**BIO-FEEDBACK OF AUDIO-ENTRAINMENT BY THE PERTINENCE OF NEURO-
TECHNOLOGY**

by

Subish Kumar Kanakaraj

B.E., Bharathiyar University, India, 1991

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Subish Kumar Kanakaraj

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Ryerson University

Abstract

EEG is Electroencephalography, which is used to measure the activity of human brain. When two slightly difference pitches are played at the same time, the perceived pitch, or the base frequency, is halfway between the two tones. When a 300 Hz tone and a 310 Hz tone are played at the same time, the resulting pitch will be perceived as 305 Hz and the beats will occur at a frequency of 10 Hz.

One may adjust an instrument to match the tone of a pitch pipe until the resulting beats disappear. These beats are referred to as monaural beats, because they can be heard with only one ear. However, one has a different experience when each tone is presented to each ear via stereo headphones. Beats perceived in this way are called binaural beats, the interaction of the two sounds and the perception of the beats occurs in the brain.

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Dedication

This M.Eng. Project is dedicated to

My Parents

&

Teachers.

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1. INTRODUCTION

1.1 EPOC

Epoc is the short form for Excess Post-exercise Oxygen Consumption. It can burn calories and fat, after its application. Even, during the training, we could burn calories to fuel our muscles. Once the training is done, it can be able to burn excess amount of calories and fat than as usual. The reason is the process involved in recovery. At any time, when exercise is done, our body has to repair the muscle fibers damage, removal of an acid called lactic acid from the muscles and repositioning of muscle glycogen levels. Also, these processes need enough calories and most of these calories produced from the body fat. EPOC is the scientific term mentioned for the effect of after burn, which is used to burn more calories longer, even one who left the gymnastics. The high intensity interval training could boost an EPOC more than the cardio done at one steady intensity level.

1.2 Neuro-Headset

The Emotiv headset reads the brainwaves and also it could sense the emotions and body moments. The Emotiv-EPOC system senses and processes the brain waves by the application of an EEG like device, which measures brain's electrical activity. By the application of non-invasive sensors, a wide range of thoughts and emotions can be measured by the Emotiv-EPOC. The earlier technologies could only detect the basic and mental states such as concentration. But the Emotiv could be able to differentiate between the emotions such as excitement and calmness. By the awareness of the audience and the utilization of new technology, Emotiv systems created a headset

that holds 16 sensors and the corresponding electronics to make the reality of the devices more than 30 detections. Fitting to the most head sizes and various hairstyles, Emotiv system designs a durable and user friendly product. While designing, the designers should keep it in mind that the sensors should be adjustable and pliable. It is necessary to have the contact points in the particular location, as well. The latest model headset relies on the headphone like actions to maintain pressure on the scalp for the support of sensors to detect the EEG signals. For the user customization and proper fit, the headset is molded from ABS plastic and soft rubber accents. The headset is available in a sleek black or orange and white in color. It is reminded inside the headset as an EEG graphic form that who and what are making the headset to work. In this Project Work, the Emotiv EEG Neuroheadset was used for the study purpose, as well as an Implementation process. There is certain research which suggests that steady state responses in humans can be recorded as a response to the amplitude or frequency modulation of a tone. Evoked potentials and brain oscillations can also be influenced by visual stimulation. Reversed checkerboard pattern stimulation is commonly used to test for neurological abnormalities due to drug abuse, Alzheimer's disease and dementia, epilepsy and schizophrenia. This same technique has also been used to induce brain oscillations of varying frequencies in healthy human participants. Studies have confirmed that auditory stimulation produces responses in the brains of most people. Many preliminary applications indicate promising results. The interest in audio entrainment technology has been growing steadily in recent years. Many research studies in the applications of audio entrainment in the areas such as Attention Deficit Disorder (ADD), Premenstrual Syndrome (PMS), alcoholism and academic performance have shown the encouraging results.

2. LITERATURE SURVEY

Brainwaves have been established that at any given time, whether awake or asleep, the brain is constantly generating the electrical impulses known as brainwaves. The brainwaves are characterized by frequency and amplitude. Amplitude is a measure of the magnitude of the voltage of the electrical impulse usually measured in micro-volts. Brainwaves are categorized by their frequencies. Human alertness is created by cohesive electromagnetic fields generated by synchronous firing of neurons in the brain. The cohesive manifolds of trans-cerebral electromagnetic fields that originate from intra cortical activity it is suspected that these manifolds are associated with the 40 Hz rhythms corresponding to alertness. The electromagnetic configurations are believed to appear most dominantly in the waking and during dreaming states. A study conducted by Richards et al in 2002, recorded the electroencephalographic activity over the left, right prefrontal, temporal occipital and occipital lobes of the study subjects, in the experiment six different configurations of the magnetic field were applied, in counter clockwise direction. Richards et al, was interested in determining the major correlates of the stream of human alertness. Richards et al, found that the power within the gamma range increased over the right hemisphere with some configurations that involved frequency modulated or pulsing. Analysis of the electroencephalograph was done using a software package for the Fast Fourier Transform (FFT). In a study conducted by McFadden in 2002, it is suggested that neurons are insensitive to the electromagnetic fields created by the brain.

The different increments of frequencies extracted were as follows:

Table 1 Different Frequency of Rhythms

Delta	1- 3.9 Hz
Theta	4.0 -7.9 Hz
Lower Alpha	8 – 10.4 Hz
Upper Alpha	10.5 – 13.0 Hz
Lower Beta	13.1 – 20 Hz
Upper Beta	20.1-34.9 Hz
Gamma	35 – 45 Hz

McFadden suggested that only the neurons that fire in synchrony will be able to create perturbations large enough to influence the electromagnetic fields therefore influencing nerve firing in a few neurons; this in turn would lead to the modulation in behaviour.

2.1 Experimental Setup

This section explains about the participants, the dependent variables and the procedures followed during the study. Also, this study involves both quantitative and qualitative research perspectives and it is based on an experimental design applying pre-tests and post-tests of repeated measurements of dependent variables within the experimental and control groups.

2.2 The Context of the Research

This study was conducted in a medium business banking division, a sub segment within the business banking services section of a large corporate and business bank. The business banking environment was characterized by high demands on the staff and the stress level among the employees was high. The banker-client relationship is based on trust, respect and confidentiality and the business banker within the banking service acts as the single point of entry for the client into the banking group. To find a minimum of 60 participants for the purpose of this study, consent

and approval for the research process was sought from and provided by the managers of two cells within the medium business service division, during meetings arranged with both of them. For the purpose of this study, the two groups were referred as Cell 'A' and Cell 'B'. With this research study being the first of its kind within that setting, both managers were excited about the possibility of addressing the needs of their staff with regards to stress management. A decision was made to conduct the testing and experimental part of this research directly within the working environment. Consequently, the testing procedures were scheduled to be conducted during office hours only, on the premises in the office blocks where Cell A and Cell B both work. In each case, a separate room was allocated to the researcher in which the testing took place. In that room there were at least two chairs, one for the researcher and one for the participant, and a table on which the equipment was set up.

2.3 The Research Participants

A group of 60 healthy males and females were chosen for the purposes of this study. All of them were, at that time, experiencing high stress levels in their work environment. The participants were drawn from business 15 bankers and administrative support staff who worked in close association with each other and the group consisted of 24 males and 36 females. They ranged between 22-60 years in age, with an average age of 41 years.

2.4 Procedures Used

All the measurement instruments that would be necessary for this study were ordered from the relevant suppliers. The headsets were provided at cost price by a local company that specializes in headset solutions for stereo sets and computers. CD copies were made of the original Program

for Deep Relaxation. A one-hour information session was conducted for the participants in both groups, to establish the context for this study, which was self-management through the use of sound and a state of appreciation or gratitude to induce a positive emotional state within the business banking environment where they were employed. During the information session, the researcher provided background information, which included an introduction to and background information about the researcher, scientific information about stress, energy medicine, the role of sound and positive emotional states, and the possible benefit for them participating in this research. The next steps were to arrange pre-test sessions, which were coordinated by the researcher and the personal assistants of the managers of Cell A and Cell B. Each session of testing was divided into fifteen minute sessions.

2.5 Recording a session

A three minute recording was made as part of the pre-test and post-test sessions using the default challenge level 2. The participant was asked to put the ear sensor on the left earlobe, while sitting back in a comfortable position and trying to relax while keeping their eyes closed. They were not able to see the computer screen and the feedback sound was turned off, preventing the participants from being aware of their heart rate and HRV (Heart Rate Variability). The Heart Rhythm Display window was opened and the recording started by clicking on the Start icon on the toolbar. A progress bar first showed the calibration of the Automatic Gain Control and took a few seconds to complete. After 20 seconds the various measurements on the Heart Rhythm Display screen started recording the heart rate and pulse wave, the accumulated coherence score and the coherence ratio. The Power Spectrum Density (PSD) graph could be viewed by clicking on the View HRV Power Spectrum icon. The recording session was ended after three minutes by clicking

on the Stop icon. The session for each participant was saved by clicking on the Save Data icon. A recording was made to measure the sound frequencies present in the voice. The participant was asked to provide the answers to three basic questions by speaking into a microphone that was connected to the researcher's computer notebook. Time necessary for completion of this task was three to five minutes.

2.6 Recording

The participant was asked to sit comfortably, with the back well supported, legs uncrossed and both feet on the ground. An explanation was given about the three questions that had to be answered when speaking into the microphone. The microphone switched on and the Voice Input screen opened on the Voice bio Analysis program. The microphone was then handed to the participant. The researcher asked the three questions, which included a base question, a stress question and a future question. The base question was asked to get a description of something neutral, for instance giving a description of their house, the garden etc. The stress question was asked to provide an opportunity for the participant to describe something that was reason for concern or causing stress in their lives. In answering the future question the participant had to describe something that made him or her feel really excited about the future, which may have been a dream they held for the future, a place they would like to visit, etc.

2.7 VIBE print™ data

On the Voice Input screen a base chart, a stress chart, a future chart and a composite chart were recorded. During each question 75-80 hits were recorded to give a total count of between 210

and 240 for the VIBE print™. When recording a session the amount of hits on the screen give an indication to provide an accurate measurement. Each VIBE print™ can be viewed either as a Graph or a Grid. The Graph should, ideally, resemble the shape of a normal sine wave as closely as possible. The Grid portion of the VIBEprint™ provides a picture of the body energy as a continual spiral. The VIBEprint™ takes a “snapshot” of that energy at the point of the physical and emotional body. If seen in 3D, the voiceprint would be a continual amount of frequency that is being recorded during that session. This ensures that enough frequency is recorded spiral itself. By highlighting the physical bodyline one is able to find the actual location of the body within the spiral, which continues up through different dimensions of physical energy, into mental and emotional energy and beyond; and continues down through physical deterioration. In assessing the VIBEprint™ it is necessary to know what octave(s) represents the physical body of the client, to then distinguish those hits that are emotional and those hits which are physical. It is important to note that not all people will have their physical bodies to be found within the same octave. Generally, they will start in one octave and drop down to finish in the next lower octave. To determine the physical bodyline you will always start with the Note of C and continue to the right. The goal is to highlight the octave with the highest number of hits. Once the bodyline drops, the line will continue in the lower octave until the end. Hits above the physical bodyline represent emotions that are causing stress for the participant. The higher the number of hits, the higher the amount of emotional stress experienced. Hits below the physical bodyline are considered physical deterioration and are of significance when symptoms of physical disease are present. The participants from both Cell A and Cell B were divided into two groups of equal numbers, for experimental and control purposes. Initially there were forty two participants in Cell A and twenty-four participants in Cell B, making a total of sixty-six participants. Due to unforeseen circumstances, the number of participants that

completed all the elements and tests included in this study was reduced to a total of sixty participants.

2.8 Data Analysis

As mentioned in the beginning, the researcher used a matched-pairs design to quasi-randomly assign participants between the experimental and control groups. Each participant was assigned a research number. The participants of each cell were ordered into alphabetical order and each assigned a case number. Hard copies of the consent forms, completed surveys and test results were filed under each participant's own research number. An MS Excel spreadsheet was created in which with a separate line was allocated to each participant to which all the scores were transferred after each test session. Age, gender and the total score of the Holmes-Rahe Social Readjustment Rating were entered immediately after the participants had been divided into their experimental or control group. The answers of the participants on the QuikScore™ POMS Standard Forms were scored by referring to the QuikScore™ Guide. Raw scores for factors T, D, A, V, F and C were obtained by adding the numbers in each column and entering the sum in the box at the bottom of the column. The raw score for the Total Mood Disturbance (TMD) score was calculated by using the following formula:

$(T+D+A+F+C) - V = \text{TMD}$ where, T=Tension, D=Depression, A=Anger, V=Vigor, F=Fatigue, C=Confusion, TMD= Total Mood Disturbance.

The value of TMD depend upon the values of T, D, A, F and C.

2.9 Outcome of the Study

The study reported here, examined the effects of the audio entrainment on the energetic and psycho-physiological balance in employees experiencing moderate to high stress levels in a business banking environment. This section is organized in terms of the results obtained from the pre-tests and post-tests of the dependent variables used as part of the research design. Both quantitative and qualitative descriptions were used for the profile of mood states. The detailed results will be reported by comparing two groups of participants, who were chosen from two divisions in the business bank. For purposes of this discussion the two divisions will be referred to as cell A (63%; n=38) and cell B (37%; n=22). The total group consisted of female (n=36) and male (n=24) participants. The participants were quasi-randomly divided into the control and experimental groups by using a matched-pair design.

2.10 Quantitative Findings

The Social Readjustment Rating Scale (SRRS) is used for the quantitative findings of the research study. The SRRS scores ranged from 50 to 466 with an average score of 208. Only 28% (n = 17) participants had low scores on the SRRS, 57% (n = 34) had medium scores and 15% (n = 9) had high scores.

Table 2 Age and SRRS Scores

	N	Minimum	Maximum	Mean	Std. Deviation
Age	60	22	60	39.22	10.593
SRRS: Holmes-Rahe Social Readjustment Rating Scale	60	50	466	207.67	89.762
Valid N	60				

Table 3 Group equivalence according to age and SRRS.

	Group	N	Mean	Std. Deviation	Std. Error Mean
Age	C	30	39.80	11.451	2.091
	E	30	38.63	9.821	1.793
SRRS: Holmes- Rahe Social Readjustment Rating Scale	C	30	207.93	87.896	16.048
	E	30	207.40	93.094	16.997

The results from an independent samples t-test confirmed the equivalence of the control group (M=39.80, SD=11.451) and experimental group (M=38.63, SD=9.821) in terms of age ($p=0.673 > 0.05$; $t=0.242$; $df = 58$) and SRRS scores ($p=0.982 > 0.05$; $t=0.023$; $df = 58$).

The dependent variables included the Profile of Mood States (POMS), the Freeze Framer 2.0®, specifically the Heart Rate, Coherence Ratio and Power Spectrum Density (PSD) as well as Voice bio Analysis™ referring to VB1(adrenal energy); VB2 (mental energy); VB3 (lowest frequency); VB4 (second lowest frequency) and VBPost (energetic balance, reported as Less, Equal or More).

2.11 The Profile of Mood States

In the case of the experimental group, statistical differences were shown for Tension-Anxiety ($p=0.018$, $t=2.51$) and Fatigue-Inertia ($p=0.013$, $t=2.63$). The following table explains the pre-test results and pro-test results. The various parameters involved are mean, standard deviation, standard mean error. The various mood states involved are tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, confusion-bewilderment, and vigor-activity.

Table 4 Profile of Mood States Results for Control Group [*Post-Test Results]

Pre and post		PRE TEST RESULTS				PRO TEST RESULTS			
		Mean	N	Std. Deviation	Std. Mean Error	Mean	N	Std. Deviation	Std. Mean Error
1	Tension-Anxiety	11.97	30	5.997	1.095	9.40	30	6.179	1.128
2	Depression-Dejection	7.73	30	7.625	1.392	6.27	30	7.144	1.304
3	Anger-Hostility	10.73	30	8.944	1.633	6.30	30	5.609	1.024
4	Fatigue-Inertia	9.37	30	6.003	1.096	7.50	30	5.841	1.066
5	Confusion-Bewilderment	8.17	30	3.343	0.610	6.93	30	3.759	0.686
6	Vigor-Activity	16.03	30	6.117	1.117	15.67	30	5.422	0.990
7	TMD	31.93	30	27.928	5.099	20.73	30	24.310	4.438
8	TMD T-score	54.40	30	8.431	1.539	50.80	30	7.289	1.331

The post- test results were compared with the pre-test results. The deviation was calculated using the standard deviation method. The standard mean error was calculated from the test results.

2.12 Qualitative Findings

This section reports on the level of compliance of the participants of the experimental group, as well as oral feedback given to the researcher by the participants about their experience while on research process. Actual level of compliance within the experimental group was determined by a Post-test Survey. Five participants (8.3%) of the experimental group used the research tools a few times, indicating seven times or less. Eleven participants (18.3%) used the research tools more than seven times during the fourteen day period while fourteen participants (23.3%) used the tools every day.

2.13 Feedback from Participants

Each participant had a chance to give feedback on their experience during the fourteen day period. The experience of the members of the experimental group varied.

(a)Positive comments included:

1. Sleeping patterns improved.
2. Felt calmer and more relaxed.
3. Felt more even-tempered.
4. Felt more joyful.
5. Experienced a 'buzz' in the office with overall more positive energy.
6. Found inner peace.
7. Mentally more focused and clear headed.
8. The music was very relaxing.
9. Experienced higher energy levels, especially during the afternoon.
10. Felt a physical change in heartbeat and in the chest area.
11. Felt completely "different".

Figure 1 Energetic Balance in the Control and Experimental Groups.

(b) Negative comments included:

1. Found it difficult to integrate the experiment in daily schedule.
2. Music duration was too long, and irritating sounds in music were bothering.
3. Feeling too relaxed and almost inefficient.
4. Would have liked a selection of music rather than repeating the same CD for 14 days.
5. Music was scary.

Different people listened to the music at different times during the day. Some used it at the beginning of their day which helped them to set the tone for the day. Somebody else listened to it during lunchtime which helped to increase energy levels during the afternoon. Some found time to listen to the CD at the end of the day, which helped them to switch off completely and very often sleep very well. Feedback from the participants in the control group ranged from non-challenge

about not being part of the experimental group to disappointed that they were not chosen to make use of the research tools. Most of them viewed the fact that they were not included in the experimental group as a positive indicator about their own stress levels. Although, the information conveyed during the information session emphasized that there would be participants in both groups with higher and lower stress levels, the perception remained that the members of the control group must have been less stressed.

2.14 Restatement of the Research Problem and Hypothesis

The current view in the new sciences is that all living beings and living systems are surrounded by subtle energy, dynamic, ever changing aspects of all living matter. When this subtle energy becomes blocked or stagnant in any part of a system, whether in the human body or in the body of the organization, imbalances occur that can lead to disease or illness. Any factor that causes stress on a system will interfere with the normal functioning of that system, and when the situation is prolonged, irreversible damage might be caused. On the other hand, any intervention that strives to better the health or wellness of an individual within an organization will improve the overall energy within that organization in positive and uplifting ways. Heightened awareness about the important role subtle energy plays within an organization amplifies a need to implement integrative, energy based and practical solutions to support employees in their effort to manage their personal energy.

One of the challenges is to measure the organizational energy, followed by interventions that focus specifically on the energy of employees as well as the energy of the organization. This research study focused on the role of personal energy, more specifically, how it can be measured

and in addition to that, what possible methods can be implemented to directly influence personal energy. The research question that resulted from these previous statements and the current knowledge available of the electromagnetic fields that surround the body was to enquire whether the management of personal energy within an organization can be approached from an electromagnetic perspective, by using sound frequencies and positive emotional states to create balance or coherence on energetic and psychophysiological levels. The research question led to the following hypotheses.

2.15 Review of Methodology

This study focused on the application of two methods to address the use of personal energy from an electro-magnetic perspective, namely sound frequency and positive emotional states. This research study was conducted in the working environment of the employees, to test the hypothesis that stress can be measured and addressed, from an electromagnetic perspective, in practical ways and in a real life setting. Actually, this took place in the medium business banking division, a sub segment within the business banking services of a large corporate and business bank, which will, for the purpose of confidentiality, remain unnamed. The medium business banking division is divided into various branches or cells that are set up throughout the areas servicing prospective clients. Two cells were chosen to be part of this research study, Cell A (N=38) and Cell B (N=22), together consisting of sixty healthy males and females who were experiencing high stress levels in their work environment. The participants were assigned, by making use of a matched pair design that referred to age, gender and stress levels as determined by SRRS. Pre-test and post-tests were used by repeated measurements of dependent variables in both groups. The experimental group also completed a Post-test Survey to determine the level of compliance to the intervention. The

working environment of the participants was chosen to do both the testing and experimental part of the research. During the experimental phase the experimental group was provided with a stereo headset and a copy of scientifically designed music, namely the AlphaRelaxationSystem. This soundtrack has been composed in such a way to induce deep states of relaxation and was chosen for that particular reason to be used by the experimental group. They requested to hear the soundtrack for thirty minutes each day, while inducing a positive emotional state. To this effect they received oral and written instructions. The control group, on the other hand, received no intervention. After fourteen days post-tests were conducted on two groups, experimental groups, by repeating measurement on dependent variables.

2.16 Research Hypotheses

The research findings will be analyzed according to the original research question and the four hypotheses that emanated from that. The results of the Holmes-Rahe Social Readjustment Rating Scale (SRRS) indicated that this research population demonstrated medium to high stress levels, with significant implications for their future health and well-being.

Hypothesis #1:

Scientifically designed music can improve energetic and psychophysiological balance within individuals experiencing high stress levels.

Hypothesis # 2:

Positive emotional states can improve energetic and psychophysiological balance within individuals experiencing high stress levels.

Hypothesis # 3:

Positive changes on an energetic level can influence the over-all climate or culture within an organization.

Hypothesis # 4:

It is possible to measure energetic changes within a “real-life” working environment.

According to the findings in this study, for the future work, there is enough reason reported to use the various analysis as valuable assessment tools of personal energetic and psycho-physiological balance within employees of companies.

3. THEORY

3.1 Neuro-Technology and Music

The neuro-technology and music underlies the psychology of music. There are three fundamental aspects underlying in the musical cognition and behavior. They are music and computers, language of music and neurobiological function. The language of music deals with musical communication, music as a natural language, organizational process operating through perceptual grouping principles or through biological patterns of emotional expression. Music and neuro-biological function includes the perception of pitch, structures of pitch, recognition of musical interval, perception of rhythm and the expression of quality. The simulation part is done by the music and computers. The computer impact towards the research area and the improvements in the musical pattern analysis implies the musical perception process simulation and the application of computer systems for the composition and synthesis. The other important aspects are perception of auditory, tone perception psychology and the psychology of speech.

We know that the music is used as a Therapy. It is understood that music belongs to the non-verbal communication process. It can be used as a tool for creating initiative towards the mentally challenged persons or behaviorally disordered people, those who are having challenging situation to show their emotions and thinking verbally. A powerful sensory stimulus can be obtained through music. In short, we could say that music is a good media between therapist and patient, patient and peers. Various studies have shown that during meditation, transcendental states, or even while experiencing glossolalia, there are neural connections and relations in the brain. An experiment was done by Slater and Beard on 69 people who had epilepsy, schizophrenia-

like psychos. Three fourth of the patients had TLE (temporal lobe epilepsy) while the rest had mystical experiences. Some characteristics of TLE patients could be emotionality, depression and aggression. However, from the data collected during the experiment, it is observed that the human belief completely uncorrelated with the presence of temporal lobe symptoms. Their data proves that it could be implicated from schizophrenia and psychosis. Dr. Michael Persinger, one of the neuro-psychologists believes that he could artificially induce a sense of presence to an abnormal person, via communication with the temporal lobe with a weak complex magnetic field derived from patterns of activity found in the brain. Lots of researchers tried to replicate the experiment, however, they all failed as the effects could not be reproduced. They might be believed that Dr. Persinger's experiment was not properly double-blinded. A scientist, Claes Granqvist states that the magnetic fields used by Persinger are too low (about 5000 times weaker than a typical magnet) in order to make any changes or influence the neurons. Therefore, there is no device that can actually influence the brain. Another convincing reason is that temporal lobe is not the only place that can produce mystical experiences.

3.2 Detecting Bio-signals with the Emotiv-Epoc headset: A Review

The bio-signals are detected by the application of Emotiv-Epoc headset. The quality and resolutions of the signals are based on the quality of the headset we used. So, it is mandatory to utilize a quality headset. The blue-tooth technology is used to obtain the good clarity and necessary depth of biological signals.

3.2.1 History of Bio-signals

Luigi Galvani (1737-1798) was a leader and specialist in the field of electricity and nervous system. At the 18th century he demonstrated that the sciatic nerve is connected with the muscle carries electricity. William Einthoven invented the ECG in 1903. He got award and the Nobel Prize in 1924 for the invention of ECG. In 1924, Hans Berger recorded the first EEG. He published a paper in 1929. He was nominated for the Nobel Prize in 1936. Allan Snyder, a physicist and neuroscientist, co-founder of the Emotiv system found the affordable EEG acquisition system to install with wireless Technology. The Bio-signals are the important parameter in the Bio-Medical Engineering applications. The bio-signals are detected by the utilization of an Emotiv- Epoc headset including the sensors. The Steady State Visually Evoked Potential (SSVEP) is an important factor while considering the brain computer interfaces. P300 Based BCI was described in 1988. Neuro-phone is a dial system for smartphones based on the P300 BCI and using the Emotiv headset for EEG data acquisition.

3.2.2 Motor Imagery

Let imagine movements of hands or feet and the resulting signals have very specific temporal, frequential and spatial features. The different problems of artifacts are on the muscles, eye blinks, eye moving left/right, up and down. The muscle artifacts such as chewing, moving the head left/right, up and down. The placement of the Epoc electrode positions explains the specific areas to obtain the Motor/Sensory functions. There is one more function called the Event-Related Potentials or ERP. It reflects the activity of brain from a grouped synchronous activity of large number of neurons.

The event related brain potentials can be classified as an exogenous and an endogenous. The exogenous is considered as sensory one and formed within the first 100ms from the stimulus. The endogenous event related brain potentials deals with the cognitive related functions.

3.2.3 Alertness, Sleep and Stress

Alertness is nothing but a state, in which one could able to show response to other things. When the level of alertness is decreased, awareness and awakesness impairments could be developed. We know that brain is responsible for keeping alertness. The alertness can be induced artificially, by stimulating the brain. The Emotiv headset has the ability to stimulate the brain. The phases of alertness are important to maintain good health.

The sleep is occurred by the sensory activity. It is different from wakefulness and it has the less ability to react to the stimuli. People may have sleep disorders and that leads to so many abnormalities. The phases of sleep are Rapid Eye Moment or REM and Non-REM. The Non-REM is again classified into three phases as NREM1, NREM2 and NREM3. The NREM1 is the stage between sleep and wakefulness. In this phase, the transition takes place from the alpha waves to theta waves. The NREM2 develops the theta activity. The delta waves are developed during the NREM3 phase.

Sleep is considered as one of the basic needs of human being, equal to the other basic needs to achieve the alertness and effective performance of life. It is observed that by having good sleep and the optimal use of alertness, one could improve the overall performance, mood and well-being. In this way, sleep and alertness play a vital role in day-to-day life.

Stress is one of the causes to create the abnormality functions in the human body. The abnormal functioning of the Autonomic Nervous System (ANS) leads to the stress, anxiety and depression. The levels of stress can be assessed by using different assessment tools such as physical assessment, psychological assessment, Heart Rate Variability (HRV) and Bio-chemical responsiveness. Usually, the people having good health possess the balance between sympathetic and para-sympathetic functions. When the threatening situation arises, the fight or flight responses activated. Even during the everyday life, when the psychological situations occur, even though it's not life threatening one, the fight or flight response could be activated.

4. IMPLEMENTATION

4.1 Emotive-Epoc Headset Position

Figure 2 Emotiv-Epoc Headset Position
(Courtesy: Ivan Martyushev, Ryerson Final Yr. BME Student)

The headset positions of the Emotiv-Epoc are shown in the figure 1. From that, the positions of the sensors are well understood. The Emotiv EEG Neuroheadset consists of 14 EEG electrodes channels and 2 reference electrodes to offer the optimal positioning and accurate results of spatial resolution. The hydrator solution application on the electrodes improves the contact between the sensors and the head. The other components involved are blue-tooth wireless transmitter and the power supply unit to charge the headset. The precautionary measures should be taken that the device should not be operated while charging. The audio entrainment implementation was done by the application of Emotiv headset. The recording was done for 2 weeks, 5 times per week and an average of 20-30 minutes of each session. The binaural beats were created by various music. Sometimes, the recording was done without any music, too.

The difference between each session was analyzed. The early morning, morning, noon, evening and late evening, week days and weekend sessions were done. The recording was done in a quite atmosphere, eyes closed and free from external disturbances. From the Comma Separated Value (CSV) file value itself, we could identify the differences in the value. For perfect results, the MATLAB functions were utilized such as FFT, wavelet, Short-Time Fourier Transform (STFT) and filter functions. The analysis was done and the better results were achieved. Usually, the frequency range applied for the audio-entrainment is between 100Hz and 107Hz. The Signal processing and Optimization techniques were really an interesting part of the implementation of this project.

5. SIMULATION

The brain entrainment can be obtained from the Neuro-Programmer 3 developed by the Transparent Corporation. The Neuro-Programmer 3 is an application developed by the software which is used for the stimulation of brain and it improves the mental abilities. Thus, it is an important tool to control the mind. We know that the frequencies of rhythms, delta is between 1 and 4Hz. Theta is between 4 and 7Hz. Alpha is between 7 and 13Hz. Beta is between 13 and 30Hz. The frequency, above 30Hz is classified as Gamma. This brain activity map is applied in the Emotiv-Epoc, too. The Epoc set includes the Bluetooth technology. This is an added advantage to gain the appropriate signals and it is helpful for the simulation process, also. A number of techniques and applications are involved in the system in order to achieve an optimal solution and a proper simulation process.

Figure 3 Test Bench Waveform

10	0	4484.102	4150.256	4200.513	4124.615	4426.154
11	0	4484.102	4151.282	4202.051	4125.128	4425.641
12	0	4484.615	4155.897	4201.538	4125.641	4427.692
13	0	4486.154	4156.41	4203.077	4125.641	4426.154
14	0	4484.615	4155.385	4205.128	4123.59	4423.077
15	0	4484.615	4156.41	4204.615	4122.564	4424.102
16	0	4485.641	4156.41	4201.026	4124.615	4425.128
17	0	4486.154	4154.872	4202.564	4126.667	4424.615
18	0	4487.179	4153.333	4205.641	4126.154	4426.667

Figure 4 Sample CSV Data

The data were recorded during the session in the format of CSV (Comma Separated Values) files. The MATLAB applications applied for the file conversion and to achieve the final results. The Fast Fourier Transform (FFT) Algorithm was used for the Simulation process. It's an algorithm used for the calculation of Discrete Fourier Transform (DFT) and the inverse of it. The parameters time and frequency are important factors for our purpose. The Fourier analysis could convert frequency into time and also time into frequency. The FFT computes fastly, those transformations by the factorization of discrete Fourier transform matrix to a majority of zero factors. The Emotiv TestBench is software, which is used for the application of the Emotiv-Epoc headset. In our project, the TestBench version v.1.5.1.2 is used for the optimization of a single signal. By using this Test bench version, we could be able to choose the options such as EEG, FFT, Gyro and Data Packets on the screen. The sample CSV data are shown in Fig. 3.

6. POST-PROCESS

6.1 Effect of After Audio-Visual Entrainment

It is well known that the electrical activity of the human brain tends to the rhythmic action and it creates the brain waves. The brain waves fluctuate depending upon the situation or surroundings. By applying the various frequencies of rhythm and the usages of flash lights or any other lighting system also, the function of the brain is varied. That leads to the change in rhythm and the brain activity. In other words, we can say that the brain is stimulated. This is also known as audio-visual entrainment. Because the entrainment done by the application of audio and visual applications.

The effect of audio entrainment has the ability to treat so many disorders. Some of the common disorders treated by the audio visual entrainment are attentionless disorder, insomnia, anxiety, stress disorder and depression. The common cause for so many disorders is the depression. The Neuro-Programmer3 audio entrainment is very effective to eliminate the depression. Usually, I used to have the audio entrainment session in different timings, such as, early mornings, morning, noon, evening and night. The TestBench brain waves were recorded for the future references. The Neuro-Programmer 3 software was used for the entrainment purpose. The recordings were done with the music and without music. The differences in the brain wave frequencies were analyzed in the presence of music and absence of music. The detailed study was done on the basis of data.

Precautionary measures were taken while the usage of the Neuro-Programmer 3 software application. I was aware about the effects of the audio entrainment. The different modes, such as, meditation, relaxation, sports, dance, rock music and so many other modes were selected and the

corresponding audio effects were got and the brain activity map was recorded. After the session, in short, I was really physically and mentally more relaxed, relieved from pain, felt free from depression and got good mood. I strongly recommend the effect and responsiveness of after having the audio entrainment to everyone irrespective of any health issues.

7. RESULTS AND DISCUSSIONS

7.1 Pros and Cons of Emotiv EEG and Traditional EEG

People use the Emotiv EEG headset and Traditional EEG machine for taking the EEG waves. On the basis of experience, most people prefer the Emotiv EEG headset. Especially, the software and SDK (Software Development Kit) of Emotiv is the mostly preferred one. Whereas, the traditional EEG needs more attention to solder the buttons, cables and put that in an enclosure.

Some of the Pros and Cons of Emotiv EEG and Traditional EEG are given below. From that, we could get an idea about both of the Emotiv and traditional EEGs.

7.2 Emotiv EEG vs. Traditional EEG

7.2.1 Pros of Emotiv

1. Emotiv is readily available, so that it's no needed to assemble the PCBs, solder the electrodes and buttons. In the case of Traditional EEG, it needs to assemble the board, solder electrodes and buttons.

2. The Emotiv research edition has a good SDK. Whereas, the Traditional EEG's software is not much appreciated by the users. Also, the Emotiv EEG is light weight and very user friendly.

3. Just saline is sufficient for the contact purpose, so that Emotiv EEG needs only minimal preparation for the scalp. For the Emotiv Insight, even no preparation is needed because it uses only dry electrodes. In traditional EEG, we have to apply the electrode gel on the scalp.

7.2.2 Cons of Emotiv

1. In the Emotiv EEG, the electrode placement has the limitation and if it's not proper, the recording may not be a good one. In the traditional EEG, we are free to place the electrodes.

2. The Emotiv research edition is expensive especially; the one which has the access to the raw data through the developer SDK, hence this factor in the traditional EEG is cheaper one.

8. FUTURE WORK

The amplitude, frequency and time measures were involved in the Emotiv-Epoc EEG headset system. To obtain the optimal results, we are in need of the good signals i.e. artefacts free EEG signals and corresponding waveform. When the data were recorded, we could see lot of EEG artefacts. In the future work, it should be eliminated. Rectification is recommended by using the high-pass filters. The MATLAB built-in function could be helpful to eliminate this issue.

FFT (Fast Fourier Transform) function and the applications for our purpose could be improved in the future work. Also, the signals got from the sensors, during the process was not up-to-date. Proper electrodes and contact should be got for the better results. More MATLAB functions and applications would be applied in the future. In this project, the TestBench software was used for the operation and implementation. Other softwares and their applications such as MATLAB could be performed.

The comparative study could be helpful to know more about traditional EEG and EPOC EEG system. More knowledge about the anatomy and physiology and the EEG functions should be thoroughly known. The headset would be utilized in different kinds of people and the variations could be identified in the future. Care should be taken, while handling the headset. Different simulations techniques might be needed in the future work. The excel files were not accepted directly in the system. It requires the CSV format. It was felt that it should be changed in the future. The optimization of a single signal requires so many parameters. In the future, the efficient and effective achievement should be done on the performance of the optimization of a single signal from the procedure.

9. CONCLUSION

By the application of literature review and research study, a thorough and detailed study about the binaural beats was done and also a confident was obtained that the positive effects, after the implementation of the audio entrainment by the application of Neuro-Technology. In this M.Eng. Project, the Optimization of a single signal from the EEG procedure is obtained. The EPOC Emotiv EEG headset was used for the signal generation purpose. The MATLAB codes were applied for the end result. The Post Process using FFT is an interesting one. There are several ways of developing BCI's exist today by using software and EEG acquisition systems. Emotiv head set, although cheap, able to detect most EEG features encountered in medical BCI. As other EEG system, Emotiv is very sensitive to all kinds of artifacts. Extra care should be taken to avoid the motion artifacts. It is concluded that the EPOC Emotiv EEG headset is an important tool for the research and study purposes of the brain signals. Thus, the optimization of a single signal is done.

APPENDICES

Appendix – A

Sample Questionnaire

The common questionnaire found in the Neuro-Programmer3 is given below. Before starting any session with the clients, it is mandatory to get the questionnaire get filled and it's also signed by the client.

1. The most interested option is:

a.Visualization b.Meditation c.Depression d.Learning e.Cognition f.Anxiety g.Motivation.

h.Well-being i.Athletic j.Insomnia k.Relief of Headache l.Addiction.

2. Check the mood option at present:

a.Quiet b.Stressed c.Hyperactive or overactive.

3. Your option to select the duration of this program:

a.10 to 30 minutes b. 30 min. to 1hour c.30 min. to 1.5 hrs.

4. Did you attend Hypnosis at any time?

a.Yes b.No

5. Do you have any Experience with Entrainment?

a.Yes b.No

6. Any brain damages, head injuries or memory challenges?

a.Yes b.No.

7. Do you have an audio-strobe or compatible machine?

a.Yes b.No.

8. Do you have any EEG device or any other provision to obtain the Bio-Optimization results?

a. Yes b. No.

9. Choose one of the following Goal categories:

a. Neurological b. Psychological c. Combination of both.

10. Are you ready to start the Session?

a. Yes b. No.

Appendix – B

i) MATLAB - Codes for Short Time Fourier Transform:

```
function [ output_args ] = stft1( eeg )

%UNTITLED Summary of this function goes here
% Detailed explanation goes here
figure;

windowSize = 512;

window = hanning(windowSize);

nfft = windowSize;

noverlap = windowSize-1;

[S,F,T] = spectrogram(eeg,window,noverlap,nfft,128);

imagesc(T,F,log10(abs(S)))

set(gca,'YDir','Normal')

xlabel('Time (secs)')

ylabel('Freq (Hz)')

title('Short-time Fourier Transform spectrum')

end
```

MATLAB Codes :

```
eeg=csvread('example1.csv');

r=eeg(:,5);

stft1(r)
```

ii) MATLAB - Codes for Wavelet

```
function [ output_args ] = wavelets( eeg )
%UNTITLED Summary of this function goes here
% Detailed explanation goes here
fs = 128;

t = (0:length(eeg)-1)/fs;

[C,L] = wavedec(eeg,5,'db4');
%construct approximations and details from the coefficients
A5 = wrcoef('a',C,L,'db4',5);
D1 = wrcoef('d',C,L,'db4',1);
D2 = wrcoef('d',C,L,'db4',2);
D3 = wrcoef('d',C,L,'db4',3);
D4 = wrcoef('d',C,L,'db4',4);
D5 = wrcoef('d',C,L,'db4',5);

% plot the approximation and details
subplot(3,2,1); plot(t,A5);
title('Approximation A5')
subplot(3,2,2); plot(t,D1);
title('Detail D1')
subplot(3,2,3); plot(t,D2);
title('Detail D2')
subplot(3,2,4); plot(t,D3);
title('Detail D3')
subplot(3,2,5); plot(t,D4);
title('Detail D4')
subplot(3,2,6); plot(t,D5);
title('Detail D5')

end
```

MATLAB Codes:

```
eeg=csvread('example1.csv');

r=eeg(:,5);

wavelets(r)
```


iii) MATLAB – Codes for FFT Function

```
eeg=csvread('demonstration.csv');  
r=eeg(:,14);  
plot(r)  
r=eeg(:,14);  
[b,a]=butter(4,50/128);  
f=filtfilt(b,a,r)  
  
f = 1.0e+03 *  
plot(f)  
Fs=128;  
T=1/Fs  
T =  
0.0078  
L=length(f);  
t=(0:L-1)*T;  
NFFT=2^nextpow2(L);  
y=fft(f,NFFT)/L;  
result=Fs/2*linspace(0,1,NFFT/2+1);  
plot(result,2*abs(y(1:NFFT/2+1)));
```

iv) MATLAB – Codes for Filter Function

```
sensor=eeg(:,5);  
plot(sensor);  
sensor=sensor(1:119);  
plot(sensor);  
wn=2.5/64;  
[b,a]=butter(4,wn);  
plot(sensor);  
reeg=abs(sensor);  
feeg=filtfilt(b,a,reeg);  
t=[1:length(feeg)]/128;  
plot(t,feeg);
```

Appendix – C

i) 5 Wavelets

ii) Short-Time Fourier Transform Spectrum

Appendix – D

Test- Bench: Waveforms

i) EEG

ii) FFT

iii) Gyro

iv) Data Packets

Appendix – E

i) Optimization of a Single Signal

(Before Filter Function)

ii) Optimization of a Single Signal

(After Filter Function)

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