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# Characteristic Analysis of Auditory Stimulation

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**Abstract**. This study was intended to analyze real time changes in characteristics of cerebral activation state based on auditory stimulus and apply the findings to the field of various neuro-feedback therapies.[1],[2] In this study, we analyzed changes in cerebral activation state of subjects after exposing them to auditory stimulus included in audible frequency band from 20Hz to 20KHz. At this time, we intended to analyze difference in audible frequency band -- which revealed various characteristics such as concentration indicator and emotional stability indicator, etc -- among subjects and use specific audible frequency for specific subjects as part of customized neuro-feedback external stimulus technique. To achieve such objective, this study was intended to present customized stimulation techniques and analyze cerebral activation status(F7, F8, T3, T4, T5, T6, O1, O2) in 30 male and female subject.

**Keywords:** Neurofeedback, Auditory, Ultrasound

## 1 Introduction

Methods for controlling various diseases have been presented amid rapid advancement of medical techniques. However, practical incidence of diseases remains undiminished in contemporary times and only post-onset treatment and control measures have been presented. The presentation of such control and treatment methods is not only desirable in terms of health promotion and extension of average life span, but also brings unwanted aspects such as side effects associated with such control and treatment. To resolve these problems, various forms of alternative medicine have been highlighted, and particularly, neuro-feedback therapeutic techniques etc., which do not involve use of drugs and surgery in psychiatric field, have come to the fore.[3],[4],[5],[6]

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This study aimed to present measures using customized external auditory stimuli in order to ensure easy application of neuro-feedback therapeutic techniques. To accomplish such objective, we intended to present customized stimulation techniques and analysis of cerebral activation status(F7, F8, T3, T4, T5, T6, O1, O2) in 30 male and female subjects and to propose technical development enabling extensive applications to various fields.

## 2 Experimental Design

### 2.1 Experimental environments

In this study, in order to analyze the changes of cerebral activation states using a sound source of an audio frequency band and the ultrasonic bandwidth, we have configured an experimental environment as shown in the figure 1 below.

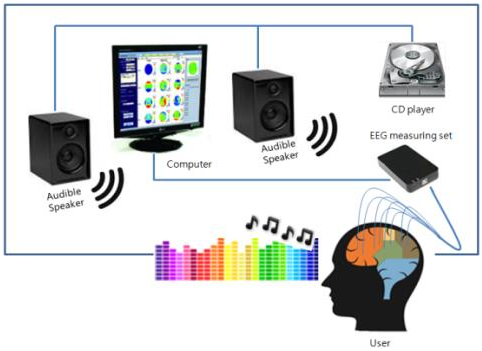


**Fig. 1.** Experimental environment (Auditory stimulation in the audio frequency band)

### 2.2 Stimulus Sound Source Selection and Electroencephalogram Extraction

The type of auditory stimulus that was used in the experiment is popular. To prevent losses owing to lyrics damaged during tempo conversion, the selected music was played with a single instrument. In order to analyze the stable state in the relaxed state, Beethoven's Pathetique 2nd Movement was selected, since it was composed in a major key, and has a tempo similar to that of a human heartbeat. The original music which was used in this experiment, has been converted from a major key to a minor key to induce changes in the emotions of the listeners, and a comparative analysis has also been carried out. In order to analyze the effect of tension through tempo change, we had the subjects listen to music 20% faster than normal, and 20% slower than normal.

Electrode arrangement for the electroencephalogram extraction follows the 10-20 international electrode placement. In this experiment, the electroencephalogram signal was extracted from 8 points (F7, F8, T3, T4, T5, T6, O1, O2) at a sampling of 256Hz and brain waves from 4 points (T3, T4, O1, O2) in a close correlation with audio-visual stimulus were analyzed

## 3 Experiments and Results

In this study, we have suggested a new analysis method based on frequency characteristics of EEG spectra in the emotions, which analyzed the four emotional states of humans, by M. B. Kostyunina and M. A. Kulikov [7] to analyze the impact of auditory stimulation sources in the audible frequency band and the ultrasound band on the cerebrum activation state. According to the reference, to classify the four emotional states (Joy, Anger, Fear, Sorrow) in humans, the frequency bandwidth value with the peak energy value among the EEG spectrum, belonging to the alpha band, and the distribution of the baseline state were analyzed and the results show that frequency bandwidth where peak energy is placed changes depending on the changes of emotional state. For the classification of emotional states, the reference measured the brain waves at 10 points of F3, F4, C3, C4, T3, T4, P3, P4, O1, O2 and was utilized in the analysis. In this study, we have utilized frequency bandwidth location, which has a peak energy in the alpha band, at 4-points of T3, T4, O1, and O2 strongly correlated with audio-visual stimulus, and energy value in baseline. Figure 2 shows the classification criteria of the emotional state which is newly proposed in this study

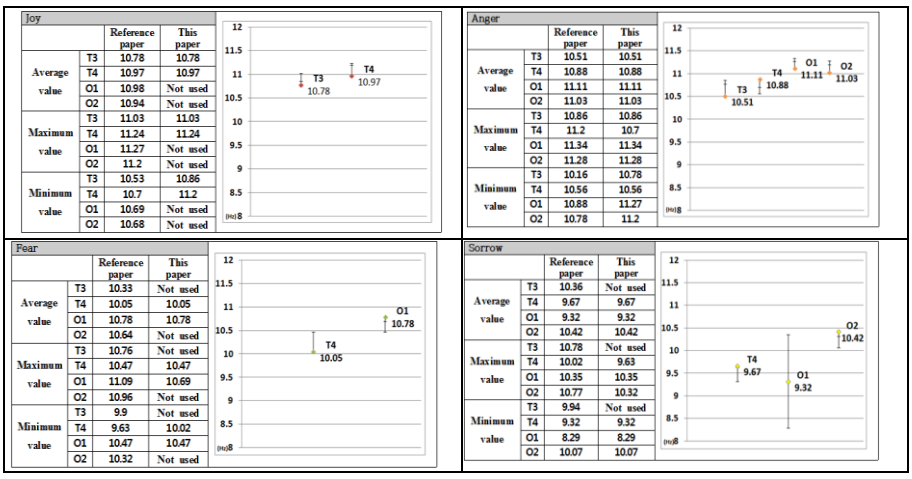


**Fig. 2.** Classification Criteria of Emotional State in accordance with the Frequency Bandwidth Where the Peak Energy of the Alpha band Is Located

Figure 2 shows the frequency band where the alpha-band peak energy is located and frequency band in the steady-state for classifying emotional state proposed in this paper.

 

**Table 1. (a)** Emotional state classification results of subjects according to the stimulus sound source in audible frequency bandwidth (Scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value).

| Major | | | | Minor | | | |
|---|---|---|---|---|---|---|---|
| **slower** | joy | 2 | 4.44% | **slower** | joy | 0 | 0.00% |
| 45 people | anger | 5 | 11.11% | 45 people | anger | 2 | 4.44% |
| | fear | 10 | 22.22% | | fear | 12 | 26.67% |
| | sorrow | 28 | 62.22% | | sorrow | 31 | 68.89% |
| **Original** | joy | 2 | 4.44% | **Original** | joy | 0 | 0.00% |
| 45 people | anger | 3 | 6.67% | 45 people | anger | 2 | 4.44% |
| | fear | 20 | 44.44% | | fear | 9 | 20.00% |
| | sorrow | 20 | 44.44% | | sorrow | 34 | 75.56% |
| **faster** | joy | 2 | 4.44% | **faster** | joy | 1 | 2.22% |
| 45 people | anger | 2 | 4.44% | 45 people | anger | 1 | 2.22% |
| | fear | 9 | 20.00% | | fear | 19 | 42.22% |
| | sorrow | 32 | 71.11% | | sorrow | 24 | 53.33% |

**(a) Emotional state classification of male subject according to the stimulus sound source in audible frequency bandwidth (Scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value)**

| Major | | | | Minor | | | |
|---|---|---|---|---|---|---|---|
| **slower** | joy | 4 | 8.70% | **slower** | joy | 1 | 2.17% |
| 46 people | anger | 4 | 8.70% | 46 people | anger | 3 | 6.52% |
| | fear | 24 | 52.17% | | fear | 22 | 47.83% |
| | sorrow | 14 | 30.43% | | sorrow | 20 | 43.48% |
| **Original** | joy | 1 | 2.17% | **Original** | joy | 0 | 0.00% |
| 46 people | anger | 5 | 10.87% | 46 people | anger | 3 | 6.52% |
| | fear | 28 | 60.87% | | fear | 22 | 47.83% |
| | sorrow | 12 | 26.09% | | sorrow | 21 | 45.65% |
| **faster** | joy | 1 | 2.17% | **faster** | joy | 0 | 0.00% |
| 46 people | anger | 4 | 8.70% | 46 people | anger | 3 | 6.52% |
| | fear | 23 | 50.00% | | fear | 27 | 58.70% |
| | sorrow | 18 | 39.13% | | sorrow | 16 | 34.78% |

**(b) Emotional state classification of female subject according to the stimulus sound source in audible frequency bandwidth (Scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value)**

Table 1 shows the classification results of men and women subject's emotions. The subjects listened to sound stimulation in the audible frequency bandwidth, and emotional state classification methods and the reciprocal correction of the distance values in the baseline state were used to obtain the results. According to the experimental results, the emotional states of 45 male subjects were classified into joy, anger, fear, and sorrow, respectively 2, 5, 10, and 28, when they listened to the music, which was played at a rate 20% slower than the original. When they listened to the original music, the results were classified into 2, 3, 20, and 20 respectively. After they listened to the original song 20% faster, the results were classified into 2, 3, 20, and 20 respectively. When they listened to the music, which was converted from a major key to a minor key in 3 different tempos, the results were classified as follows (20% slower: 0, 2,12, and 31, Original: 0, 2, 9, and 34, 20% faster: 1, 1, 19, and 24). In addition, the same experiment was performed on female subjects in the same way as male subjects, and the results were classified as follows (Major-20% slower: 4, 4, 24,

and 14, Major-original: 1, 5, 28, and 12, Major- 20% faster: 1, 4, 23, and 18). (Minor-20% slower: 1, 3, 22, and 20, Minor-original: 0, 3, 22, and 21, Minor-20% faster: 0, 3, 27, and 16)

**Table 2.** Emotional state classification of subjects according to the stimulus sound source in audible frequency bandwidth (Log scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value.

| Major | | | | Minor | | | |
|---|---|---|---|---|---|---|---|
| **slower** | joy | 14 | 31.11% | **slower** | joy | 15 | 33.33% |
| 45 people | anger | 7 | 15.56% | 45 people | anger | 4 | 8.89% |
| | fear | 14 | 31.11% | | fear | 11 | 24.44% |
| | sorrow | 10 | 22.22% | | sorrow | 15 | 33.33% |
| **Original** | joy | 18 | 40.00% | **Original** | joy | 13 | 28.89% |
| 45 people | anger | 5 | 11.11% | 45 people | anger | 5 | 11.11% |
| | fear | 11 | 24.44% | | fear | 10 | 22.22% |
| | sorrow | 11 | 24.44% | | sorrow | 17 | 37.78% |
| **faster** | joy | 12 | 26.67% | **faster** | joy | 13 | 28.89% |
| 45 people | anger | 4 | 8.89% | 45 people | anger | 5 | 11.11% |
| | fear | 12 | 26.67% | | fear | 18 | 40.00% |
| | sorrow | 17 | 37.78% | | sorrow | 9 | 20.00% |

**(a) Emotional state classification of male subject according to the stimulus sound source in audible frequency bandwidth (Log scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value)**

| Major | | | | Minor | | | |
|---|---|---|---|---|---|---|---|
| **slower** | joy | 10 | 21.74% | **slower** | joy | 7 | 15.22% |
| 46 people | anger | 3 | 6.52% | 46 people | anger | 5 | 10.87% |
| | fear | 25 | 54.35% | | fear | 18 | 39.13% |
| | sorrow | 8 | 17.39% | | sorrow | 16 | 34.78% |
| **Original** | joy | 13 | 28.26% | **Original** | joy | 11 | 23.91% |
| 46 people | anger | 4 | 8.70% | 46 people | anger | 5 | 10.87% |
| | fear | 21 | 45.65% | | fear | 21 | 45.65% |
| | sorrow | 8 | 17.39% | | sorrow | 9 | 19.57% |
| **faster** | joy | 10 | 21.74% | **faster** | joy | 4 | 8.70% |
| 46 people | anger | 5 | 10.87% | 46 people | anger | 5 | 10.87% |
| | fear | 18 | 39.13% | | fear | 23 | 50.00% |
| | sorrow | 13 | 28.26% | | sorrow | 14 | 30.43% |

**(b) Emotional state classification of female subject according to the stimulus sound source in audible frequency bandwidth (Log scale applies to major-minor conversion, tempo conversion, and reciprocal of the distance value)**

To exclude the effect caused by the sensory organs' characteristics, the reciprocal of the distance value of the log scale was applied to the results in Table 1. It can be seen that the classification results in Table 2 are slightly different from the results shown in Table 1.

 

## 4 Conclusion

According to the results of experiments in this study, changes to cerebral activation status was observed in subjects, depending on auditory stimuli which was presented, and furthermore, it was found that there was difference, depending on subjects, in auditory stimuli that would be needed to induce specific cerebral activation status in subjects. That is considered attributable to difference in sensory organ characteristics of respective individual subjects and existing learning experience of cerebrum. Thus, customized external stimuli tailored to users would be needed to be presented to apply the results of this study to specific fields.

## References

1. E. Ernst: Intangible risks of complementary and alternative medicine. J Clin Oncol. 19, 2365–2366 (2001)
2. C. Xue, A. Zhang, V. Lin, C. Da Costa, D. Story: Complementary and alternative medicine use in Australia: a national population-based survey. J Altern Complement Med. 13, 643–650 (2007)
3. Steven W. Anderson, Antoine Bechara, Hanna Damasio, Daniel Tranel & Antonio R. Damasio: Impairment of social and moral begavior related to early damage in human prefrontal cortex. Nature Neuroscience, 2, 1032-1037(1999.
4. Davidsin, R. J. et al.:Thalamic metabolic rate predicts EEG alpha power in healthy contral subjects but not in depressed patients, Biological Psychiatry , 45, 943-952(1999)
5. Hodges, J. R., Patterson, K., Oxbury, S., &Funnell,E.: Semantic dementia.Brain. 115, 1783-1806( 1992)
6. Towle, V. L., Bolanos,J., Suarez, D., Tan, K., Grzeszczuk, R., Levin, D. N., et al.: The spatial location of EEG electrodes: locating the best-fitting sphere relative to cortical anatomy. Electroencephalography and Clinical Neurophysiology. 86, 1-6 (1993)
7. M. B. Kostyunina, M. A. Kulikov: Frequency characteristics of EEG spectra in the emotions.

 