View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Archivio della ricerca- Università di Roma La Sapienza

RESEARCH ARTICLE OPEN ACCESS

Is it necessary to measure all brain regions for the assessment of PAF?

Sushma Rathee[1], Divya Bhatia[1], &Rajbir Singh[2]
[1]*Maharishi Dayanand University, Rohtak, India*
[1]*Sapienza University of Rome, Rome, Italy*
[2]*Shree Guru Gobind Singh Tricentenary University, Gurugram*

ABSTRACT
From decades of research, electroencephalography (EEG) has been proved as a potential non-invasive medical technique to measure the electrophysiological activities of brain. Alpha is one of the most prominent frequency bands of EEG because of its applications in cognitive enhancement and biofeedback methods. 300 participants were included in the present study to investigate the relationships between their cognitive performance and Peak Alpha Frequency (PAF). Brain activity was recorded from all significant brain regions in 250 participants and only from occipital region in 50 participants. The aim of the present study was to ensure the brain region which is the most dominant one to measure PAF/ IAF. Power Spectrum Density (PSD) method was used for EEG signal analysis. Interrelationship among PAF, IAF and PAF of six individual electrode positions was also explored. Findings reveled that parieto- occipital electrode points are sufficient to assess one's peak alpha frequency.
Keywords: Peak alpha frequency (PAF), Individual alpha frequency (IAF), Power Spectral Density (PSD), Factor analysis, Electroencephalography(EEG).

Date of Submission: 20-12-2017 Date of acceptance: 03-01-2018

I. INTRODUCTION

In an adult brain billions of neurons communicateto each other and transfer the information which gives rise to different mental states such as arousal, relaxation and preparedness. An electroencephalogram (EEG) is the electrical activity of brain recorded non- invasively from scalp. An EEG is being used to detect potential changes in brain associated with different brain states. Small, flat, metal discs electrodes are attached to the scalp in order to record the electrical impulses in the brain and send signals to a computer, where the activity is recorded. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain[1] which gives rise to different brain waves.EEG wavesare defined as:Delta(0.1 to 3.5 Hz) rhythm, which is dominant during deep sleep of adults and also found in adults with brain disorders such as dementia and schizophrenia; Theta (3.5 to 7.5 Hz) waves arefound usuallyin meditation and light sleep (or drowsy) mainly observed at frontal, temporal and parietal regions; Alpha(7.5 to 14 Hz) waves are dominant in awakeand relaxed state. Beta (13 to 30 Hz) waves appear during intense mental activity or the state of stress; Gamma (above 40 Hz) waves appear during the burst of insight and high level of information processing task [2].

Alpha frequency

The alpha rhythm is the most prominent EEG wave pattern found in adults with closed eyes who are awake but relaxed.Alpha wave has been found in every region of brain but the greatest amplitude is recorded from the posterior and occipital regions of the cerebral cortex [3]. Results from various studies indicate that: 1) Females tend to have higher mean frequencies of alpha waves than males. 2). Alpha wave amplitudes vary with the participant's attention to cognitive tasks when performed with the eyes closed as well as open eyes.In general, amplitude of alpha waves isreduced when participants open their eyes and are attentive to external stimuli, although some of them trained in relaxation techniques can maintain high alpha amplitude even after exposure of external stimuli [4].Alpha waves are produced by posterior regions of the head in both hemispheres, but higher amplitude is found in the dominant hemisphere in electrode points such asC_3 andC_4[5].

Peak alpha frequency (PAF) corresponds to the discrete frequency with the highest magnitude within the alpha range, and is also known to be slower in children and the elderly, although it also varies across individuals[6, 7].***Individual alpha frequency (IAF)*** measures the average of waves, rather than peak, within the boundaries of

alphafrequency for each individual, and has been used as a different, and possibly more accurate measure of spectraldistribution than PAF [6]. The median for high and low PAF is considered 10Hz. Though EEG *alpha* can be recorded from several electrodes point on the scalp but the multiplicity of attaching electrodes always causes a distress to the subject as well as the experimenter. Since there appears a lot of concordance in patterns of *alpha*, could it be obtained from a few electrodes point without losing inherent information particularly in case of estimating PAF/IAF of the participants. Therefore the present study was conducted to assess the alpha brain waves in different areas and most importantly to focus onthe specific brain region which can be a representative of PAF/IAF.

Power Spectrum Density

Many researchers have used different methods to analyze EEG frequencies such as linear, non- linear, time domain, frequency domain and time- frequency domain. One of the most dominant method to estimate the strength of the signals is power spectrum density (PSD). PSD is a function readily available in the EEGLAB toolbox. Spectral analysis has been performed in many studies of human sleep signals [8] and EEG signals during hypnosis [9]. One more recent study accessed the dominance of alpha frequency in brain using PSD and concluded that the parietal channels in EEG are the best to look into alpha bands [10].

II. METHOD

Participants:

A total of 300 self reported healthy young adults(Male = 151, Female = 149) from age group 18 to 30 years (mean = 22.8, SD = 2.8)whovoluntarily participated in the studywere selected from Haryana, India. Participants did not report any neurological or psychiatric history and also provided their written informed consent before proceeding to the study. They were briefed about the EEG technique, procedure and usefulness.The sampling method adopted for participant'sselection was incidental-cum-probabilistic sampling. The participants were either provided with the compensation or course creditsfor their participation. Most of the participants were residents of Haryanaregistered in graduate programs in colleges and universities, a homogenous population of Indian ethnicity.

Equipment:

EEG was recorded with a 19 Channel, portable, digital, easy to use EEG machine provided by Medicaid Systems, Chandigarh, India with 15 inches laptop (Dell Vostro 3568, Intel core i5 processor, Refresh rate 60 Hz). Silver Chloride plated metal disc electrodes were used to measure the brain activity from scalp.

Procedure:

Participants were instructed to thoroughly clean their hair and dry them before their participation in thestudy.EEG data were collected in an isolated room with peaceful environment, florescent lighting and no other person waspresent except for the participant and the experimenter.The participants were fitted with the electrode cap and impedance was reduced below 5kOhmsand resting state EEG was recorded for 8-10 minutes. Participants were seated comfortably on an arm-chair during the recording and were instructed to stay still, relaxed and eyes closed.Electrodes were placed using 10-20 international electrode placement system with reference electrodes at ear lobes and data were recorded in eyes closed condition. Six electrodes, relevant to alpha waves [Fz, Cz, P_3, Pz, P_4, O_1] were selected for further analysis using Power Spectrum Density method [10].

EEG Data Analysis:

Eye blink artifacts were removed after visual inspection of raw EEG data which then was analyzed using the EEGLAB toolbox on MATLAB. First two minutes data for each participant was divided into three epochs of 40 seconds. Power Spectrum Density (PSD) function in the EEGLAB toolbox was applied to each set of data which showed different peaks for each of the frequency range for each electrode point. The highest peak in the alpha frequency range was visually inspected and noted down for each data set which was the PAF for the corresponding data set. Three PAFs for each electrode point were calculated using PSD and the average of it makes the PAF for the corresponding electrode. The average of peak frequency of all six electrodes makes the individual alpha frequency for each participant. Statistical analysis on the PAF and IAF was performed by SPSS statistics software. The descriptive analysis for demographic variables, correlationsand factor analysis were performed on the data.Factor analysis is the standard and frequently used technique to establish a validity of construct [11]. Hence, principal component method with varimax rotation was attempted for the analysis.

III. RESULTS AND DISCUSSION:

The inter-correlations among IAF and PAFs obtained from six electrode points as well as the results of factor analysis are shown in Table 2. The overall age of the sample was 22.38 (SD=2.82) years. The average PAF for all participants is 9.93 Hz (SD = 2.01) whereas the average IAF happens to be 8.65 Hz (SD = 1.41).

TABLE 1: Description of the variables, Age of participants, Individual PAF for Six electrode points,Overall IAF of sample,overall PAF of sample.

	N	Mean	SD
Age (yrs)	300	22.38	2.82
Fz	250	8.56	1.59
Cz	250	8.59	1.64
P3	250	8.82	1.82
Pz	250	8.86	1.85
P4	250	8.76	1.74
O1	300	8.74	1.76
IAF	300	8.65	1.41
PAF	300	9.93	2.01

TABLE 2: Inter correlationsof individual PAF of each electrode point, overall IAF, overall PAF and Principal Axis Factor Analysis (N= 250)

	C_Z	P_3	P_Z	P_4	O_1	IAF	PAF	Factor (Rotated) Loadings
F_Z	.390**	.259**	.282**	.260**	.281**	.558**	.476**	.558
C_Z		.451**	.412**	.374**	.228**	.630**	.506**	.659
P_3			.574**	.527**	.412**	.741**	.584**	.773
P_Z				.578**	.325**	.738**	.568**	.762
P_4					.467**	.742**	.591**	.771
O_1						.737**	.591**	.638
IAF							.768**	.971
PAF								.835

TABLE: 3 Skewness and Kurtosis of all electro-physiological variables.

	F_Z	**C_Z**	**P_3**	**P_Z**	**P_4**	**O_1**	**IAF**	**PAF**
N	250	250	250	250	250	300	300	300
Mean	8.65	8.64	8.89	8.92	8.82	8.80	8.68	10.02
SD	1.59	1.64	1.85	1.86	1.78	1.77	1.41	2.01
Skewness	1.36	1.34	1.03	1.09	.98	1.10	1.31	.343
SE Skewness	.154	.154	.154	.154	.154	.141	.141	.141
Kurtosis	1.83	1.35	.150	.476	.127	.609	2.11	-.863
SE Kurtosis	.307	.307	.307	.307	.307	.281	.281	.281

It was found that overall average IAF and PAF across the participants had strong positive correlations which also happen to be strongly correlated with PAFs of all electrodes points;strongest correlations were found with the parieto- occipital electrode points.

To know the similarities or differences between PAFs obtained from six different electrode points; factor analysis was performed onthe IAF, overall PAF andPAFs of six electrode points.It was found that there was one principal component which explained 15- 20 % of the variance. It was therefore revealed that PAF/IAF can be obtained from any one or two electrode points from Parieto-occipital region of the brain.

This procedure is likely to reduce the experimenter's burden and participant's discomfort. Moreover, IAF/PAF are individualistic variables; moreover, people can be categorized into two bands low IAF/PAF (8 to 10 Hz) and high IAF/PAF (10 to 13 Hz) [12]. It is true that IAF/PAF aredispositional/traits and distributed normally in large sample. The succeeding figures (Figure 1 and 2) demonstrate this construct.

The description of PAF for different electrode points on the scalp revealed deviations from normality whereas the distribution of IAF and overall PAF exhibited quite a normal distribution (Table 3, Figure 1 & 2). Since the factor analysis (Table 2) and distributions (Table 3) indicated that

IAF/ PAF is a fit variable with lesser Skewness and Kurtosis to be considered as idiographic. It is also indicated that our data falls in the range of low alpha band (M IAF= 8.68 H_Z with M PAF= 10.00 H_Z) andIAF/ PAF exhibited distributions closer to normality.

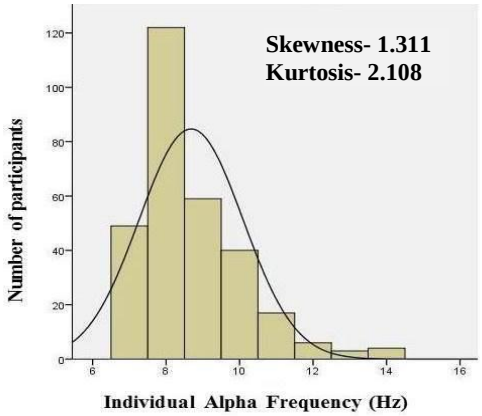

Fig: 1 Frequency Distribution of Individual Alpha Frequency (IAF).

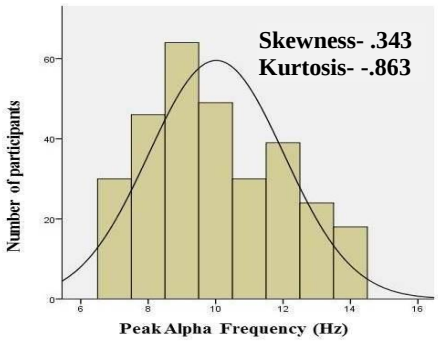

Fig: 2 Frequency Distribution of Peak Alpha Frequency (PAF).

IV. CONCLUSION

The aim of the present study was to ensure the specific brain region which can represent PAF/ IAF. We concluded that to measure PAF/ IAF, a small interval of 6 to 10 minutes from any two parieto-occipital electrodes may work. Occipital region is the best representative of PAF/ IAF. Our findings have neuro-psychometric significance with reference to the potential of EEG peak alpha/ individual alpha as an individualistic variable as it exhibited a to be near normaldistribution in a large sample. It is true in the majority of idiographic features. Since a good degree of evidences suggest its relationship to healthy mental functioning as well as cognitive performances and cognitive preparedness[12, 13, 14, 15]. The results suggest that Although some larger sample parametric studies with crossections of age band in healthy adults population is also required. Nonetheless PAF of EEG has potential to be considered as a system variable with a scope of wide array of variables.

V. FUNDING

"Authors acknowledge Department of Science and Technology, Government of India for financial support vide reference no. SR/CSRI/40/2014, Dated 26.06.2015 under Cognitive Science Research Initiative to carry out the work".

ACKNOWLEDGMENTS

The authors thanked Dr. Lokesh Gupta, Assistant Professor, SGT University, Gurugram, India for his constant guidance and support during the project.

REFERENCES

[1]. Niedermeyer, E. and da Silva F.L. Electroencephalography: Basic Principles, Clinical Applications, and Related Fields(Lippincott Williams & Wilkins, 2004).
[2]. Bablani, A., & Agrawal, S.K. (2015). Alpha Rhythm Analysis from Frontal Lobe using EEG based BCI. International Journal of Advance Research in Computer Science and Management Studies , Vol 3(7).
[3]. Teplan, M. (2002). Fundamentals of EEG measurement. Measurement science review, 2(2), 1-11.
[4]. Pflanzer, R., Uyehara, J.C. and McMullen, W. Electroencephalography I(Biopac Student Lab, PP 1-4, 2007).
[5]. G. Deuschl and A. Eisen q. Recommendations for the Practice of Clinical Neurophysiology: Guidelines of the International Federation of Clinical Physiology(Elsevier ScienceB.V.,1999)
[6]. Klimesch, W. (1997). EEG-alpha rhythms and memory processes. International Journal of Psychophysiology, 26, 319–340.
[7]. Posthuma, D., Neale, M. C., Boomsma, D. I., & de Geus, E. J. C. (2001). Are smarter brains running faster? Heritability of alpha peak frequency, IQ, and their interrelation. Behavioral Genetics, 31, 567–579.
[8]. Amin, M. S., Azim, M. R., Latif, T., Hoque, M. A., &Hasan, F. M. (2010, July). Spectral analysis of human sleep EEG signal, Proc. 2nd IEEE International Conference on Signal Processing Systems (ICSPS), Singapore, 2010(Vol. 3, pp. V3-106).
[9]. Deivanayagi, S., Manivannan, M., & Fernandez, P. (2007). Spectral analysis of EEG signals during hypnosis. Int J SystCybern Informatics, 9, 75-80.
[10]. Valipour, S., Shaligram, A. D. &Kulkarni, G. R. (2014). Detection of an alpha rhythm of EEG signal based on EEGLAB. International

Journal of Engineering Research and Applications,4(1), 154-159.

[11]. Anastasi, A. and Urbina, S., Psychological testing 7th Edition(Prentice Hall, New York, 1997).

[12]. Angelakis, E. Peak Alpha Frequency: an Electroencephalographic Measure of Cognitive Preparedness.Ph.D dissertation, University of Tennessee, Knoxville, USA, 2002

[13]. Angelakis, E., Lubar, J. F. &Stathopoulou, S. (2004) Electroencephalographic peak alpha frequency correlates of cognitive traits. Neuroscience Letters. 371 (1).60-63.

[14]. Angelakis, E., Lubar, J. F., Stathopoulou, S., &Kounios, J. (2004). Peak alpha frequency: An electroencephalographic measure of cognitive preparedness. Clinical Neurophysiology, 115(4), 887-897.

[15]. Angelakis, E., Stathopoulou, S., Jennifer, L., Green, F. D. L., Lubar, J. F., &Kounios, J. (2007). EEG Neurofeedback: A brief overview and an example of peak alpha frequency training for cognitive enhancement in the elderly. The Clinical Neuropsychologist . 21 , (1).

International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

Sushma Rathee "Is it necessary to measure all brain regions for the assessment of PAF?." International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 12, 2017, pp. 72-76.