REVIEW ARTICLE

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A – Study Design
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Investigating the Impact of Environment Noise and Music on the Human Brain by using a Brain-Computer Interface (BCI)

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SUMMARY

Efforts to advance brain computer interface (BCI) to aid people who have lost communication and movement abilities (neuromuscular disorders) are becoming popular and are obtaining funding from many Institutes. But it has remained untapped in other areas e.g. manufacturing, the military, the law, etc. Hence, the aim of the project is to investigate the impact of environmental sound (noise & music) on human thinking using the Electroencephalography (EEG) tool. The project is started with a subject literature review and then concentrates on the investigation of the kind of BCI signals and how EEG works. The information will be analyzed and classified to serve as references in the analysis of environmental noise level and music. The project is divided into two scenarios of treatment: the noise – silent – noise – silent form and the second treatment using noise – the silent – music – noise form. The next step is measuring and then analyzing the brain signals in a variety of sound levels. In this state, the comparisons of impact sound from two treatments are presented. Finally, the project shows that the music sound treatment produces a stable graph of brain response when compared with the noise sound treatment. As a consequence, people within pleasant sound will be more relaxed and focused on doing the task.

Key words: brain computer interface, electroencephalograpy (EEG), environmental noise, music sound, signal processing

INTRODUCTION

Encouraged by people's increasing demand for quality of life, decreasing noise levels to reach a comfortable sensation is very important. The project will focus on the investigation of environmental noise impact on human brain performances. The sources of environmental noise such as cars and the wind can badly affect mood, cause reduced relaxation, disturb the educational process and reduce the chance of privacy [1]. Social, technical and medical approaches have been carried out on wide topics of noise research. Jessica Errett and colleagues [2] have investigated the effect of noise on productivity with six noise conditions over 20, 40, 80, and 240 minute trials. Mathematic problems, verbal reasoning and a typing test are implemented to do the experiment. According to the questioner's results, it can be concluded that the perception of noise can impact performance. In other research, Nassiri [3] has reported that when the noise harmonic index was negative (treble noise) the performance was significantly affected. The research employed an experimental design consisting of 3 independent factors for sound pressure level (SPL), noise schedule factor and the noise harmonic index factor. The sources of noise in this experiment were continuous, fluctuating and intermittent noise. Moreover, Brian and David [4] in their research reported that despite music's distinct difference from noise it too affects human performance both negatively and positively. A moderate level of music is optimal for activities requiring careful attention and concentration (i.e. driving) because it closely resembles one's comfort level. However, the determination of a moderate level is subjective to the listener.

According to previous research, the maximum noise permissible as a function of any noise source needs to be specified in order to avoid a reduction in the work performance. As a consequence, signals noise behaviours are to be the important point in this investigation. One of the methods to understand the impact of the noise level in the human body is employing the Brain-Computer Interface (BCI). The Brain-Computer Interface (BCI) popularly called a '*mind machine*' interface (MMI) is a new style of direct communication pathway between the human brain and an external device e.g. a robot. Even though over the past 15 years, productive BCI research programmes have arisen significantly especially in biomedicine areas for neuromuscular disorders, such as amyotrophic lateral sclerosis, brainstem, stroke and spinal cord injury [5], the BCI could be widely used in other areas.

There are two methods to measure the brain signals in the BCI model, the invasive and non-invasive in a tool like an electroencephalography (EEG). EEG is the most common brain measurement tool in the BCI and it has developed into one of the most important and widely used methods to recognize and classify the different brain activation patterns associated with a mental task like neural network, fuzzy logic, etc. The EEG signal configuration is related to the person's level of consciousness. It can be used to detect the impact of environmental noises correlated to work performance. A disturbing signal from the noise level could be released by sound therapy (music therapy). The project is divided into three steps for optimizing the EEG position, investigating the impact of environmental noise in work performance and creating the music therapy for realizing the environmental noise. It will be a research first to use a brain computer interface (BCI) model to investigate the environmental impact (of noise) on human behaviour.

LITERATURE REVIEWS

Brain computer interface (BCI) will help disorders people to do some activities. It is possible for people to get a task done by just thinking about it. The BCI system works on capturing the brain signals and directing them to a computerized electronic device. The machine should learn to discriminate between different complex patterns of brain activity as accurately as possible and the BCI users should learn via different neuron feedback configurations to modulate their EEG activity and self-regulate or control them. Figure 1 shows a conceptual BCI system in any possible output interface model. According to the graph, there are three main basic steps in the BCI process. The first step is data (signal) acquisition, working to obtain information about what is going on the human brain using electroencephalography (EEG). EEG is developed by some electrodes positioned on the scalp to register the differences in potentials between the various regions of the brain and to generate a graph call electroencephalogram that expresses data from neuronal activity over time. Electrode-scalp contact impedance should be between 1 kΩ and 10 kΩ to record an accurate signal [6]. The electrode-tissue interface is not only resistive but also capacitive and it therefore be-

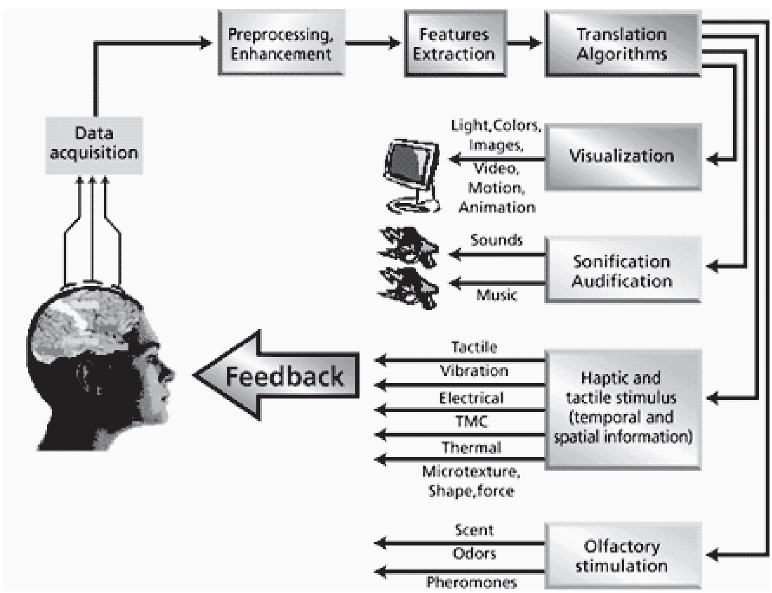

Figure 1. Conceptual BCI system with various kinds of Neurofeedbacks [12]

haves as a low pass filter. The impedance depends on several factors such as the interface layer, the electrode surface area, and the temperature. EEG gel creates a conductive path between the skin and each electrode that reduces the impedance. The use of the gel is cumbersome, however, as continued maintenance is required to assure a relatively good quality signal.

Once the brain signals have been digitized they are processed by a one or more feature extraction method. These processes are intended to extract the specific characteristics of the signals, which encode the messages or command elicited in the user's brain by either evoked or spontaneous inputs. Feature extraction methods could either extract information from the signal in time domain, e.g., evoked potential amplitudes or transform the brain signals to be analyzed in different domains, like the frequency domain or time – frequency domain [7]. The features extracted for use in BCI systems will provide a better or worse separability for the control classes used depending on where on the scalp they are coming from and where in its domain they are. Features found on the alpha and beta band are more likely to provide better separability of classes than features found in other frequency bands. After features have been extracted and selected, the next step is classification by a linier method (e.g. Bayesian Clasifiers) or by a non-linier method (e.g. Neural Network). The final step is connecting the classification features into the output device such as a computer screen or virtual reality environment. [Cabrera, A. R. (2009). Feature extraction and classification for Brain-Computer Interfaces. Aalborg: Center for Sensory-Motor Interaction (SMI), Department of Health Science and Technology, Aalborg University]

The brain computer interface (BCI) is widely used in the biomedical to transform people who have lost their ability to communicate or to move. Febo Cincotti et al. [8] investigated in their research a non-invasive brain computer interface system to operate an assistive device for fourteen patients with severe motor disabilities due to progressive neurodegenerative disorders. Marcin kolodziej [9] in his journal reported that genetic algorithm (GA) is useful to apply efficient methods of feature and electrodes selection. The paper also shows which frequencies of the EEG spectrum are the most important. Krusienki D.J. et al. [10] have stated that the signals processing scheme is the most important design aspect of BCI. This paper discusses the crucial questions and strategies for BCI signal processing proposed by workshop participants. Ruiting Yang [11] reported in his thesis that the BCI is considered as a pattern recognition system and the two main parts of feature extraction and classification. These features and classifiers were compared in the result analysis.

RESEARCH METHODOLOGY

Based on the project aim, the research is looking for the impact of environmental sound on the brain performance. The results of the research are very sensitive to the number and location of EEG electrodes. The best selection of electrodes will get better signals recorded from the participant's brain. There are two scenarios in investigating the impact of sound in human thinking by using the tool of Electroencephalography (EEG). The first scenario is treatment with composition noise (14s) – no sound (15s) in a 10-minute duration test. The format of the sound composition is presented in Figure 2a. The sources of noise are the sounds of a traffic jam with a loudness range of between 36 dB to 84 dB. The input analyzer from Stim 2 software is employed to edit the noise wave. The Stim 2 software is coupled with the STIM Audio System Unit to provide the environment treatment in brain performance. The software provides the best response accuracy possible, the dB level of the sound files can be controlled by the software, and the user has the option to use the mouse, keyboard, or the four-button response pad as the subject response device. The device will send precisely timed trigger pulses to the SCAN acquisition system and these will appear as trigger type codes in the continuous data file.

The first step of the experiment is to create the auditory stimuli using the sound editor in the software menu. Figure 2b. describes the sound analyzer for traffic jam noise. From the picture it can be seen that the noise wave is not well-regulated in frequency and amplitude, there are dramatic changes in the value from high to low conversely

The second scenario for the environmental treatment is the block combination of noise (14s) – no sound (15s) and music (14s) with a total of 18 blocks as described in Picture 3a below. The kind of noise is traffic jam as in the first treatment and the music noise is that of a famous song one liked by the subject of experiment. The sound analyzer for the song is presented in Picture 3b. From the picture it can be seen that the music wave is better regulated than the noise wave in term of frequency and amplitude, there are smooth changes in the value of amplitude from high to low conversely.

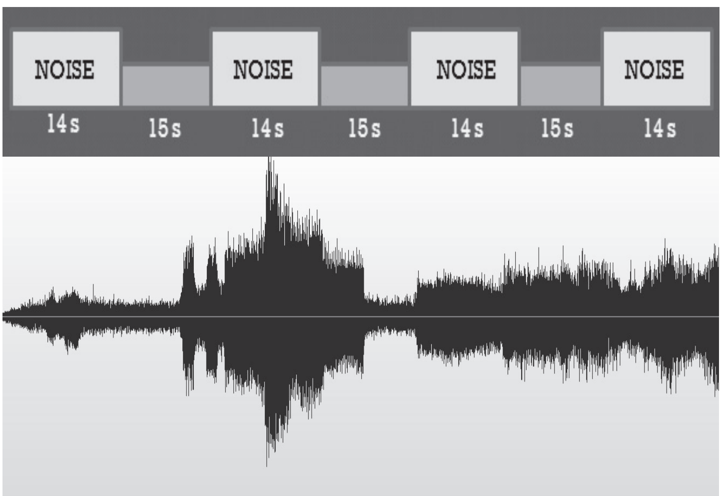

Figure 2.a. Sound treatment configuration in the EEG first test. b. depicts the sound analyzer for traffic jam noise

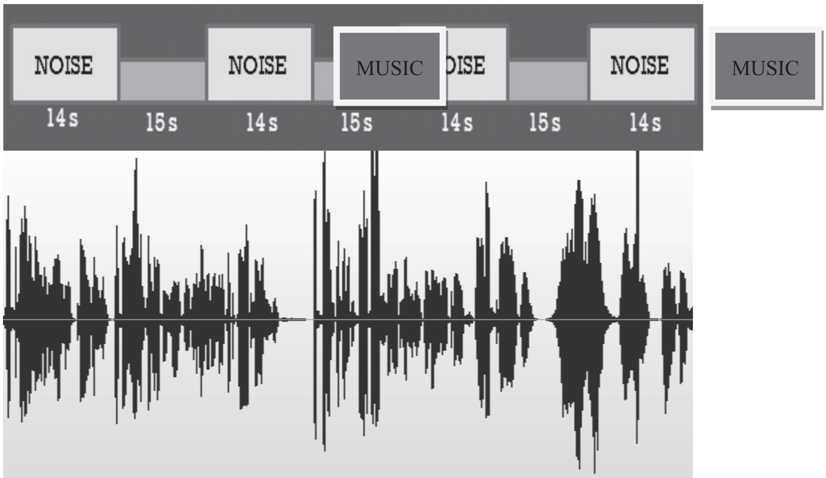

Figure 3a. Sound treatment configuration in the EEG second test, b. the sound analyzer for music treatment

To conduct an experiment test, participants will get BCI treatment for learning tasks under any level of noise generated from a car, motorbike, the spoken voice, the wind, etc. Then the brain signals data are collected by the EEG method. The processing and classification of the brain signal employs a non linier (neural network) method. The signal behaviours are to be the basic for analyzing the impact of environmental sound on the brain performance. This is indicated by a signal configuration which should have the same frequency and same amplitude compared to that for doing a normal task without noise disturbance. The comparison of the work performance in the different treatment is the key result in this research.

RESULT AND ANALYSIS

To do the research, engineers should define the time line measurement contents of the inter-trial interval, the stimulus duration and the response window correlated with the number of trials and the seed values. Figure 4 shows the time

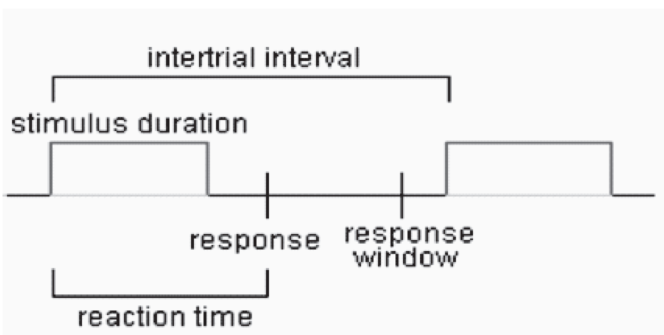

Figure 4. The time line structure of the Gentask sequence editor

line of the treatment in the Gentask editor. According to the first and second of the sound treatment forms, the stimulus duration is 1500s, the response window is 1000s and inter-trial interval duration is 4500s.

The definition of the time line structure should be entered into the table of the Gentask editor as shown in Table 1 below. The Repeat Block command is used to copy and repeat a block of events in a sequence file. For example, the first treatment has an event noise – silent – noise is called one block and it will be repeated by some block followed by the log duration of the treatment. For the reason of the complexity of the experiment, the first scenario has duration of 10 minutes and second scenario is 15 minutes in duration or 44 copy blocks for each treatment (scenario).

The next step after finishing the Gentask input is conducting the research with one subject person and 2 treatment scenarios. The first activity is filling gel into the scalp for every hole to connect the electrodes with the brain signal by means of 42 systems. Figure 5a shows the neuroscan tool with 42 channels of wire connected to the scalp. The monitor will control the quality connectvitas between the brain signal and the electrode as indicated by the colour blue for poor connectivity and black for good connectivity. The next step is doing the experiment as described

Table 1. Gentask sequence editor for the first treatment of the experiment

No	Mode	Duration	Window	ITI	X POS	Y POS	Response	Type
1	SND	0.00	0.00	ASAP	85	0	-1	1
2	SND	0.00	0.00	ASAP	0	85	-1	2
3	SND	0.00	0.00	ASAP	85	0	-1	1
4	SND	0.00	0.00	ASAP	0	85	-1	2
5	SND	0.00	0.00	ASAP	85	0	-1	1

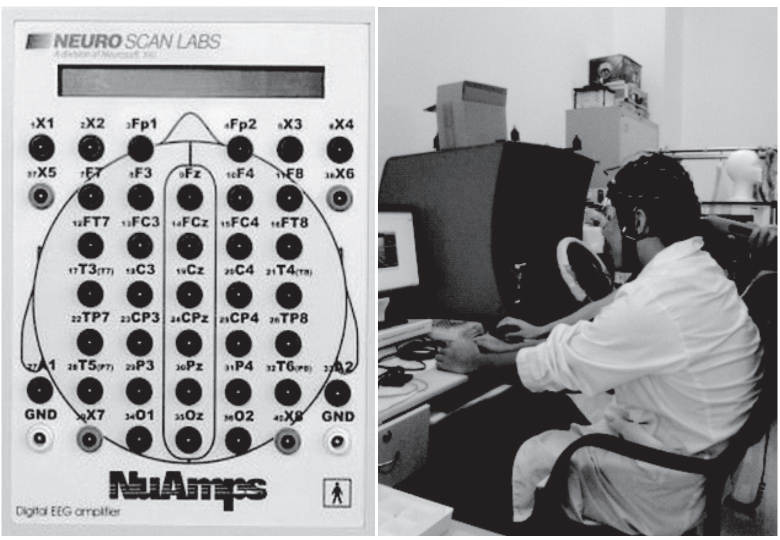

Figure 5. a. NeuroScan amplifier for electrodes positioned on the scalp, b. Experiment of environmental sound impact in human thinking using EEG equipment

in Figure 5b. The environmental noise/ sound should be controlled only from the experiment speaker. There the subject of the research is supported to focus on the experiment in order to give the best response with fewer signal noise.

On the basis of the experiment, analysis of the results is divided into two categories for the first treatment (1st event: noise – silent) and for second treatment (2nd event: noise - music - silent). The result analysis is worked out based on the number of electrodes in the scalp contact to brain signals e.g. electrode FP1, F7, FT7, TP7, T4, CP3, etc.

According to Figure 6, the occipital lobe has the function to process the visual information, the frontal lobe is used for motor planning, and the temporal lobe is addressed to auditory processing. To analyse the impact of sound in human thinking, the experiment only investigated the electrodes in the temporal lobes for the left brain (T3, TP7, T5) and the right side (TP8, FT8, T6) for both of the 2 experiment scenarios. Both sides of the brain produce the same configuration as is explained in Figure 7a for electrode T3, 7b for electrode TP7 and Figure 7c for electrode T5. It can be summarised that all the signals data have the same pattern (fluctuation pattern). According to the picture, it is clear that noise from the traffic jam influenced the electrodes signal from the human brain as indicated by the unstable (wave) signal form with maximum signals energy @ 84 µv. In summary, the noise can disturb human focus in the auditory process.

By using the same analysis, the second scenario (second treatment) worked by a combination of noise – silent – music amazingly produces a stable pattern with low signals energy at average @ 7 µv. This means that the second scenario produces a better impact on human activity than the first scenario. It can be concluded that music (sound that makes the subject feel enjoyment/happiness) can experimentally reduce human fatigue or can increase human endurance. As a consequence, pleasant music will boost a worker's performance. Something of interest to be discussed in future research.

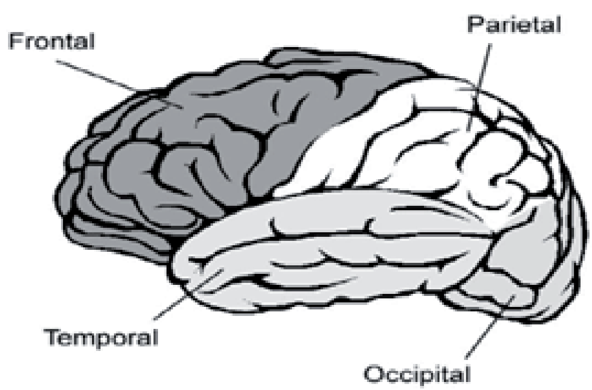

Figure 6. Four various lobes for performing different functions in the human brain [14]

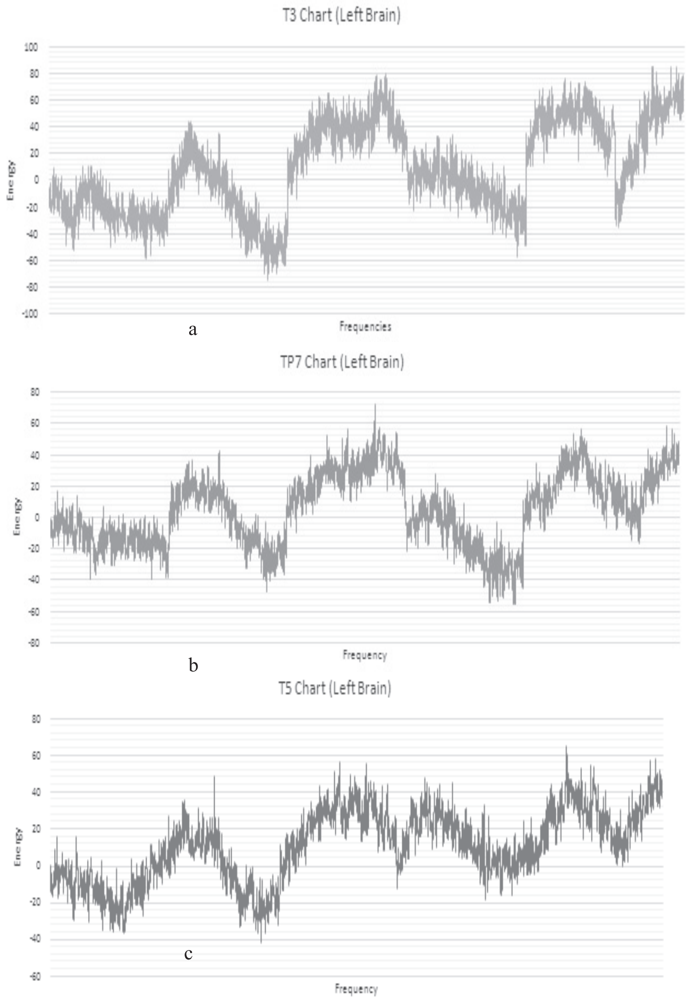

Figure 7. EEG performance for the first scenario of the experiment; a. Brain signal from T3, b. Brain Signal from TP3, Brain signal from T5

CONCLUSIONS & FURTHER WORK

The research successfully completed all the research objectives in investigating the impact of different sound treatment on human performance. The treatment of noise from traffic jam produced more signal energy and more fluctuated signals in the auditory process. This means that the noise sources can adversely impact on human performance, human concentration and human health. Compared to the noise treatment, the treatment of noise – music produced a small variation in energy signals. In sort, music (pleasant sounds) can successfully improve the human brain performance in any kind of work.

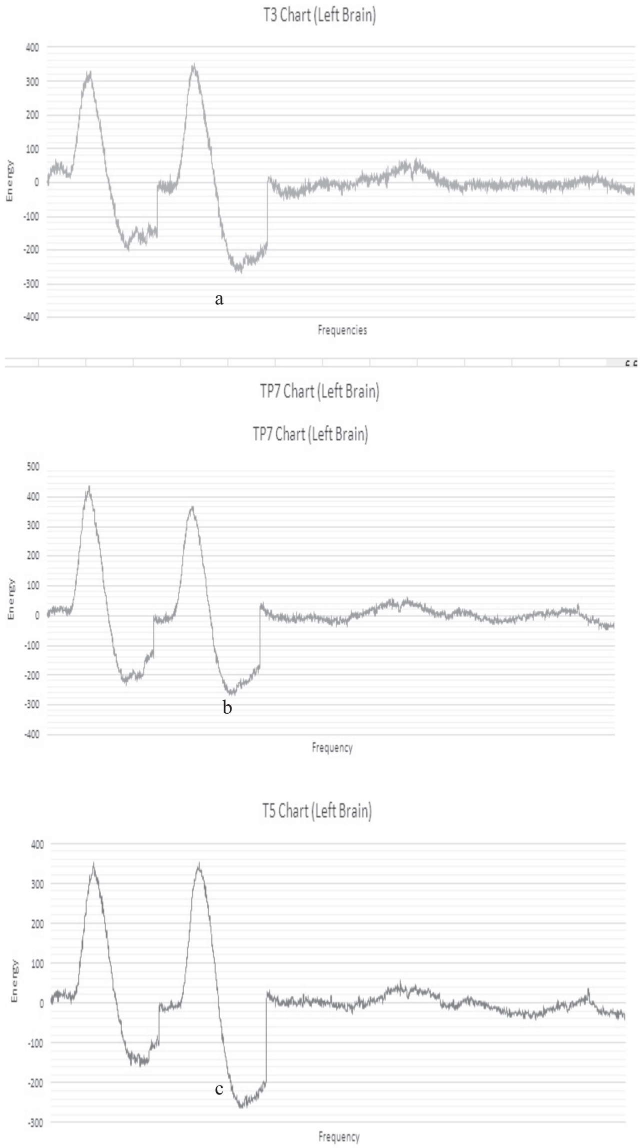

Figure 8. EEG performance for the second scenario of the experiment; a. Brain signal from T3, b. Brain Signal from TP3, Brain signal from T5.

The further research suggestions are presented based on the experiences and the limitation facilities experienced while working on this project. Any future project should increase the total number of the experiment factors. An updating of the equipment would give difference results in registering the brain signal.

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