A Study on Human Brain Activity during Music Listening using EEG Measurement

EEG 計測を用いた音楽鑑賞時の人間脳活動に関する研究

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Abstract: Entertainment is a happy activity for people, and could help people to improve the quality of their life. Among many entertaining ways, listening to music is one of the most popular and convenient ways. In this paper, we conducted experiments to measure the brain activities using a portable EEG (Electroencephalogram) system, when the subjects were listening to beautiful music or unpleasant noise. The EEG data were analyzed after the acquisition from the experiments. Epochs of music and noise conditions were extracted separately, and their ERPs (Event-related potentials) were calculated. ERP differences between music and noise epochs were observed in several sessions. But at present the experimental results were still lack of repeatability due to the limitation of the current portable system. Further work is in plan for both experiment setup improvement and more advanced data analysis.

Keywords: brain activity measurement, EEG (electroencephalogram), ERP (event-related potential), music listening

要約：エンタテイメント作品を享受することは、私たちに楽しみであるだけでなく、生活の質を向上することにも繋がる。音楽鑑賞はさまざまな娯楽活動の中でも、きわめて広く行われ、しかも容易に享受されている娯楽活動である。本研究では、美しい音楽と不快なノイズを聴いているときの被験者の脳活動を携帯型脳波計を用いて計測し、その EEG データを収集した。さらに得られたデータを分析することで、個々の事象関連電位（ERP）を求めた。いくつかの実験セッションにおいて、両者の EPR の間に差異が観察された。残念ながら現状の携帯型脳波計を用いては計測条件を一定に保つには限界があり、全体的に実験結果の再現性は高くない。今後はさらに条件を改善しながら実験を重ね、データを詳しく解析していく予定である。

キーワード：　脳活動計測、EEG、脳波、事象関連電位（ERP）、音楽鑑賞

1. Introduction

In the modern days, entertainment is an easy way to make the people happy, calm or exciting. In this way, entertainment is helpful to improve the quality of people's life. Among various entertaining ways, listening to music is one of the most popular and easy hobby for people. Especially, listening to popular classic music usually makes people relaxed and moved. Several researches have been conducted to study the brain activity related to listening to music (Jatupaiboon, N., et al., 2013, Lin, Y. P., et al., 2010), where the happiness or emotion related to the music listening was detected using neural networks based on EEG. In these researches, besides of the music stimuli, the subjects also watched the visual stimuli when they were listening to the music (Jatupaiboon, N., et al., 2013), or multimedia stimuli were presented (Lin, Y. P., et al., 2010). In this paper, we conducted experiments using audio stimuli only, without any other types of stimulus added upon them. We tried to elucidate if there were any differences in the brain activities when people were listening to beautiful music or unpleasant noises. We measured human brain activities based on EEG (electroencephalogram) when subjects were listening to a serials of audio stimuli consisted of music and noise clips.

2. Experiment Methods

2.1 Experiment apparatus

EEG is a non-invasive method to measure human brain activities for both healthy persons and patients. As we know, the brain consists of billions of neurons. When we interact with the outside world, neurons produce spikes of voltage to form electrical pulses travelling in the brain. These electric currents produce electric potentials which can be detected by the electrodes on the scalp. Collecting these potentials over time gives us the EEG signals. By analyzing these data, the corresponding brain activities can be inferred.

A portable EEG system of Emotiv EPOC (Emotiv Inc., 2014) was utilized in our experiments (as shown in Fig.1). It is a wireless EEG system and able to be applied for

Fig. 1: The portable EEG system Emotiv EPOC from Emotiv, Inc.

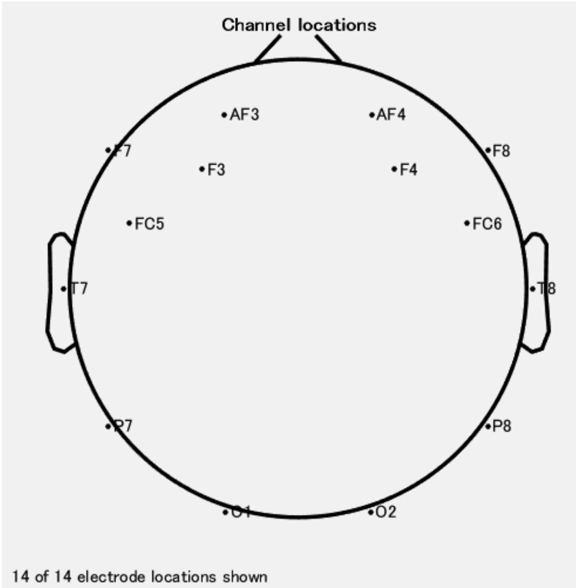


Fig. 2: The locations of 14 electrodes of Emotiv EPOC on a scalp diagram.

researches in entertainment, market research & usability testing and neuro-therapy. This system has 14 channel electrodes and is the first commercial EEG to not use dry sensor technology. The electrodes are located at the positions of AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4, according to the international 10–10 system (American Electroencephalographic Society, 1991). The locations of the 14 electrodes are shown in Fig. 2.

2.2 Experiment stimulus and data acquisition

During the experiments, the subjects listened to the audio stimuli while closing their eyes. The audio stimuli consisted of 13 types of music clips, 6 types of noise clips and silence clips. The music clips were cut from 13 pieces of classic music, and lasted for 20 seconds. Each music clip was played once in one experiment session. As the contrast stimulus, 6 types of noises were created, and each were repeated twice except for one type, which was repeated for three times. Each noise clip lasted for 5 seconds. All these music clips and noise clips were presented randomly during an experiment session. Between every music and noise clips, a 3 second silence clip was inserted. Figure 3 shows the stimulus sequence in one experiment session.

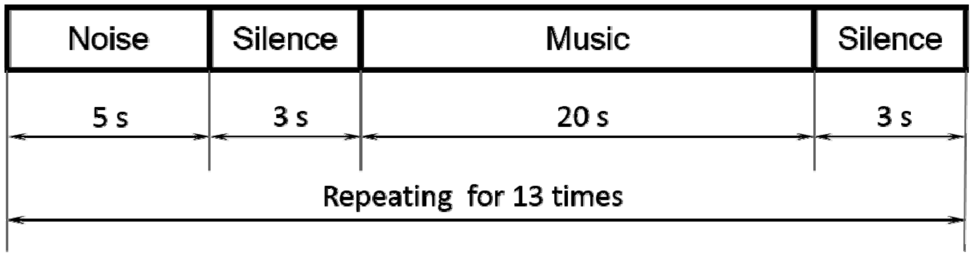


Fig. 3: Sequence of the stimuli in one experiment session

The EEG data were acquired when the subjects were listening to the audio stimuli described as the above. An Emotiv EPOC headset was mounted on the subject's head, and the contact quality of the electrodes was adjusted so as to get good signals. During the data acquisition, the subjects were sitting on a chair in a comfortable way. They wore the stereo earphones, and were asked to try to concentrate on the listening and keep their eyes closed and being quiet without the body movements. The EEG data collected by the emotiv EPOC were sent to a PC via the wireless connection. Four subjects participated in the experiments. One subject was measured for 3 experiment sessions, and two subjects for 2 sessions, and another subject for 1 session. Each subject took part in only one session one day, and the multiple sessions for each subject were measured in different days.

2.3 Data analysis

An event-related potential (ERP) is regarded as reflecting the brain activities caused by a specific cognitive or motor event, such as listening to music, etc. (Luck, 2005), and can be obtained ERP by averaging a series of EEG data for the same type of events. After the EEG data were acquired from the experiments, we analyzed the data using the open source software EEGLAB (Delorme, A. & Makeig, S., 2004), and calculated the ERPs from the EEG data. The epochs of the music and noise stimuli were extracted separately from the entire EEG data, and their ERPs were plotted in both images and potential graphs. In this paper, all acquired EEG data was used for the analysis without excluding any artifacts. The EEG data were analyzed for each session and each subject respectively. ERPs for all 14 channels was examined for all sessions and all subjects.

3. Results and Discussions

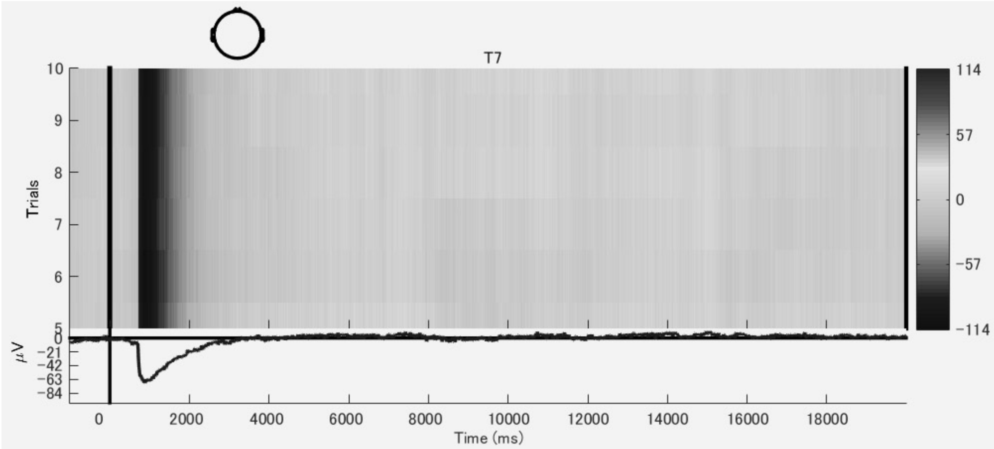
It was found that the brain activities measured based on EEG varied from session to session and from subject to subject. The examples of the ERP results are shown in Fig. 4 and Fig. 5. Only the results for one electrode T7 which was reported to be one of the electrodes which gave better results to happiness detection (Jatupaiboon, N., et al., 2013) were picked up. The location of T7 is in the left temporal area (as shown in Fig. 2).

Fig. 4 shows the experiment results of one session for subject A. In Fig. 4 (a), the ERP image together with the ERP potentials of the 20-second classic music epochs are shown. The ERP data shows that there was a negative peak in the ERP at nearly one second after the music clip started. Fig. 4(b) shows the potentials of both music epochs and noise epochs for the first 5 seconds, because the noise clip only lasted for 5 seconds. The graph shows that the ERP for the noise epochs has a small positive peak at about 300 ms after the noise clip started, and the ERP value is quite small during the whole epoch.

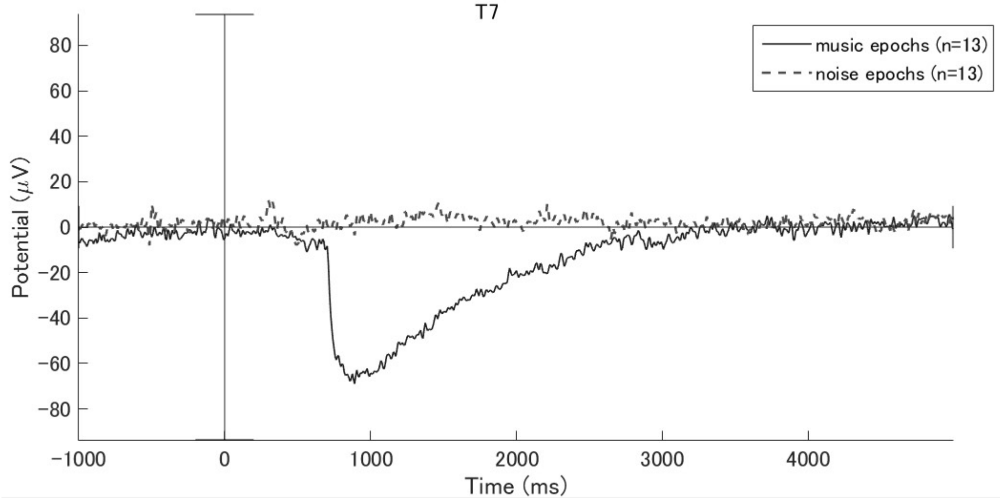
Similarly, the experiment results of another session for another subject B is shown in Fig. 5. In Fig. 5 (a), a negative peak of the ERP was observed at about 3 s after the music clip was played. After that, the ERP continued to vary greatly in the 20 s epoch duration. In Fig. 5(b), the graph shows that there are negative peaks in the ERP for both music and noise epochs. The peak for the noise epoch appeared a little earlier than the music epoch.

The above experiment results are the two examples of the ERPs from the total 8 sessions where 14 channels existed for each session. By analyzing the ERPs for all sessions and subjects, it was found that the current ERP results did not have good repeatability. Even for the same subject who had showed remarkable differences in the ERPs between listening to music and noise clips, the ERPs from another session which was conducted in another day would change greatly, and only little difference in ERPs could be observed between the two kinds of epochs.

A possible reason could be that because the Emotiv EPOC system is a portable system good at the convenience for the setup, it is not so good for the precise experimental measurement. The electrodes are fixed on the plastic arms, and their positions cannot be adjusted to fit each subject (as shown in Fig.1). Therefore, the actual sensor locations relative to the brain areas may vary from subject to subject. In addition, the plastic arm is difficult to be set at the same positions for every setup. These

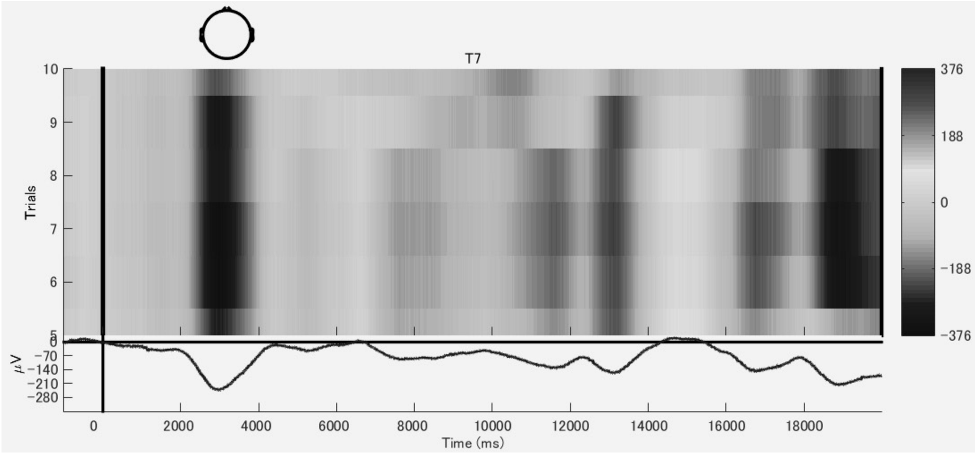


(a)

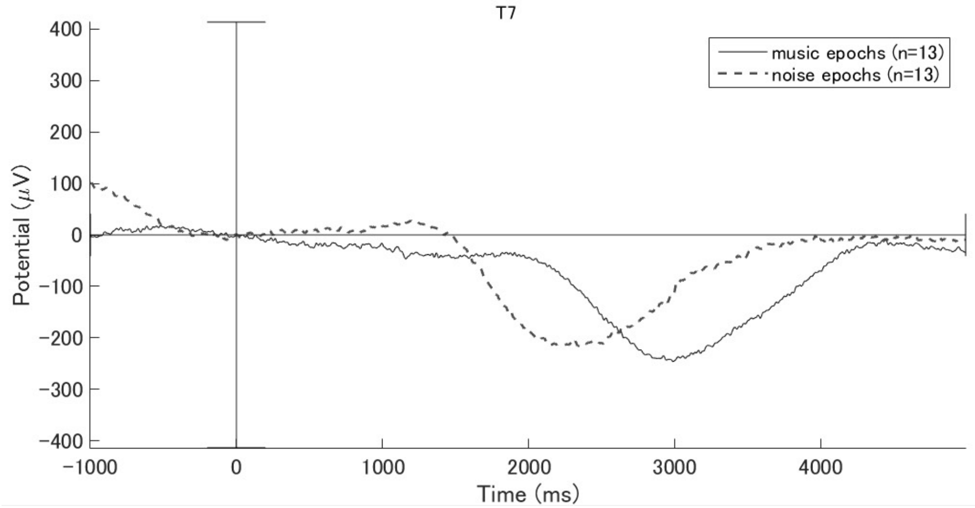


(b)

Fig. 4: Examples of EEG results on channel T7 for one session of subject A. (a) The ERP image and potential graph when the subject was listening to the 20-second classic music. (b) The potential of the first 5 seconds for both music epochs and noise epochs. Solid line: ERP for music epochs; Dashed line: ERP for noise epochs.



(a)



(b)

Fig. 5: Examples of EEG results on channel T7 for one session of subject B. (a) The ERP image and potential graph when the subject was listening to the 20-second classic music. (b) The potential of the first 5 seconds for both music epochs and noise epochs. Solid line: ERP for music epochs; Dashed line: ERP for noise epochs.

experimental conditions could be the reason why the acquired EEG data did not have good repeatability. In order to obtain better experimental conditions, the calibration method of the sensor locations should be introduced in the future experiments. Furthermore, there may also be some artifacts to influence the experiment data. The artifacts should be examined furtherly in our future work. The ICA (independent component analysis) method is also considered to be applied in our future data analysis.

4. Conclusions

In this paper, we measured the brain activities using a portable EEG system, when the subject were listening to music and noise clips. The EEG data were acquired using a 14 channel Emotiv EPOC system. 13 types of music clips and 6 types of noise clips were created and utilized as the stimuli in the experiments. The EEG data were analyzed after the acquisition from the experiments. Epochs of music and noise conditions were extracted separately, and their ERPs were plotted in image and potential graphs. The differences in ERPs between music and noise epochs were observed in several sessions. But at present the experimental results were still lack of repeatability due to the limitation of current portable system. Further work is in plan for both experiment setup improvement and more advanced data analysis in order to clarify the difference in the brain activities when people are listening to beautiful music and unpleasant noise.

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References

American Electroencephalographic Society (1991): American Electroencephalographic Society Guidelines for Standard Electrode Position Nomenclature. J. Clin. Neurophysiol 8: 200-2.

Delorme, A. & Makeig, S. (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics. Journal of Neuroscience Methods 134:9-21.

Emotiv Inc. (2014): product specs sheet, https://emotiv.com/product-specs/Emotiv%20EPOC%20Specifications%202014.pdf

Jatupaiboon, N. Pan-ngum, S. and Israsena, P. (2013): "Real-Time EEG-Based Happiness Detection System," The Scientific World Journal, vol. 2013, Article ID 618649, 12 pages.

Lin, Y. P., Wang, C. H., Jung, T. P., et al. (2010): "EEG-Based Emotion Recognition in Music Listening: A Comparison of Schemes for Multiclass Support Vector Machine", IEEE Transactions on Biomedical Engineering, vol. 57, no. 7, pp. 1798–1806.

Luck, Steven J. (2005): An Introduction to the Event-Related Potential Technique. The MIT Press.

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