# Semi-Professional Music Educations Long Term Effects and Cerebral Adaptations among STEM Students

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**Abstract**

In this study, we investigate a baseline for EEG activity as an initial step of our major project and we specify our experiment tasks. In our main project we investigate the cerebral adaptations among STEM (Science, Technology, Engineering, and Mathematics) students with and without prior semi-professional music experience. If we can determine that music education causes mental adaptations and affects student performances in a positive manner on certain types of tasks, new studies about how music education can be used to improve STEM Majors educational performance and their professional skills in the future. Accordingly, we need to specify the experiment tasks.

All subjects are given a standardized test to attain similar characteristics within the control and the experimental groups with regards to general features, such as handedness, gender, age, and ability features such as comprehension and perception. Then, all subjects are given a main task and EEG (Electroencephalography) values are captured in the course of performing the task. We are not only investigating the patterns of directly related areas in the brain (e.g., as measured through common frequency activity patterns), but also other parts as they might be related. The goal of this study is to uncover if and how participants with musical education background exhibit different characteristics from the control group of students.

It is a well-known fact that musicians brains undergo some adaptations during the long times of motor activity training and complex finger-exercise practicing. The adaptations declared are such as expanded area in the corpus collosum, both right and left hemispheres, increase in the number of glial cells, synaptic density and capillaries as microstructural adaptations. There are a lot of studies investigate cerebral adaptations but there is no study that shows how do these physical adaptations change people's other activities, responses or approaches to different tasks.We hope to enlighten the correlation between the musicians and STEM professionals in order to develop new techniques for STEM education. To asses our hypothesis we will find a method to generate an EEG baseline for every objects.

# 1 Introduction

In this study, we investigate a baseline for EEG activity as an initial step of our main project and we specify our experiment tasks. In our main project, we investigate the cerebral adaptations among STEM (Science, Technology, Engineering, and Mathematics) students with and without prior semi-professional music experience. During the literature search, we saw that some studies exposed professional musicians' brains to some physical adaptations during extended periods of motor activity and complex finger-exercises [1] but there is no study that investigates how these adaptations effect their non-musical activities, or how semi-professional musicians' brains are changing over time and how these adaptations effect their professional activities.

Considering the way that education leads to professional life, we decided to do the study among STEM students. If we can determine that semi-professional music education changes the brain and these adaptations cause a positive difference in their professions, then we may have suggestions for improving the STEM students performances and professional skills.

There are many psychology studies about music and the brain: how music influences human perception and cognitive skills, so on. They mostly utilize questionnaires to assess music's influences. But as we'll mention in the second part, their qualitative form sometimes give rise to contradicitons, controversions and unreliable outcomes. On the other hand, in our study we intend to restrain contradictions by using computational methods. Our first step is generating a baseline for better understanding of EEG data.

Character of EEG data is too noisy [2] and too sensitive to occular and any kind of muscular activity[3]. In some studies[4], EOG (Electrooculography) is employed to detect eye blinks and remove these artifacts. In some studies[3,5], EEG technicians or experts clean the artifacts of the data with visual examination. Naturally, the more number of channels (electrodes) the EEG device has, the better accuracy we obtain. In this study, we use a one-channel EEG (headset) device. The electrode is resting on the forehead above the eye (FP1 position). Employing one electrode for EEG readings isn't necessarily a negation. Small number of electrodes provide practicability and save time[4]. So, it is important to achieve good performances with 1-2-3 channel EEG devices. To accomplish a good performance for our main study, we need to clean our data from eye blinks. We call it generating a baseline. Fast Fourier Transformation is one of the most common method in signal processing problems. FFT is important in EEG analysis as well because it is used in decomposing EEG signals. EEG signals comprise different frequency bands which are called brain-waves. Each brain wave is active in different locations during specific activities. In this study, we explore which frequency band or bands give us the more accurate information about eye blinking and can we find a correlation between eye blink and mental states or other frequency bands. It is important because our EEG device has only one channel and it measures only one location.

Deciding to the experiment task is another challenge. Most of the EEG studies are about diagnosing Alzheimer's disease, epileptic seizure prediction or motor function disorders. Accordingly, the most common experiment tasks are imagination of moving a leg or arm, spinning of a three dimensional object[4]. Our main research object is to find out the difference

-if there is a difference- in people's approaches on different tasks. Unfortunately, there is no pinoeer study that we can take as an example.
The remainder of this paper is structured as follows. In Section 2, we offer a wide perspective to neuromusic research, describe how brain is associated with music, and the measuring techniques in neuroscience technology. In part 3, we describe our methodology and experiments. We conclude and describe future works in part 4.

# 2 Related Works and Background

## 2.1 Research on NeuroMusic

Benefits of music for human health is known among people. In the early 90's, a study which was conducted among college students, showed that listening to classical music could improve spatial IQ, which is known as the 'Mozart Effect' [6]. After that, some researchers repeated the same experiment with college students, preschool children, and with monkeys. Due to different reasons, none of them could replicate the result and observe a contribution of music in the spatial - reasoning tests[7]. Albeit the Mozart Effect is controversial, many studies showed that music causes physical adaptations in the brain.

Despite the lack of a generally accepted definition, it can be said that Neuromusical research is a specialized neuroscience branch which studies the adaptations and stimulations in the brain caused by musical activity. Neuromusical research uses neuro-imaging techniques, and it differs from the psychology studies which cover music and the brain. In many Neuromusical studies, brain signals are measured or monitorized during listening or performing of music. By this way, neuromusical studies give us realistic evidence and prevent contradictions like 'the Mozart Effect'.

According to an illuminating research in the neuromusical research field [8] the current literature can be classified in the following ways, Perception and Cognition, Affective Responses, Musical Performance, Memory and Learning, Brain Plasticity and Neural Development, Genetic Factors, and Neural Correlates of Music Processing.

In addition to that, some neuromarketing companies who work on how brains respond to new songs and help the recording industry to find out if the popular song can be a hit or not.

In our study, objects are not going to perform musical activities during the measurements, but we are going to examine musically altered brains, while they are performing some of the standardized reasoning tests. Therefore, it can be said that it is a neuromusical study.

It is important to be aware that neuromusical research has its own limitations. We do not have the opportunity to do ablation on the brains of subjects and restrictions on measuring and imaging. As we mention in the Measuring Techniques, EEG is nearly imposssible to use while the object's performing music because of the device's sensitivity on blinking eye, and the other imaging techniques are limited due to their physical conditions.

## 2.2 Musical Brain

The whole brain consists of three basic divisions: the forebrain, the midbrain, and the hindbrain, and these divisions includes different regions responsible for different kinds of perception. The forebrain is responsible for a variety of functions including receiving and processing sensory information, thinking, perceiving, producing and understanding language, and controlling motor function. Also it includes cerebrum and cerebral cortex. The hindbrain includes the cerebellum, pons, and medulla oblongata and it is primarily concerned with autonomic (i.e., involuntary) processes such as the regulation of breathing and heartbeat . The midbrain and the hindbrain together make up the brainstem. The midbrain is the portion of the brainstem that connects the hindbrain and the forebrain. Instead of stating each region's function in detail from a medical neuroscience approach, we are going to express how they are associated with music.
In Table 1 below it is shown that how each cortex is affected from musical activity or how they are associated wity music.

This table is going to help us to observe the level of activation difference in the related brain regions during the applications of the standardized tests among control and experiment groups and the table is used to find a correlation between the activated regions and adaptated regions because of the long music education and performance among the experiment group objects.

## 2.3 Measuring Techniques

It is not wrong to say development in the measuring and imagining technology gave neuroscience opportunity to look deeper than anything. There are eight imaging and measuring techniques being used in the field depending on the studies' needs, limitations, or opportunities. These techniques are : Magnetic Resonance Imaging (MRI), Functional Magnetic Resonance Imaging (fMRI), Positron Emission Topography (PET), Electroencephalography (EEG), Event Related Potentials (ERP), Magnetoencephalography (MEG), Transcranial Magnetic Stimulation and Diffusion Tensor Imaging(DTI). We don't talk about all of these techniques because each of them has a long developing history and complicated principles. We are only going to use the Electroencephalography (EEG) in this study.

Table 1: Core brain regions associated with musical activity [9]

| Core Brain Region | Musical Activity |
|---|---|
| Motor Cortex | Movement, foot-tapping, dancing, and playing an instrument |
| Sensory Cortex | Tactile feedback from playing an instrument and dancing |
| Auditory Cortex | The first stages of listening to sounds, the perception and analysis of tones |
| Prefrontal Cortex | Creation of expectations; violation and satisfaction of expectations |
| Cerebellum | Movement such as foot - tapping, dancing, and playing an instrument. Also inolved in emotional reactions to music |
| Visual Cortex | Reading music, looking at the performer's music (including one's own) |
| Corpus Callosum | Connects left and right hemispheres |
| Hippocampus | Memory for music, musical experiences, and contexts |
| Nucleus Accumbens | Emotional reactions to music |
| Amygdala | Emotional reactions to music |

## 2.4 Electroencephalography

Brain is like a bioelectric generator. The surface of every neuron is covered by synapsis and the activity between the synapsis has an electrical behavior. This behavior produces measurable electrical fluctuation. EEG measures this electrical pattern through electrodes placed on the scalp of a subject.

In advanced studies and professional EEG measurements, 21 electrodes are located on the surface of the sculp. To place the electrodes with good accuracy, an EEG - Electrode map must be used, which is standardized by the American Electroencephalographic Society. The sensitivity of the electrodes may vary depending on their positions.

The Electroencephalogram (EEG) is analyzed using a fast Fourier Transform . The frequency spectrum of the normal EEG of the brain is in the range of 1 - 50 Hz. This range is divided into 4 common frequency ranges. All of them have different characteristics.

The alpha waves have the frequency spectrum of 8-13 Hz and can be measured from the occipital region in an awake person when the eyes are closed. The frequency band of the beta waves is 13-30 Hz; these are detectable over the parietal and frontal lobes. The delta waves have the frequency range of 0.5-4 Hz and are detectable in infants and sleeping adults. The theta waves have the frequency range of 4-8 Hz and are obtained from children and sleeping adults [11].

EEG readings are very sensitive to interference, body motion or even eye movement. For this reason, EEG studies do not usually incorporate active physical tasks and tend to measure listening or thinking activities [8].

# 3 Procedure and Experiments

In this study we have specified the tasks that the objects are going to perform and we searched for some ways and techniques to analyize the eeg data. These two steps are important before we start recognizing the pattern we look for. The diffuculty of working with EEG data is that it is not possible to keep all of the environment variables constant and measure only what we search for. Due to this reason, we want to understand very basic patterns like closing eyes, opening eyes, and blinking eyes because these are the patterns we will run into most during our experiments. Brain is like an interdependent system. During an activity, more than one region is stimulated. That's why we need to know where to look to eliminate these basic patterns from the patterns we are searching for.

We chose some standardized tests for the objects. These are Verbal Reasoning, Numerical Reasoning, Abstract Reasoning, Mechanical Reasoning, and Space Relation tests. We are not going to talk about the tests in detail but we should say that they are important in these fields, respectively: sciences,lab work and toolmaking, computer programming, mechanics and engineering, visualizing three dimensional objects from two dimensional patterns and design[12]. We chose these because they can be applied to everybody regardless of their majors.
We will have three groups: STEM students, Music students as control groups and STEM students as the experiment group. During the experiments, our purpose is to find:

- which regions are stimulated in the control groups, and
- which regions are stimulated in the experiment group (are there any different regions ?).

If there is any different regions then we'll search for a correlation between the common and differentiated regions.

Our system includes NeuroSky - MindwaveMobile headset and a Winsows 7 desktop. We are using Matlab, MindStream java application and R statistical programming languages as the developing tools. It is the least expensive way to get into EEG analysing research and it is compatible with computers and mobile devices. It safely measures the EEG signals and outputs the EEG power spectrums. The device has a headset, a sensor arm and an ear - clip. The reference and ground electrodes are on the ear clip and sensor electrode is on the sensor arm above the eye (FP1 postion) [13]. In the data file there are 12 different data sets includes time stamp, poor signal level, attention, meditation, delta, theta, low alpha, high alpha,low beta, high beta, low gamma, high gamma.

In Figure 1, we have illustrated our preliminary data. This data belongs to a test with open eyes for five minutes and closed eyes for the next five minutes. Different colors shows different frequency bands. As we mentioned in Part 2.4, each of the waves has different frequency and amplitude ranges. Also, the waves are effective in the different regions of the brain. We wanted to indicate this plot because it can be seen that each brain-wave's amplitude range and frequency components are different. At the beginning, we should have found which wave is more related to the eye movements. We expected to see higher amplitude level in the first five minutes and

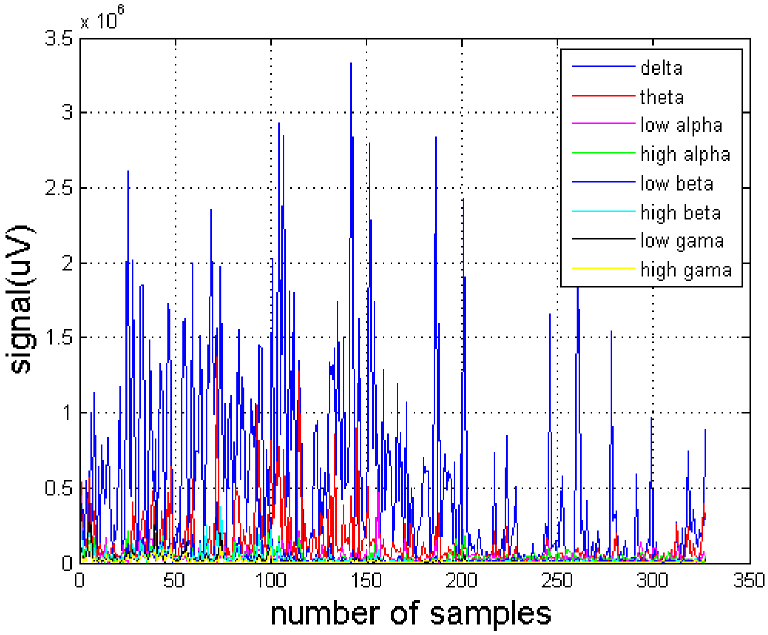


Figure 1: All the different attributes are illustrated in the same plot to show they have different amplitude and frequency ranges. It can be observed that, in a particular area they get very different values.

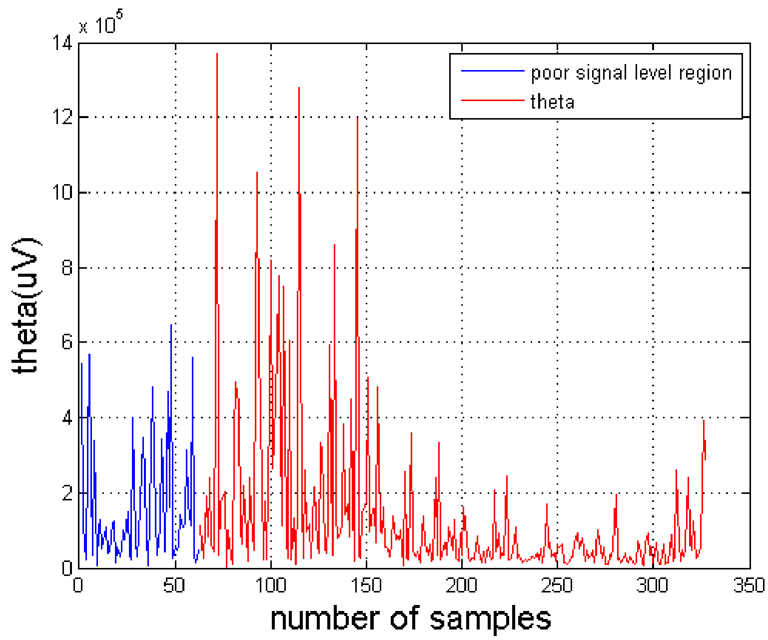


Figure 2: In this test, the object's eyes are open for five minutes and closed for five miutes. Theta waves showed the most expected pattern. The blue region demonstrates the poor signal level. It is very hard to say there is an exact open-eyes pattern in the first five minutes, without removing it.

smaller amplitude level in the second five minutes.

After we analyized each of the waves, we found one wave pattern which is closest to the expected pattern. In Figure 2, we illustrated the theta wave of the same test we described above. One of the data sets we obtain from our device is the poor signal level. It is high when the signals are unreliable. We observe it is usually high for a few seconds at the beginning of the measurements, then it gets lower. To obtain the patterns we are looking for, we had to trim the data which is shown with blue color. In this region the poor signal level is the maximum. Therefore the signal in this region is not dependable and useless. We colored it separetly to show its speciousness.

# 4 Conclusion

In this study, we investigate a baseline for EEG activity as an initial step of our main project and found how to detect a very basic pattern like open and close eyes. This is important because these patterns are expected to be the base pattern in our future work. Also, we decided the standardized tests as the main task, experiment and control groups. Deciding to the experiment task was a challenge for us. Because most of the EEG studies are about diagnosing Alzheimer's disease, epileptic seizure prediction or motor function disorders and there is no pinoeer study that we can take as an example. For future work, we are going to start experiments on STEM students. And, we are going to search the EEG analysis techniques to deploy in our main project.

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