including Z-score and nonparametric technique and P-300 component of EEG are used to classify the controlled healthy and MCI patients.

III. DESIGN AND IMPLEMENTATION

A. Implementation Flowchart

EEG signals are time varying signals with respect to voltage. In clinical and research field quantitative analysis of EEG is focused due to the requirement of digital signal processing. Therefore, EEG signal should be processed with respect to time as a random variable and voltage. This will provide random set of discrete signals. This is obtained by process of sampling, quantizing and analog to digital conversion.

The sampling of EEG signal is done by keeping the statistical properties unchanged. The EEG signal is sampled at regular intervals of δ_t, thus changing the continuous signal into set of impulses known as discrete signals. This is performed by appropriate analysis of sampling theorem. Most of the EEGs are sampled at the sampling frequency of 256 to 2048 Hz amplitude levels. The implementation flowchart is shown in Fig.5

B. Probability Distribution

EEG digitized signal values of $a(t_i)$ is compared to one of the stochastic process and is distinguished by the histogram analysis considering stationarity. The continuous EEG is replaced by a string of numbers $a(t_i)$ which represents signal amplitude at chronological sample moments. When 'n' sample points are taken in the interval of 2δ (sampling

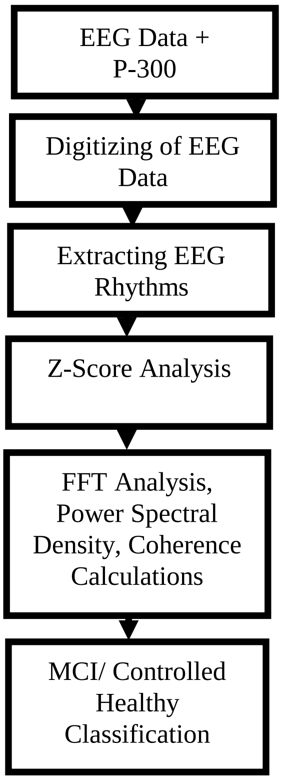

Fig. 5. EEG Implementation Flowchart [22]

theorem), the relative frequency of occurrence with 'a' point is obtained. i.e. n/N. where N is the total number of sample variables in discrete form of EEG signal. The set of values p(a(ti)) is the signal probability distribution considering the mean and moments. The mean or average of the sample function is given by:

$$E[x(t_i)] = \left[\sum_{c=1}^{N} x.p(a(t_i) = x\right] = m_i \qquad (2)$$

The nth central moments can be defined from the above equation. The first moment E[x(ti)] is called as the mean and the second central moment is called variance of a(ti). The third central moment is calculated form the skewness factor β1. The fourth moment 'kurtosis' is derived from the fourth central moment and then Z score hypothesis is formed depending upon the samples taken.

C. Correlation Function and Spectra

The successive values of an EEG signal which results into a stochastic process are not necessarily independent. To calculate the degree of interdependence joint probability distribution is is found for successive discrete values. The covariance and autocorrelation is from the sampled values of EEG are calculated using the following expectation

$$\emptyset_{xx}(\tau_k = \left(a(t_i)a(t_i + \tau_k)\right) = \frac{1}{T} \qquad (3)$$

This time average is called autocorrelation function. The Fourier transform of the autocorrelation function is calculated and it is called as power density spectrum. The windowing technique is applied and close relationship is calculated to obtain the variance.

The EEG signals are realized as random processes and these signals are characterized by corresponding probability distribution and its moments by autocorrelation function.

The average zero-crossing rate is used to calculate the moments of the power spectral density.

D. Power Spectral Analysis

EEG signal is defined in terms of frequency by establishing the frequency bands of EEG rhythms of alpha, beta, delta and theta. The period analysis technique is used to obtain the information of the frequency components of the EEG signal. The appropriate method to obtain the analysis of signal is Fourier analysis.

E. Selection of EEG signals

The 256 and 1024 sampling period artifact free EEG data was collected form RMS 24 channel EEG machine to set up the data file for further analysis. Then, Fourier transform technique applied to convert the signal into frequency domain. In filter processing, the EEG data under 0.45 Hz and over 50 Hz is removed or excluded. Using the Inverse fast Fourier transform) to process data by the inverse transform. And at last Z score statistical analysis is done.

IV. RESULTS AND DISCUSSIONS

The appropriate distribution of the EEG amplitude is examined by observing the topographical maps. The distribution of delta, theta, beta and alpha is flat enough all over the cortex. Alpha is highest at the occipital region and is present at the posterior portions of the head.

The Z scores are calculated for finding out the abnormalities and to provide correct analysis of absolute power, relative power, and coherence and mean frequency.

The statistical table provides the Z-score values that give the information about raw scores and reference group average values.

The Z-score analysis provides a suggestion of the kind of the disorder while magnitude provides the harshness of the disorder.

Odd examination that clusters jointly may be analytic of a localized irregularity of cortical functions. That means enlarged value of theta value of absolute and relative power linked with asymmetries in the similar region may be an suggestion of localized area dysfunction.

Regional abnormalities can be associated with dementia, depression or stress. Understanding of the position of the abnormality with reference to the MCI patient and in correlation with the EEG signal; QEEG is necessary to perform.

A. QEEG Analysis

The QEEG analysis is done for Female patient in the group of MCI (z scores shown later) form 30 samples with age of 68 years. The EEG analysis was performed on RMS-24 channel machine as shown in the figure. The bipolar montages are selected according to the 10-20 electrode system with linked years.

The qEEG study were abnormal from normal and showed dysregulation in bilateral frontal lobes especially in the right frontal lobe, bilateral temporal lobes especially in the left temporal lobe, bilateral parietal lobes especially in the right parietal lobe and bilateral occipital lobes especially in the right occipital lobe.

LORETA (8Hz.) showed deregulation in the right better temporal gyrus, right inferior parietal lobule, right posterior insula and right fusiform gyrus.

The frontal lobes are occupied in executive functioning, abstract thinking, expressive language, sequential planning, mood control and social skills.

The temporal lobes are concerned in acoustic analysis of brain activities, short-term memory, and accessible speech on the left and features identification on the right.

The parietal lobes are implicated in visual-spatial information processing, short-term memory, executive attention, accessible speech on the left and empathy control and awareness of emotional expression in others on the right (e.g., prosody).

The occipital lobes are involved in the visual processing of colour, form, movement, visual perception and spatial processing.

The posterior insular cortex is involved in autonomic system regulation and representation of the physiological state of the body. This is involved in analysing the colour information, body and face identification, word detection, and within-category identification. To the extent there is difference from normal electrical prototypes in these structures, then sub-optimal execution is predictable.

The Linked Ears power spectral investigation were abnormal from usual with extreme power in bilateral frontal regions especially in the right frontal region over a broad frequency range, excessive power was present in bilateral temporal regions especially in the left temporal region from 1 - 3 Hz, extreme power was present in bilateral parietal regions especially in the right parietal region over a wide frequency range and excessive power was also present in bilateral occipital regions especially in the right occipital region from 1 - 4 Hz.

EEG amplitude irregularity, consistency and EEG phase were unusual from normal, especially in frontal, temporal, parietal and occipital regions. Elevated coherence was there in frontal, temporal, parietal and occipital regions which point out compact functional differentiation. Reduced coherence was present in frontal, temporal, parietal and occipital regions which indicate reduced practical connectivity. Both circumstances are regularly associated to reduced speed and effectiveness of information processing.

The Fig.6 shows surface neurofeedback recommendation. These are the values obtained by the clinical evaluation of the patient by comparing the reference values of the database results. The delta, theta frequencies are obtained in the polar and central regions of the electrodes.

The coherence neurofeedback is also shown in the figure -6 below. This figure shows the values of all EEG frequencies considering all electrodes. Such figures are obtained for all other patients.

The Fig. 6 shows the Z score coherence values taken as a example for particular duration of EEG (for Some seconds). The Z score coherence values of various electrodes are shown according to the EEG rhythms.

The networks Z scores are calculated using the spectral analysis and using the Neuroguide software the following results are obtained. The Broadman areas of the Z circle considering all the population score are calculated and obtained as follows as shown in figure-7 below.

The anxiety, addiction and poor attention values are treated under MCI condition.

The Z-score FFT summary is shown in the following Fig-6. The following figure shows the various statistical parameters using the Z- score analysis

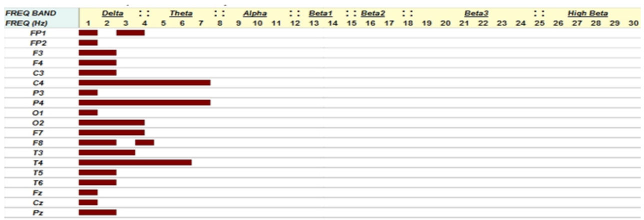

Fig. 6. Coherence neuro-feedback analysis values

Z score FFT values for different electrodes showing the parameters of Addiction, Anxiety and Attention which in turn can be related to dementia is shown in figure 7.

The example obtained from the linked ears bipolar montage with absolute power is shown in figure 8 below.

The laplacian bipolar montage Z score FFT absolute power is shown in the figure 9 and 10.

The different values of Z-score analysis for FFT amplitude asymmetry is shown below in figure 11 with all values of Z.

The different values of Z-score analysis for FFT amplitude asymmetry is shown below in figure 11 with all values of Z.

Montage: Statistical Information of Electrode values. The following table 2 shows the average value of the corresponding electrodes. The EEG record length is about 3:48 and edit length is about 1:20

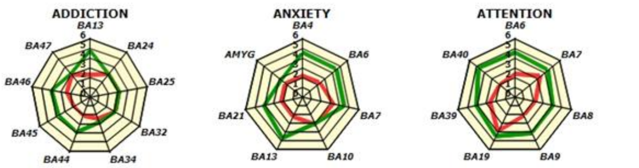

Fig. 7. Z-Score FFT Values

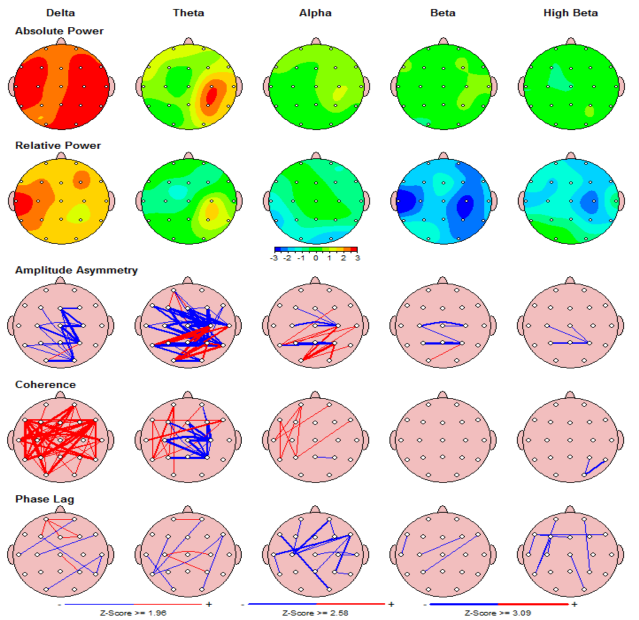

Fig.8. Linked ear bipolar montage statistical parameters

Linked ear bipolar montage statistical parameters for various values of Z score is shown in figure 8. The Z score of 1.95, 2.56 and 3.09 are considered. The Z score are calculated considering the relative power and absolute power of the various electrodes placed into the scalp. The coherence values of various electrodes, phase lag analysis which is useful for EEG rhythms analysis is also calculated using this montage statistics.

Absolute power analysis is shown in the figure 9. The absolute power is calculated for a particular time range of EEG signal. The graph of absolute power shows frequency vs. magnitude. The absolute power is calculated for all electrode voltage values.

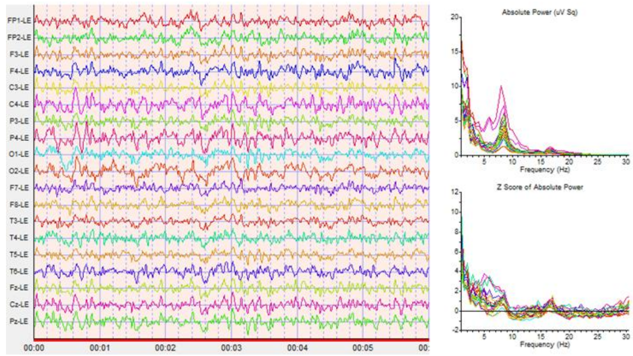

Fig. 9. Absolute power analysis

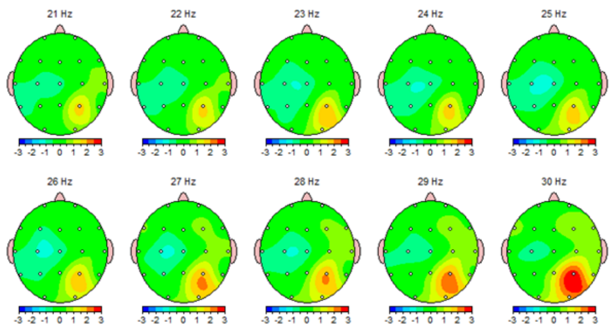

Fig. 10. Z-Score Asymmetry

Z-Score asymmetry is obtained in figure 10. This figure shows the asymmetry values of all electrodes at various frequencies. The frequencies are taken at random.

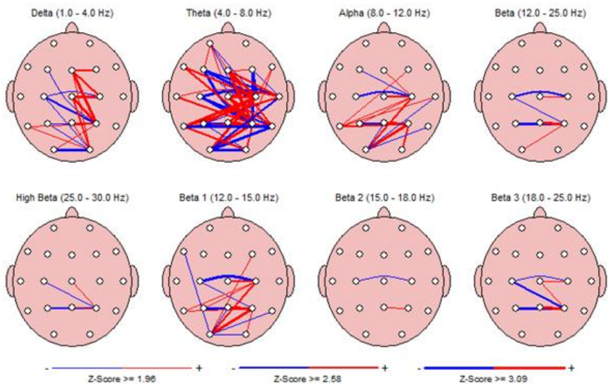

Fig. 11. FFT amplitude Asymmetry

FFT amplitude Asymmetry is shown in the figure 11. The FFT values for different A score is calculated for some duration of the EEG signal which provide proper frequency analysis

Table III. Z-Score values of Electrodes

Electrode	Split Half		Test Retest
Average	0.94		0.94
FP1	0.88		0.87
FP2	0.97		0.88
F3	0.90		0.92
F4	0.95		0.91
C3	0.92		0.95
C4	0.96		0.96
P3	0.94		0.93
P4	0.94		0.96
O1	0.94		0.91
O2	0.96		0.94
F7	0.88		0.86
F8	0.94		0.96
T3	0.92		0.96
T4	0.94		0.96
T5	0.94		0.95
T6	0.97		0.96
Fz	0.91		0.95
Cz	0.93		0.95
Pz	0.95		0.94

The EEG frequency analysis obtained is described below

- α waveform is typically experimental in the posterior area of the head
- β waves are practically occurred in the parietal and frontal area of the scalp
- θ wave is documented across the temporal and parietal area of the scalp with an amplitude series of 5 μv to 10μv.
- δ wave can be traced frontally in adults and subsequently in children
- δ wave can be recorded frontally in adults and posteriorly in children

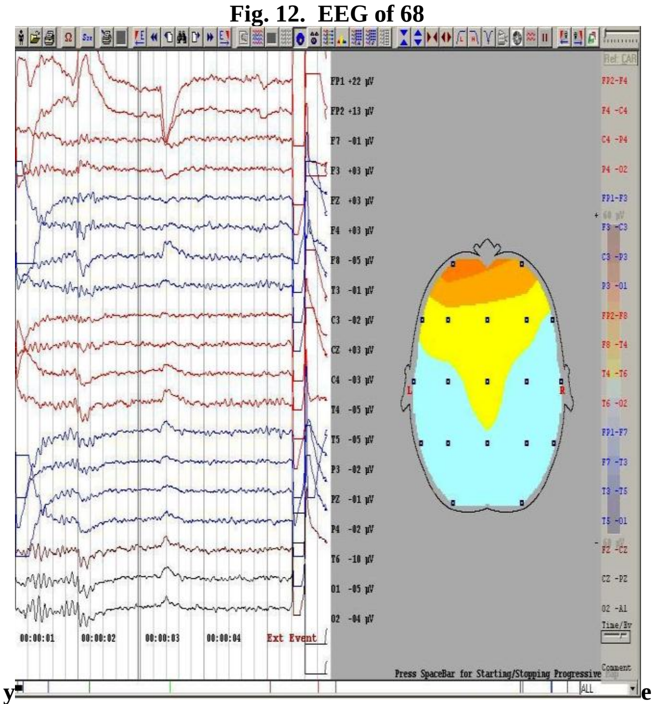

Fig. 12. EEG of 68 years old male patient

A 68-year old male patient with fluctuating memory complaints and mild extra pyramidal signs that started a couple of years ago. Clinically, AD was suspected as cause of his symptoms. His EEG (24 channels; source derivation) was moderately severely abnormal with an evident slowing of the background rhythm (peak frequency 6.3 Hz, only theta-delta activity at the posterior EEG channels.

B. P-300 RESULTS

Fig. 13. P-300 wave of MCI patient

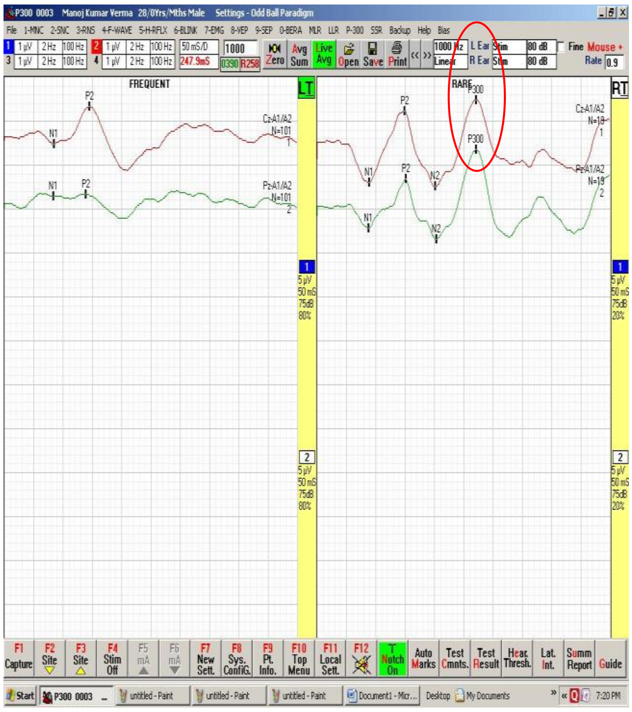

Fig. 14. P-300 wave of normal patient

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Table-IV: P-300 test results of MCI patient

Montage (L)	N1 (mS)	P2 (mS)	N2 (mS)	P300 (mS)	P300-N2 (µV)
Cz-A1	63.54	119.79	167.71	318.75	0.86
Cz-A1	87.5	114.58	189.58	297.92	0.1

Montage (R)	N1 (mS)	P2 (mS)	N2 (mS)	P300 (mS)	P300-N2 (µV)
Cz-A1	66.67	109.38	167.71	282.29	1.22
Cz-A1	68.75	103.13	171.88	281.25	0.71

Table V. P-300 test results of controlled healthy

Montage (L)	N1 (mS)	P2 (mS)	N2 (mS)	P300 (mS)	P300-N2 (µV)
Cz-A1	84.38	144.79	-	-	0.86
Cz-A1	84.33	138.54	-	-	0.1

Montage (R)	N1 (mS)	P2 (mS)	N2 (mS)	P300 (mS)	P300-N2 (µV)
Cz-A1	88.54	148.96	201.54	270.83	10.30
Cz-A1	87.50	151.04	203.13	270.83	10.50

The finding of the proposed explains about choosing the proper quantity of EEG which can be used to study the different Neuro-physiological diseases. The statistical analysis of the EEG shows the comparison between the reference values and calculated values of the patients. Also, Event related potential P-300 helps in analyzing the neuro test more correctly, since electrode placement, time required for test is easy as compared to EEG analysis.

The limitation of the existing study is that, the database considered is small. At least 100-150 patient database is to be collected and this will be included in the future work.

V. CONCLUSION

This part of the paper discusses about the different parameters that are evaluated for the two groups controlled healthy and MCI

- EEG can be used as a way of analyzing of pre-stage Alzheimer disease i.e. MCI. Different deviations are created in the EEG signals. If the EEG signals are slowed down, compact difficulty, Perturbations in synchrony actions are some of the irregularities found.
- EEG signals of patients affected by pre-Alzheimer's disease, Mild Cognitive Impairment, and controlled healthy samples were examined and processed by concerning a time-frequency analysis.
- The analyzed datasets have often been small and additional studies are needed to confirm those promising results. However, the above results can be used to classify and analyze the EEG as a useful clinical evaluation tool in the discrimination of established dementia.
- EEG-based detection of the progress of dementia and classification of its severity are highly desirable viewing methods in medical practice due to its less cost and convenient features make it a promising technique.
- EEG can then be of help in a specific differential diagnosis to make one of the diagnoses a more or less likely cause of the patient's symptoms.

The inspection on Mild cognitive impairment collection of samples exposed the mass posterior sluggish frequency rhythms of EEG dropping the beta and alpha behavior whereas the occipital movement of the alpha and beta band in the controlled healthy group is rising. The results illustrated the allotment of delta and theta power analysis or slow cerebral measure for both controlled healthy and the MCI. A decrease of delta at the sub-frontal areas for the standard and middle regions is related to the cognitive rejection at the hippocampal area. Investigation of EEG exposed statistically noteworthy changes of slowing the EEG movement of the MCI group. There is a boost in delta and theta at the posterior and left temporal region of the brain (T6, T5) and prefrontal lobe (F7, F8) of the brain amongst the MCI over the controlled normal aging group and increase in Beta 1 and Beta 2 over the temporal areas among MCI group. Also, there is a noteworthy reduction in alpha rhythm frequency at the central region (C3, Cz, C4) and posterior region.

In early stages of the disease, relative theta power increases together with a decrease in relative beta power and slowing of the peak frequency. In later stages, further slowing occurs reflected by additional decreases in relative alpha power and increases in relative delta power. However, in early stages of dementia the EEG can also be normal, especially in patients whose symptoms start at a later age.

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