# Stress Reduction in College Students Using 10.7 Hz Alpha Entrainment

Himanshu Dev, Bipan Kaushal,

M. E Student, Department of Electronics and Communication Engg, PEC University of Technology, Chandigarh, India

Asst. Professor, Department of Electronics and Communication Engg, PEC University of Technology, Chandigarh,

India

**ABSTRACT:** Anxiety is a tense emotion which is characterized by nervousness and uneasiness. Brainwave entrainment (BWE) is one such method which is used to relieve anxiety and to aid relaxation. With regard to this, the present research work focuses on relieving stress and anxiety by the application of binaural beats. The brain states with respect to these different emotional states of the subject is analyzed using brain mapping technique called EEG. Along with EEG, a neurocognitive test named Spielberg anxiety test has also been used to support the study. Also, the scope of research is around state anxiety where the subjects is induced with stress and then relaxed using BWE. Binaural beat of 10.7 Hz frequency has been used for the audio stimulation.

**KEYWORDS:**EEG; alpha wave; brainwave entrainment; binaural beats; stress

## I. INTRODUCTION

Brain is the central organ of a human body which constitute central nervous system. Brain has innumerous neurons which communicate through electrical impulses. These impulses are responsible for our actions and thought and hence mood. Each activity and emotion is related to some particular dominant frequencies which can be analysed using EEG [1] [2].

Anxiety/stress is defined as the response of the body towards distress which can be emotional or physical [3].has become a part of our daily chores where we face many stressors resulting from our hectic lives .Such a state is vulnerable to psychological factors and can lead to serious mental disorders[4]. But this anxiety is curable if it is dealt and managed early. . Here state anxiety has been dealt with. State anxiety is personality state which shows how people react in a specific situation. Personality states can be evoked by an appropriate stressors .Various methods have been explored to alleviate this distress. One such method is brainwave entrainment(BWE).

BWE is a technique which harmonizes brainwave and works to achieve optimal mental and emotional health [5] [6]. The present paper explores BWE through binaural beats (BB). In BB technique two different frequencies are given to each ear through headphones which are then perceives as single frequency which is the difference of the two original frequencies, produced in the superior olivary nucleus [7]. The present paper uses an upper alpha frequency of 10.7 Hz to train the brain.

The brain states in the entire procedure areanalyzed using electro- encephalogram(EEG). EEG uses electrodes on the scalp to read the brain frequencies. It is a non-invasive method which is often used because of its good temporal resolution and low cost[8] [9]. Through EEG, a relative observation can be made between the states before and after audio stimulation.

Spielberg's State Trait Anxiety Inventory has been used to measure the changes in stress levels. Out of the two forms available only the state anxiety form is used to understand that the binaural beats can lead to reduction in stress levels as seen as a reduction in STAI scores.

The current work has following objectives:

(i)    To study the changes being accompanied by the binaural beats stimulation on modifying the brain wave pattern.

(ii)     To study the power spectral density of the brain waves and particularly the changes in power in the alpha band.

(iii)    To observe the changes in stress levels seen as changes in the Spielberg's State Trait Anxiety Inventory

## II. RELATED WORK

In [3] authors acquired the EEG signals from the participants after showing them the images taken from the IAPS database. Also, along with the EEG other psychophysiological signals were acquired like the respiratory rate (RR), skin conductance (SC) and blood volume pulse (BVP). They obtained a classification accuracy of 80.1 % for EEG, 81.5% for psychophysiological and 82.6% for the fusion between them using the Elman classifier. In [4] 500 production operators from the manufacturing sector were asked questionnaires. The purpose of the study was to understand the role of ergonomic workstation factors in affecting the work stress outcome. The result of the study pointed out that workstation ergonomic factors are very important for maintaining a healthy and competent human resource. In [5] researchers examined whether a 2 min session of binaural beats designed to obtain a response at 7Hz (theta) or 16 Hz (beta) could affect vigilance or cortical frequencies. The results of the study pointed out that a 2 min session of binaural beats is not enough to significantly affect the cortical frequencies or vigilance.

## III. METHODOLOGY

I.    Participants

The study includes the participation of 9 subjects( 6 males and 3 females) aged between 23 to 26 years. None of the subjects had any history of mental illness or any psychological disorder. Subjects were introduced to the protocol of the study and were asked to relax during the whole process. In addition to this, they were not imparted with the information regarding the purpose of the study. The permission to conduct the study was taken from the PGIMER, Chandigarh, India ethics committee.

II.    Neuro- cognitive tests

Along with EEG, a separate pre and post neuro-cognitive test is also conducted to aid the research called the Spielberg state anxiety test. In the pre-test session, the subjects is given a stimuli to induce stress in the form of traffic noise. Participant is exposed to the stressor for 10 minutes.  After the completion of this, he/she is asked to fill the Spielbergstate anxiety form with reflects his current mood and mental state. This pre-test is conducted before acquiring the signal through EEG and in similar way post-test is conducted after the entrainment session to observe the changes in the state of the person.

III.    EEG signal acquisition

The experiment was conducted in an air conditioned room with no electromagnetic interferences. The EEG equipment used is the RMS MAXIMUS EEG which is a 24 channel system. It has a notch filter at 50 Hz. Eectrodes are placed on the scalp following the 10/20 international standard of electrode placement. These electrodes cover areas: frontal(Fp1, Fp2, F7, F3,Fz,F5,F7), left temporal(T3, T5), right temporal(T4, T6), central(C3, Cz, C4), parietal(P3, Pz, P4) and occipital(O1,O2). It uses the sampling rate of 256 Hz it is also equipped with user selectable sensitivity ( 7.5μV/mm).

For audio stimulation binaural beat is generated using two frequencies of 440 Hz (left ear) and 450.7 Hz (right ear) which give the final beat frequency of 10.7 Hz. The whole session was conducted inside a well-ventilated room with proper temperature and humidity control. Frequencies are produced with the help of Audacity version 2.1.2 software.

IV.    Procedure

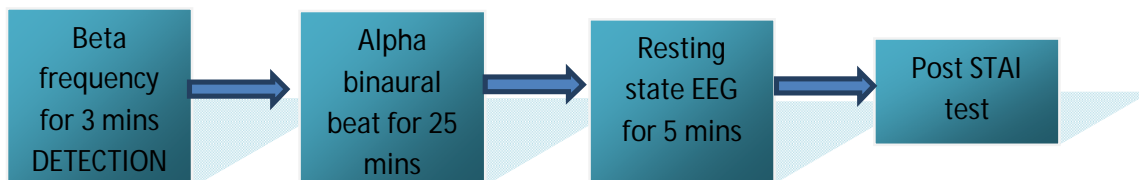The whole procedure is depicted in the following figure:
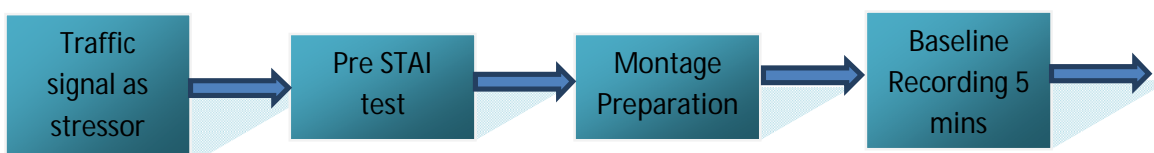
Fig. 1. The experimental procedure to obtain EEG signals

Subject is asked to lie down and relax with eyes closed during the whole session. Then electrodes (25 electrodes including one for ECG) are placed following the 10/20 standard. After this, baseline of the subject is recorded under the condition of silence. After this, auditory stimulation through BB is given through headphone with first few minutes of beta to-----(reason) followed by upper alpha of 10.7 Hz. This BB session lasts for 28 minutes. After the completion of entrainment,5 minutes of silence is again recorded. During the experiment, subject asked to open his/her eyes for few seconds to avoid dizziness.

## V.    SIGNAL ANALYSIS

EEG data has been recorded in real time using RMS MAXIMUS. During recording, events are marked for movement related to eye movement and jaw movement. These are considered as artifacts and need to be rejected for a clean EEG.
        Data analysis and artifact removal is done through MATLAB tool named EEGLAB.  This tool imports EEG recording from MAXIMUS in ASCII format. The imported data is filtered using basic FIR filter. Once the desired format is imported, the data is split in two time intervals as:
(i)        5 minutes data before binaural stimulation (Pre analysis).
(ii)       5 minutes data after binaural stimulation (Post analysis)
    These two classes of data are first subjected to artifact removal using independent component analysis. After this, spectral maps are constructed to show the stretch of alpha activity in different areas of brain. Also, Relative energy ratio is calculated to measure the relative change in percentage of alpha during pre and post analysis.

## IV. RESULTS

The results obtained belong to the three different categories. Firstly, we obtain the power spectral density plots. These plots gives us the distribution of power in dB for each electrode as a function of frequency in Hz. Here, in fig. 2. Power spectral density plot for the subject 1 is shown. Secondly we obtain the relative energy ratios which measures the energy in the alpha band relative to the whole brain. The relative energy ratios gives us a way to measure changes in stress as an increase in alpha power is associated with increase in calmness and decrease in stress levels. Thirdly, we obtain the STAI scores which are generally used to measure an individual's stress levels. The higher score in this test represents higher stress levels and lower score represents reduced stress levels.

# International Journal of Innovative Research in Computer and Communication Engineering

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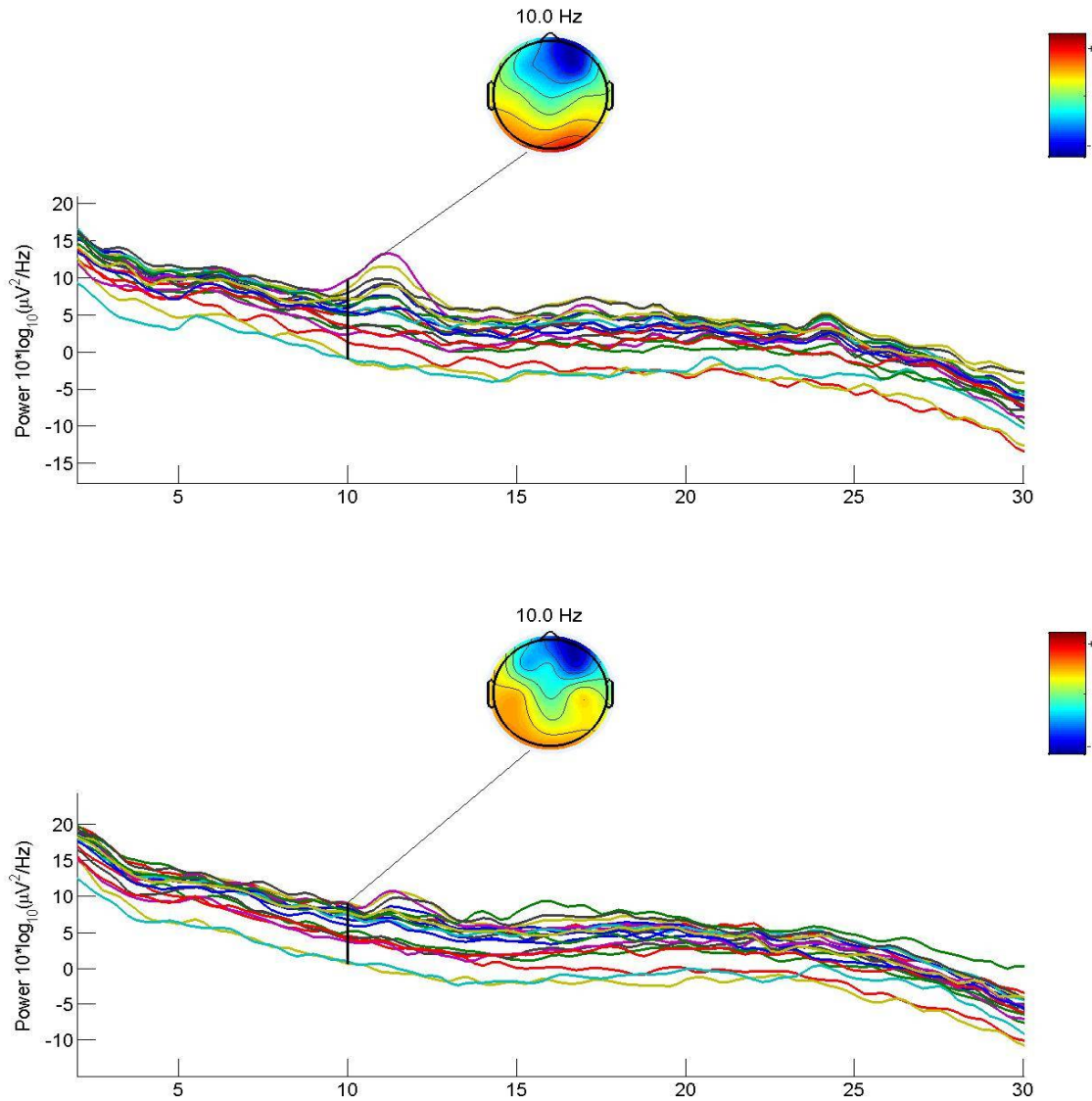**Vol. 4, Issue 6, June 2016**



Fig. 2.Power Spectral Density before applying the binaural beats and after applying the binaural beats stimulation

Table 1. Relative Energy Ratio

| Elecrodes | Subjects | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S1 | | S2 | | S3 | | S4 | | S5 | |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Fz | 0.081 | 0.096 | 0.108 | 0.123 | 0.061 | 0.066 | 0.046 | 0.052 | 0.113 | 0.142 |
| Cz | 0.202 | 0.249 | 0.130 | 0.155 | 0.150 | 0.172 | 0.048 | 0.059 | 0.063 | 0.069 |
| Pz | 0.485 | 0.553 | 0.201 | 0.239 | 0.320 | 0.362 | 0.055 | 0.075 | 0.086 | 0.083 |
| Fp1 | 0.747 | 0.101 | 0.076 | 0.085 | 0.063 | 0.070 | 0.048 | 0.045 | 0.080 | 0.073 |
| Fp2 | 0.061 | 0.084 | 0.067 | 0.090 | 0.076 | 0.068 | 0.035 | 0.039 | 0.075 | 0.062 |
| F3 | 0.113 | 0.160 | 0.100 | 0.101 | 0.085 | 0.084 | 0.054 | 0.064 | 0.078 | 0.085 |

| F4 | 0.106 | 0.136 | 0.135 | 0.160 | 0.095 | 0.116 | 0.050 | 0.065 | 0.076 | 0.080 |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| C3 | 0.337 | 0.408 | 0.165 | 0.182 | 0.164 | 0.167 | 0.056 | 0.086 | 0.108 | 0.122 |
| C4 | 0.248 | 0.302 | 0.266 | 0.321 | 0.222 | 0.250 | 0.049 | 0.069 | 0.088 | 0.100 |
| P3 | 0.519 | 0.594 | 0.256 | 0.342 | 0.289 | 0.329 | 0.067 | 0.091 | 0.156 | 0.215 |
| P4 | 0.460 | 0.529 | 0.365 | 0.452 | 0.343 | 0.382 | 0.060 | 0.100 | 0.178 | 0.173 |
| O1 | 0.541 | 0.627 | 0.484 | 0.571 | 0.416 | 0.432 | 0.078 | 0.115 | 0.336 | 0.359 |
| O2 | 0.535 | 0.624 | 0.512 | 0.647 | 0.421 | 0.412 | 0.080 | 0.131 | 0.412 | 0.396 |
| F7 | 0.120 | 0.205 | 0.137 | 0.179 | 0.077 | 0.071 | 0.059 | 0.065 | 0.109 | 0.107 |
| F8 | 0.129 | 0.181 | 0.150 | 0.198 | 0.095 | 0.110 | 0.055 | 0.067 | 0.134 | 0.106 |
| T3 | 0.311 | 0.393 | 0.232 | 0.283 | 0.137 | 0.125 | 0.061 | 0.077 | 0.159 | 0.193 |
| T4 | 0.318 | 0.385 | 0.274 | 0.345 | 0.170 | 0.192 | 0.052 | 0.083 | 0.173 | 0.185 |
| T5 | 0.493 | 0.569 | 0.410 | 0.532 | 0.292 | 0.283 | 0.064 | 0.090 | 0.219 | 0.270 |
| T6 | 0.409 | 0.425 | 0.415 | 0.565 | 0.285 | 0.308 | 0.066 | 0.100 | 0.156 | 0.292 |

Table 2. STAI Questionnaire

| | S1 | | S2 | | S3 | | S4 | | S5 | |
|---|-----|------|-----|------|-----|------|-----|------|-----|------|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| | 58 | 53 | 56 | 53 | 36 | 36 | 45 | 38 | 41 | 37 |

## V. DISCUSSIONS AND CONCLUSIONS

The study analyzed the increase in alpha activity for different persons after giving them alpha stimulation for effectively 25 mins. The increase in the relative alpha band energy implied reduction in person's stress level. The amount of reduction was not quantified but relative increase or decrease was measured.

Out of the 19 electrodes used a majority of 6 persons showed increased alpha power in F3, F4, Fz, F8, T3, C3, C4, Cz, P3, O1 electrodes. It can also be seen from the power spectral density plot the increase in the peakness of the spectra in the alpha band. This confirms the increase in power in the alpha band.

Table 2. also shows the STAI state test scores of 5 subjects. The scores are obtained from the STAI state anxiety test conducted in the study. The test results show us the related changes in the stress level that can be observed through their scores. The decreased STAI scores show us that the stress levels in the individual have reduced.

From the current study it is clear that the alpha brainwave entrainment has the potential to decrease anxiety/ stress levels in humans. The current research only focused on the short term changes occurring in the brain waves. It is possible that the changes persist for a much longer duration, which in itself is a topic of further research.

## REFERENCES

1   Bronzino J. D.. 1995. Principles of Electroencephalography. In: J.D. Bronzino ed. The Biomedical Engeneering Handbook, pp. 201-212, CRC Press, Florida.
2   Azevedo, Carvalho F. A. , Grinberg L. R., Farfel L. T., Ferretti J. M., Leite, R. E., Lent.R., Herculano-Houzel, S. and Others. 2009, 'Equal numbers of neuronal and nonneuronal cells make the human brain an isometrically scaled-up primate brain', Journal of Comparative Neurology, 513 (5), abstract.
3   Mohammad Ali Khalizadeh, et al. ,"Qualitative and quantitative evaluation of brain activity in emotional stress", Iranian Journal of Neurology, Vol. 8, No 28, 2010.
4   Zafir Mohamed Makhbul and Durrishah Idrus, " Work stress issues in Malaysia", Malaysia Labour Review , Vol. 3, No. 2:13-26, 2009.
5   Peter Goodin, Joseph Coprciari, Kate Baker, Ann-Marie Carrey,Michele Harper and Jordy Kaufman, "A High Density EEG Investigation into Steady State Binaural Beat Simulation", Journal Plos One, Vol 7, Issue 4, April 2012
6   Ossebaard HC. "Stress reduction by technology? An experimental study into the effects of brainmachines on burnout and state anxiety", . Appl Psychophysiology Biofeedback. 2000;25(2):93-101.
7   Huang, T. L., and Charyton, C. (2008). A comprehensive review of the psychological effects of brainwave entrainment.  ALTERNATIVE THERAPIES, Sep/Oct 2008, VOL. 14, NO. 5.
8   Niedermeyer E. and da Silva F.L "Electroencephalography: Basic Principles, Clinical Applications, and Related Fields" . Lippincot Williams & Wilkins, 2004.
9   Ahmad Rauf Subhani et al.,"EEG Signals to Measure Mental Stress", ICPSB, Vol. 20, No 2, 2012.

## BIOGRAPHY

**Himanshu Dev**is a Master's student in the Electronics and Communication Engineering Department, PEC University of Technology, Chandigarh, India. His research interests are in the fields of brainwave entrainment, EEG analysis etc.

**Mr. Bipan Kaushal**is Asst. Professor in the Electronics and Communication Engineering Department, PEC University of Technology, Chandigarh, India. His research interests are in the fields of filter design, microelectronincs etc.