# Alpha Activity in EEG and Intelligence

Shah Aqueel Ahmed[1], Dr D. Elizabath Rani[2] and Dr. Syed Abdul Sattar[1].

1. Royal Institute Of Technology And Science, R. R. Dist., A.P. , INDIA

informaqueel@gmail.com, syedabdulsattar1965@gmail.com

2. GITAM UNIVERSITY, Vishakhapatnam, A.P. INDIA

kvelizabeth@gitam.edu

## *ABSTRACT*

*Intelligence of a human being in general is considered as to its variations in the ability to learn, to function in society, and to behave according to contemporary social expectations Intelligence of a human being is associated with brain the brain is considered as the most complex biological existent structure. Electroencephalograph (EEG) is an instrument used for recording the electrical activity of the brain. EEG is the variation of the electrical fields in the cortex or on the surface of scalp caused by the physiological activities of the brain. EEG is currently the most widely adopted method for assessing brain activities. Detecting the changes of these waves is critical for understanding of brain function. In clinical applications, spontaneous EEG signals can be divided into several rhythms according to their frequency. They are $\delta$ rhythm (0.1-4Hz), $\theta$ rhythm (4-8Hz), $\alpha$ rhythm (8-13), $\beta$ and rhythm (13-30Hz). The EEG signals have close relationships with the cerebral diseases, mental status and human qualities like intelligence. As a consequence it is very useful to analyze process and classify the EEG signal on the basis of frequency bands and then extract their underlying features and so as to correlate with normal and abnormal functioning of brain, sleep, mental status and also with intelligence. In this paper we propose to conduct pointed literature survey of alpha activity and intelligence correlation. We propose to conduct test on subjects by computer, EEG interface. We propose to conclude from practical experimentation, whether there is a correlation between alpha activity power and intelligence.*

## *KEYWORDS*

*EEG (Electroencephalography), IQ (Intelligence Quotient), FFT (Fast Fourier Transform.*

## 1. INTRODUCTION

EEG activity in 13-15 bands was studied by Paterson M.B; Cluck h, Mack JL and found correlation with intelligence D Posthuma, M.C Neale, D.I Boomsma, and EJC Degeus have studied correlation between alpha peak and intelligence. The encyclopedia Britannica gives various theories of intelligence starting from Herbert Spencer Francin Galton etc have defined intelligence as ability to carry out abstract thinking in the book “the making of intelligence” Ken Richardson has pointed out various definitions of intelligence and measurement of IQ. He has

also pointed out that the origin of intelligence is in the brain and it can be proved experimentally. He points out various philosophers like Plato, Australia, Gabrial Murfy etc defining intelligence. The IQ was proposed by German scientist William Stern as below:

$$IQ = \frac{\text{Mental Age}}{\text{Chronological Age}} \times 100$$

The book "Mega brain" by Michel Hutson gives techniques how intelligence is proved. He gives the instrumental method. Norbert Fauovec claims that experiments have proved that alpha activity power is more with gifted persons.

### 2.1 DEFINING INTELLIGENCE

Most people have an intuitive notion of what intelligence is, and many words in the English language distinguish between different levels of intellectual skills, bright, dull smart, stupid, and clever, slow, and so on. Yet no universally accepted definition of intelligence exists and people continue to debate what, exactly, it is. Fundamental questions remain: Is intelligence one's general ability or several independent systems or abilities? Is intelligence a property of the brain, a characteristic of behavior, or a set of knowledge and skills? The simplest definition proposed is that intelligence is whatever intelligence tests measure. But this definition does not characterize the ability well, and it has several problems. First it is circular: The tests are assumed to verify the existence of intelligence tests exist, and they do not all measure the same thing. In fact, the maker's measure. Finally, the definition says very little about the specific nature of intelligence. Abilities are as follows Visual-Arithmetic- Spelling. These separate scores are spastically analyzed, and from them a general intelligence quotient.

TABLE 1: FREQUENCY RANGES OF DIFFERENT EEG ACTIVITY

| EEG Activity | Lower Frequency | Upper Frequency |
|---|---|---|
| Delta | 0 | 4 |
| Theta | 4 | 8 |
| Alpha | 8 | 13 |
| Beta | 13 | 30 |

We have collected data of number of subjects and computed IQ from written tests. We have separated$\alpha,\beta,\delta,\theta$**.** We have computed percentage power. We have tried to compare percentage power of$\alpha,\beta,\delta,\theta$ with IQ, relative IQ. We have calculated difference of alpha power and IQ. The results are interesting.

# 2. ALGORITHM

Programming is dividing into three parts

I) Taking the EEG waves
II) Calculate the Relative power for all waves
III) Calculate the % Difference with IQ & KIQ

$$Sum(1) = \sum_{Delta\,lower}^{Delta\,upper} Mg(k)$$

$$Sum(2) = \sum_{Theta\,lower}^{Theta\,upper} Mg(k)$$

$$Sum(3) = \sum_{Alfa\,lower}^{Alfa\,upper} Mg(k)$$

$$Sum(4) = \sum_{Beta\,lower}^{Bata\,upper} Mg(k)$$

$$Sum(0) = Mg(0) + ... + Mg(N-1)$$

Where Delta lower = Delta lower* N/Fs
Delta Higher = Delta higher* N/Fs

## 2.1 PROCEDURE

The students of Engineering are having good intelligence, hence student of mentally retarded school, subjects with various abnormalities in the brain are collected. The data collection is done for 1 hour continuous record of EEG using Polysomnography.

### 2.1.1 PERCENTAGE POWER CALCULATION

After applying the FFT to an EEG signal, the magnitude values are stored for each band. The lower cut of frequency and upper cut of frequency is defined depending upon the frequency range of each band. Only the signals between the upper band and lower band of EEG remain as they are. The graphical results for each band like Delta, Alpha, Beta and Theta are calculated as follows:

Theta higher = Theta higher* N/Fs
Theta Lower = Theta lower* N/Fs
Alpha lower = Alpha lower* N/Fs
Alpha higher = Alpha higher* N/Fs
Beta Lower = Beta lower* N/Fs
Beta higher = Beta higher* N/Fs

Where
Fs = Sampling Frequency (250Hz)
N = N Point DFT

Percentage power in each band is calculated as:

Delta percentage power = Sum (1)/Sum (0)
Theta percentage power = Sum (2)/Sum (0)
Alpha percentage power = Sum (3)/Sum (0)
Beta percentage power = Sum (4)/Sum (0)

## 3. INTELLIGENCE STANDARD

The time, weight, length etc. have the international standards based on comparison with standard parameters. Similarly unless a base of intelligence is assumed the relative measurement of intelligence cannot be done. For this purpose Prof. S.G. Kahalekar's alpha activity is considered unit, i.e. 100. The comparative KIQ can be direct unit of intelligence parameter.

Figures in Table 2 show how Alpha activity is dominating all other activities in all montages, which is termed as Relative Power Frequency Band. Bar graph shown in Figure 1.4 gives the comparison between different Alpha activity, IQ and the KIQ and shows the clear cut relation between alpha activity and the IQ; also it shows the IQ level of subject with respect to KIQ. Bar graphs in figure 1.5 and 1.6 give us an idea of individual subject's IQ levels and KIQ level respectively. Figures in table 3 & 4 shows us how the percentage power of alpha activity is related to the performance of the subjects in their SSC exams. From table 5 relations between all the parameters which were being considered for the analysis is getting clear, which gives a broad picture of relationships between Alpha activity, SSC marks, IQ and KIQ. Percentage difference between alpha activity and SSC marks is shown by table 6, from which it is clear that difference is acceptable and our technique is not far away from the accuracy. And at last table 7 gives us the comparison between all the parameters of 20 subjects, which is self explanatory in explaining the relationship between IQ of person and his/her power of alpha activity.

TABLE 2: RELATIVE POWER FREQUENCY BAND

| MONTAGES | DELTA | THETA | ALPHA | BETA |
|---|---|---|---|---|
| FP2-F4 | 2.2 | 20.1 | **61.2** | 16.5 |
| F4-C4 | 0.6 | 25.5 | **71.3** | 2.6 |
| C4-P4 | 15 | 14.4 | **49.9** | 20.6 |
| P4-O2 | 5 | 23.1 | **66.1** | 5.8 |
| O2-A2 | 1.3 | 3.3 | **87.8** | 7.6 |
| A2-F2 | 2.9 | 17.4 | **56.5** | 23.1 |
| F2-T6 | 2.4 | 32.4 | **61.7** | 3.5 |
| T6-O2 | 4.3 | 10.3 | **49.9** | 35 |
| FP1-P3 | 4.5 | 16.3 | **71.8** | 2.4 |
| F3-C3 | 1.9 | 17.4 | **57.5** | 23.1 |
| C3-P3 | 4.5 | 16.3 | **70.8** | 8.4 |
| | | | | |

| | | | | |
|---|---|---|---|---|
| P3-O1 | 1 | 23.1 | **66.1** | 9.8 |
| T3-T5 | 1.6 | 24.5 | **71.3** | 2.6 |
| T5-O1 | 2.9 | 13.4 | **60.5** | 23.1 |
| O1-A2 | 3.2 | 12.5 | **59.5** | 24.8 |
| FP2-F8 | 1.8 | 14.6 | **55.8** | 27.3 |
| F8-T4 | 2.4 | 25.8 | **57.5** | 14.5 |

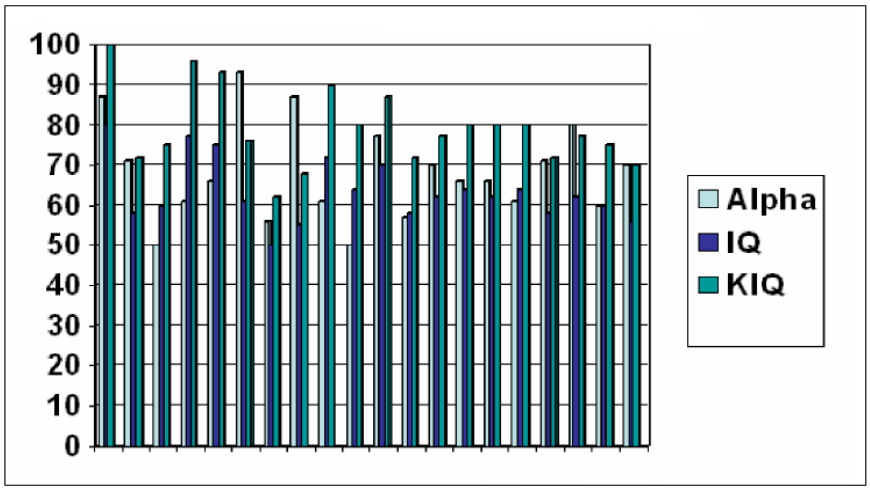


Fig.1.4 Bar Graph for Alpha, IQ, KIQ

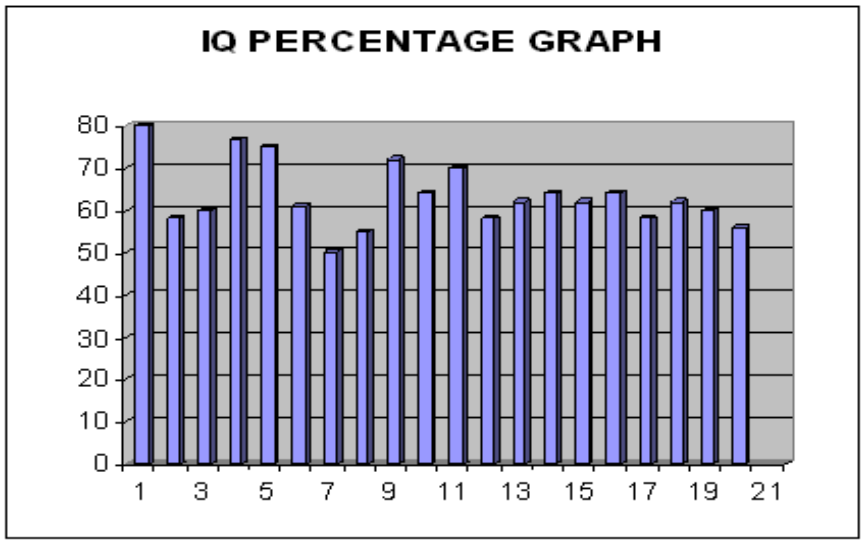


Fig.1.5 IQ Percentage

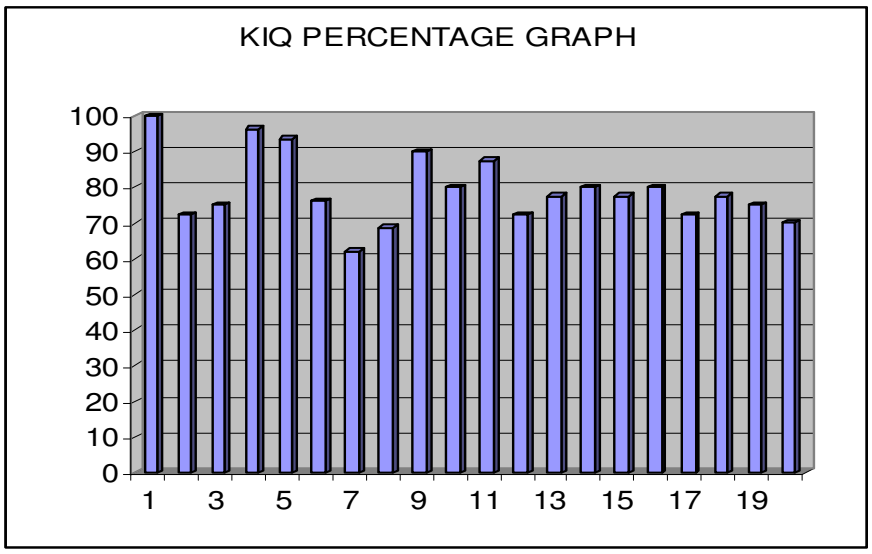


Fig.1.6 KIQ Percentage

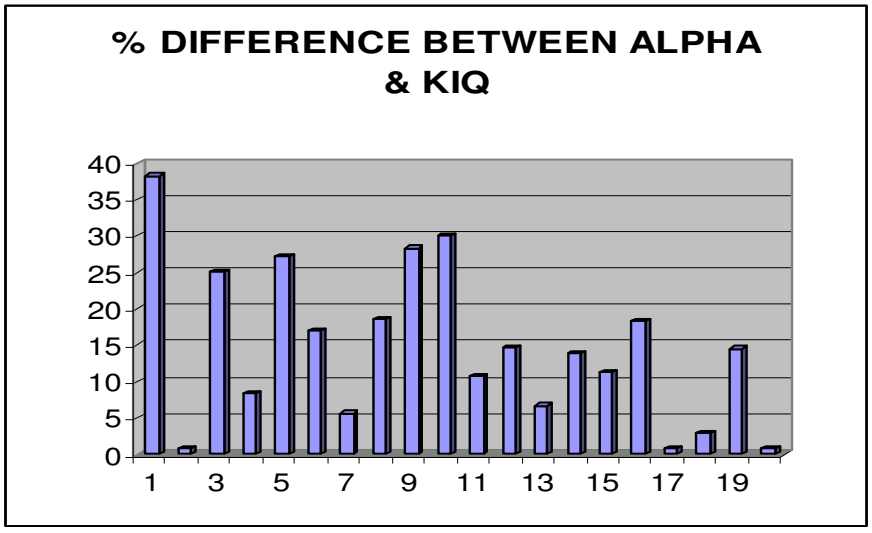


Fig.1.7 % Difference b/w Alpha & KIQ

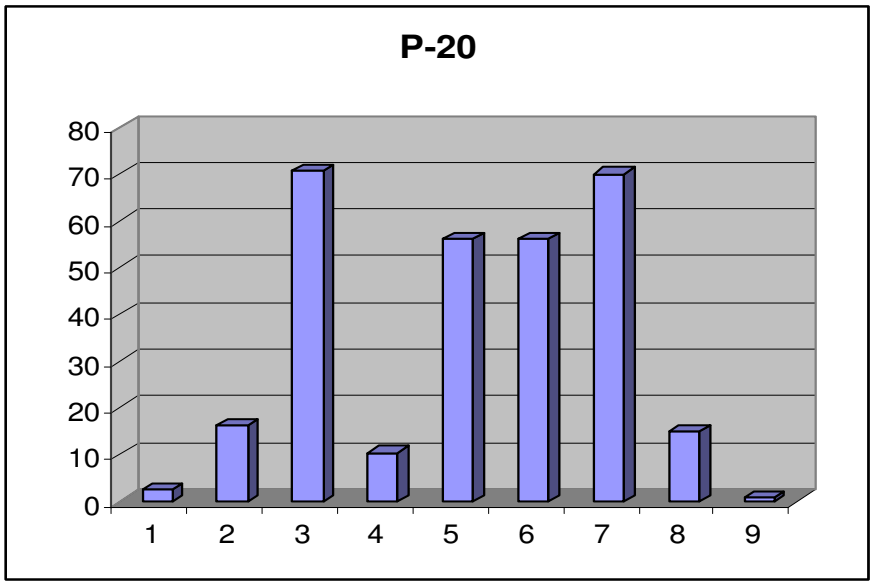


Fig.1.8 % Difference b/w Alpha & KIQ (P-20)

TABLE 3: MAX. % POWER OF ALPHA ACTIVITY BY PSG OF 5 SUBJECTS.

| S.N. | PATIENT NAME | MAX. % POWER OF ALPHA ACTIVITY BY POLYSMOGRAPHY |
|---|---|---|
| 1 | PT-1 | 85.6 |
| 2 | PT-2 | 72.3 |
| 3 | PT-3 | 65.8 |
| 4 | PT-4 | 50.2 |
| 5 | PT-5 | 48.7 |

TABLE 4: MAX. % POWER OF ALPHA ACTIVITY COMPARED WITH SSC MARKS

| S.N. | COMPUTED MAX.ALPHA ACTIVITY POWER | SSC MARKS | % DIFFERENCE |
|---|---|---|---|
| 1 | 85.4 | 83 | 2.4 |
| 2 | 72.0 | 71 | 1 |
| 3 | 65.5 | 63 | 2.5 |
| 4 | 50.1 | 55 | 4.9 |
| 5 | 48.9 | 50 | 1.1 |

TABLE 5: POWER OF ALPHA ACTIVITY COMPARED WITH IQ, SSC MARKS, AND KIQ

| S.N. | IQ | SSC | KIQ | ALPHA POWER |
|---|---|---|---|---|
| **1** | **80** | 83 | 84.6 | 85.6 |
| **2** | **73** | 71 | **76** | 72.3 |
| **3** | **67** | 63 | **61.8** | 65.8 |
| **4** | **50** | 55 | **46** | 50.2 |
| **5** | **43** | 50 | **48.1** | 48.7 |

TABLE 6: MAX. % POWER OF ALPHA ACTIVITY COMPARED WITH SSC MARKS

| S.N. | MAX. % POWER OF ALPHA ACTIVITY BY POLYSMOGRAPHY | SSC MARKS | %IFFERENCE |
|---|---|---|---|
| 1 | 85.6 | 83 | 2.6 |
| 2 | 72.3 | 71 | 1.3 |
| 3 | 65.8 | 63 | 2.8 |
| 4 | 50.2 | 55 | 4.8 |
| 5 | 48.7 | 50 | 1.3 |

TABLE: 7 GRAPHICAL RESULTS OF ALPHA ACTIVITY AND INTELLIGENCE

| **S. No.** | **NAME OF A SUBJECT** | **RELATIVE POWER FREQUENCY BAND** | | | | **SSC MARK** | **I Q** | **KIQ** | **% DIFFERENCE** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **DELTA** | **TETA** | **ALPHA** | **BETA** | | | | **IQ-ALPHA** | **KIQ-ALPHA** |
| P-1 | Prof.S.G.Kahaleka | 02.2 | 20.1 | **61.2** | 16.6 | **70** | **80** | 100 | 18.2 | 38.2 |
| P-2 | Monalikar Nagesh | 00.6 | 25.5 | **71.3** | 02.6 | 58 | 58 | 72.2 | 13.3 | 0.9 |
| P-3 | Umer Pasha | 15.0 | 14.4 | **49.9** | 20.6 | 60 | 60 | 75.0 | 10.4 | 25.1 |
| P-4 | Mandale Pramod | 01.3 | 03.3 | **87.8** | 07.6 | 77 | 77 | 96.2 | 10.8 | 8.4 |
| P-5 | Bharti Gajanan | 05.0 | 23.1 | **66.1** | 05.8 | 75 | 75 | 93.5 | 8.9 | 27.2 |
| P-6 | Rakhonde Nilesh | 02.9 | 17.4 | **56.5** | 23.1 | 50 | 50 | 62.2 | 6.5 | 5.7 |
| P-7 | Abdul Wahab | 02.4 | 32.4 | **61.7** | 03.5 | 72 | 72 | 90.0 | 10.3 | 28.3 |
| P-8 | Abdul Naeem | 04.3 | 10.3 | **49.9** | 36.0 | 64 | 64 | 80.0 | 14.1 | 30.1 |
| P-9 | Sardeshpande A.S | 04.5 | 16.3 | **76.8** | 02.4 | 80 | 70 | 87.5 | 6.8 | 10.7 |
| P-10 | Ganesh Rathod | 01.9 | 17.4 | **57.5** | 23.1 | 58 | 58 | 72.5 | 0.5 | 14.7 |
| P-11 | Atar Imran K | 04.5 | 16.3 | **70.8** | 08.4 | 62 | 62 | 73.5 | 8.8 | 6.7 |
| P-12 | Mhatre Pranal | 01.0 | 23.1 | **66.1** | 09.8 | 64 | 64 | 60.0 | 2.1 | 13.9 |
| P- | Man Mohan Singh | 03.0 | 18.1 | **66.2** | 11.7 | 62 | 62 | 71.5 | 4.2 | 11.3 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | | | | | | | | | | |
| P-14 | Landgu Mohan | 02.4 | 28.4 | **61.7** | 07.5 | 64 | 64 | 82.0 | 2.3 | 18.3 |
| P-15 | Tolnur Prashant | 01.6 | 24.5 | **71.3** | 02.6 | 58 | 58 | 62.2 | 13.3 | 0.19 |
| P-16 | Kadve Sachin | 02.9 | 13.4 | **60.5** | 23.1 | 60 | 60 | 75.5 | 0.5 | 24.5 |
| P-17 | Saleem choudry | 03.2 | 24.5 | **59.3** | 26.8 | 78 | 50 | 62.2 | 13.3 | 10.3 |
| P-18 | D.Altaf khan | 01.8 | 14.6 | **65.8** | 27.3 | 78 | 80 | 70.0 | 10.4 | 15.7 |
| P-19 | Nayeem Ahmed M | 02.4 | 25.8 | **57.5** | 32.5 | 81 | 80 | 80.0 | 10.8 | 6.17 |
| P-20 | Syed Mujstar | 04.1 | 32.6 | **65.8** | 35.3 | 74 | 75 | 87.5 | 8.9 | 23.9 |

## 4. CONCLUSION

The α activity can be measured using latest instruments. The literature supports the correlation of α activity with intelligence. The data recorded also supports correlation between α activity and human intelligence. Hence we conclude that the Alpha activity has more correlation (less % Difference) as compared to other waves. Alpha activity is related is to Intelligence Quotient. The tables show only few results. Actually 200 subject test data is available. In Table 7.5 Relative Power Frequency Band, alpha activity is calculated by FFT. We observe that the power of alpha activity is maximum as the subject is in alert and awake state, more over the power of alpha activity is maximum in O2-A2.Thus we conclude that the alpha activity is responsible for intelligence, and is dominant at all points in a awake and alert person and is at maximum at O2-A2.

## 5. REFERENCES


[1] Patterson M.B, Gluck h, Mack JL, Journal of Neuroscience, 1983, Sep, 20(3-4) pp 161-71.

[2] D posthuma, M.C.Neale, D.I. Boomsma, and E.J.C. Geus. "Are smarter Brains running faster? Heritability of Alpha Peak frequency IQ, and their correlation", Journal of Behavior Genetics, Vol.31, No.6, Nov 2001

[3] Encyclopedia Britannica, 1985, 15th edition, Vol 21, PP710-711.

[4] En Richardson, "The making of intelligence", Orion House, London, 1999, PP66.

[5] Michel Hutson, "A new tool and technique for brain growth", Mega brain Ballantine Books, New York, Aug 1987 PP 51-60. Norbert Jauovec, Journal of Intelligence, vol.3 issue3, Nov-Dec 1996, pp 159-173 Elsevier science.

[6] BW Jervis, G W Morgan spectral analysis of EEG Responses medical and biological Engg and computing May 1989, PP 230

[7] J Banquet EEG and Meditation Journal of EEG and Clinical Neurophysiology Vol. 33 (1972) PP 449-458

[8] Sepideh Sadaghiani, Rene Scheeringa, Katia Lehongre, Benjamin Morillon, Anne-Lise Giraud and Andreas Kleinschmidt, "Intrinsic Connectivity Networks, Alpha Oscillations, and

[9] Tonic Alertness: A Simultaneous Electroencephalography", Functional Magnetic Resonance Imaging Study /The Journal of Neuroscience, July 28, 2010 • 30(30):10243–10250

[10] Jeffrey S. Johnson, David W. Sutterer, Daniel J. Acheson, Jarrod A. Lewis-Peacock and Bradley R. Postle, " Increased alpha-band power during the retention of shapes and shape-location associations in

visual short-term memory ", Frontiers in Psychology, Original Research Article published: 10 June 2011

[11] Byoung-Kyong Min and Hae-Jeong Park, " Task-related modulation of anterior theta and posterior alpha EEG reflects top-down preparation", BMC Neuroscience 2010, 1471-2202/11/79

[12] Andreas Fink, Barbara Graif and Aljoscha C. Neubauer, " Brain correlates underlying creative thinking: EEG alpha activity in professional vs. novice dancers", NeuroImage 46 (2009) 854–862

[13] Sullivan, T.J.; Deiss, S.R., Tzyy-Ping Jung, Cauwenberghs, G., "A brain-machine interface using dry-contact, low-noise EEG sensors", Circuits and systems, 2008, IEEE International Symposium, May 2008, Pg no 1986 – 1989.

[14] EEG Alpha power and intelligence Elsevier Vol 30 Issue 3 May-June 2002