NEUROPHYSIOLOGY

Effect of High-Resolution Audio Music Box Sound on EEG

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ABSTRACT

Objective: **High-resolution audio music box sound has the possibility of music therapy with positive hypersonic effect.**

Design: **A clinical study.**

Materials and Methods: **Subjects were healthy young adults. They underwent EEG. They were exposed high-resolution audio music box sound. Topographical EEG mapping was done with using VitalTracer and ATAMAPII programs as a new topographical brain mapping approach.**

Results: **α2 and β1 wave band power significantly increased with high-resolution audio music box sound. α wave band power increased with high-resolution audio music box sound.**

Conclusions: **These results suspect that high-resolution audio music box sound has the effect of increasing of vigilance and relaxation of the brain.**

KEY WORDS

positive hypersonic effect, high-resolution audio music box sound, topographical EEG mapping, VitalTracer, ATAMAPII

INTRODUCTION

High-resolution audio rendering of the sound of a natural stream increases α wave on EEG and reduces sweat caused by mental stress[1-6)]. Brain activation with high-resolution audio has been investigated using PET and EEG[2,5-8)]. Hypersonic effect is a phenomenon in which sounds containing significant quantities of non-stationary high-frequency components above the human audible range (max. 20 kHz) activate the midbrain and diencephalon and evoke various physiological, psychological and behavioral responses[1-4)]. Inaudible high-resolution audio affects brain activity. High-resolution audio exerts beneficial effect on physiological functions determined by EEG and blood flow in the brain. The role of biological system other than auditory air-conduction in the emergence of hypersonic effect is suspected[1-4,6,9-17)]. High-resolution audio music box sound is considered to be helpful for music therapy with positive hypersonic effect. Here we investigated effect of high-resolution audio music box sound on EEG.

MATERIALS AND METHODS

The study content and method were explained in detail to 15 healthy individuals (female, n = 10; male, n = 5; 20.4 ± 1.2 years old). All of whom provided written consent to participate in the study, which was approved by the Prefectural University of Hiroshima, Ethics Committee. The study proceeded in accordance with the ethical principles established in the Declaration of Helsinki.

Subjects rested on the chair with closing eyes and underwent EEG (Neurofax, Nihon Kohden, Tokyo, Japan). Electrode locations and names were specified by the International 10-20 system. 19 recording electrodes (plus ground and system reference) were used. They rested for 4 minutes without sound. Thereafter they listened to high-resolution audio music box sound or high-cut for 3 minutes randomly. Then they rested for 2 minutes without sound. Thereafter they listened to high-resolution audio music box sound or high-cut for 3 minutes randomly.

The melody of high-resolution audio was part of the musical, "HALKA" (written by Stanislaw Moniuszko in Poland). A vintage Polyphone music box made in Germany over 100 years ago played the music in Hiroshima city. 192 kHz sampling and 24-bit high-resolution recording was done using microphone (B & K 4939-A-011, Brüel and Kjær, Nærum, Denmark) and sound analyzer (B & K PULSE). The

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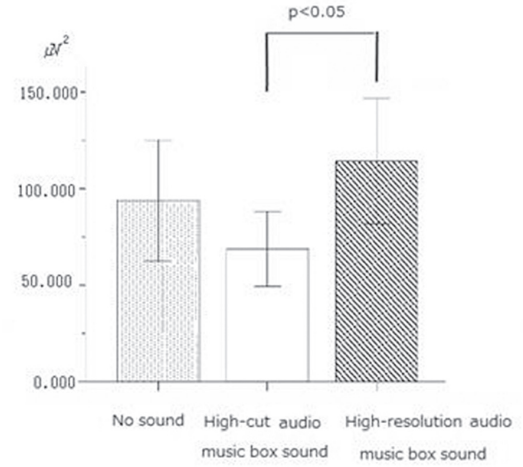

Figure 1. α2 wave band power significantly increased with high-resolution audio music box sound (P < 0.05). α2 wave band power decreased with high-cut audio music box sound.

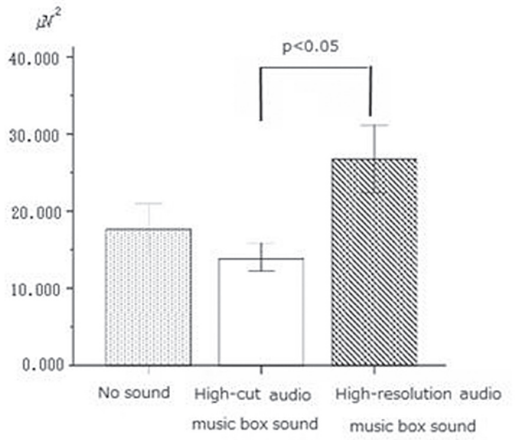

Figure 2. β1 wave band power significantly increased with high-resolution audio music box sound (P < 0.05). β1 wave band power decreased with high-cut audio music box sound.

audio analyzer showed successful recording of high-resolution audio music box sound. High-cut audio music box sound was produced by passing this recording of high-resolution audio music box sound through programmable low-pass filter with removing > 20-KHz sound from high-resolution audio music box sound.

An experiment was done with doing a precise acoustic control in the simple soundproof room. Sound measurement devices consisted of microphone (B&K 4939-A-011) and sound analyzer (B&K PULSE). The result of an analysis was indicated in the plasma display 60 inches. A back ground noise was about 50 dB sound pressure level. A main amplifier (Accuphase P7100, Accuphase, Yokohama, Japan) and a network audio (pioneer N-50, Pioneer Co., Ltd. Tokyo, Japan) were used as a audio player. Bilateral main speakers (JBL K2-S9500) were arranged in 1.3 m interval. Subjects sited on the position of the apex of the equilateral triangle. The main speakers included fixed Pioneer PT-R100 1.2 m-tall super twitter speakers those replay high resolution audio located close to the ears of subjects. Each front of speakers was adjusted to face the subjects. Subjects listened to the high-resolution audio music box sound or high-cut while seated on a chair. The sound level was generated at 65-70 dBA on a chair.

Base line EEG was stable 5 second EEG of no sound. EEG of the high-resolution audio music box sound or high-cut was stable 5 second EEG of last 3 minutes of the high-resolution audio music box sound or high-cut. Frequency mapping analysis was done with using VitalTracer and ATAMAPII program (Kissei Comtec Co., Ltd., Matsumoto, Japan) in occipital regions. Spectral analysis was performed over three frequency bands: 8-10 Hz (α1), 11-13 Hz (α2) and 14-20 Hz (β1). The power of each frequency band and the power ratio of each frequency band to all the frequency band (0.5-40 Hz) were determined.

Data are presented as means ± SD. The reliability of the results was assessed using Student's t-test. Probability values of < 0.05 were regarded as being statistically significant in all tests. All data were statistically analyzed using SPSS (IBM SPSS Statistics 19) software.

RESULTS

α wave emerge most in occipital regions. α1 wave band power increased with high-resolution audio music box sound. α1 wave band power decreased with high-cut audio music box sound. α2 wave band power significantly increased with high-resolution audio music box sound (P < 0.05) (Figure 1). α2 wave band power decreased with high-cut audio music box sound. β1 wave band power significantly increased with high-resolution audio music box sound (P < 0.05) (Figure 2). β1 wave band power decreased with high-cut audio music box sound.

The power ratio of α1 wave band increased with high-resolution audio music box sound. The power ratio of α1 wave band decreased with high-cut audio music box sound. The power ratio of α2 wave band increased with high-resolution audio music box sound. The power ratio of α2 wave band decreased with high-cut audio music box sound. The power ratio of β1 wave band increased with high-resolution audio music box sound. The power ratio of β1 wave band decreased with high-cut audio music box sound. The power ratio of α wave band increased with high-resolution audio music box sound. The power ratio of α wave band decreased with high-cut audio music box sound.

DISCUSSION

The EEG has been used for neuroscience[1-4,6,9]. EEG is sensitive to a continuum of states ranging from stress state, alertness to resting state, hypnosis, and sleep[1-4,6,9]. The EEG is the complex irregular oscillation changing with time, so the spectral analysis was developed as a method of quantifying EEGs. Furthermore the progress of computer technology recently enabled us to analyze EEGs automatically. Electronic devices used for VitalTracer and ATAMAPII are portable. Then these programs can be employed in psychophysiological studies for aged or handicapped persons.

α is the frequency range from 7 Hz to 14 Hz[1-4,6,9]. Hans Berger named the first rhythmic EEG activity he saw as the "α wave". α activity is an indicator of memory and cognition. Thalamo-cortical and cortio-cortical networks play an important role in the generation of α rhythmicity. During normal state of wakefulness with open eyes β wave is dominant. In relaxation or drowsiness α activity rises and if sleep appears θ and δ waves increase. During normal state of wakefulness with close eyes α2 and β1 waves are dominant at occipital regions among young healthy subjects. During normal state of wakefulness with close eyes α1 wave is dominant at occipital regions among elderly healthy subjects. In this study, α2 and β1 wave band power significantly increased with high-resolution audio music box sound among healthy subjects with close eyes. Then we considered that increasing of wakefulness was occurred with high-resolution audio music box sound. This situation appears to be both relaxing and adequately activation of brain. In previous study, we already reported that some of classic music made both relaxation and adequate stress and that in brain cortex some classic music made fruitful concentration and attention[2,5-8]. We also reported that high-resolution audio music box sound appeared to generate beneficial concentration and attention in the cortex of the brain and that music-box classic music sound containing high-resolution audio also exerted beneficial effects on physiological functions determined by blood flow in the brain[1-4,6, 9-17]. Our study supports these positive hypersonic effect of high-resolution audio music box sound. α and β wave band power and the power ratio of α and β wave band decreased with high-cut audio music box sound. We speculated that a level of wakefulness with close eyes decreased with high-cut audio music box sound.

The definite difference of the power ratio of each frequency band was not shown in this study with high-resolution audio music box

sound. This is because that during normal state of wakefulness with close eyes α and β waves are dominant at occipital regions. The other wave is rear, then the power ratio of α and β wave band is already fixed. The value of changes is not so large as make definite difference of the power ratio of each frequency band. Though the tendency above-mentioned is the results of group analysis, in individual some subjects had the definite differences, and the other had no differences. As for this, we speculated that the effect of high-resolution audio music box sound had difference among the subjects. But we could not clarify the cause of the results.

How high-resolution audio music box sound produces a physiological effect on brain activity is still unknown, there are some explanations[1-6]. One is that high-resolution audio music box sound might change the response characteristics of the tympanic membrane in the ears and produce more realistic acoustic perception, which might increase pleasantness. Another explanation is that the increased feeling of comfort by being exposed to the supersonic sound is not caused by the direct effects, but rather by canceling the adaptation of the hearing senses. The other explanation is that high-resolution audio music box sound might be conveyed through pathways distinct from the usual air-conducting auditory pathway and therefore might affect the deep-lying brain structure. Human body has a number of receptors enabling the perception of acoustic waves. On the skin surface there are numerous vibration and touch detectors. It was reported that the vibratory stimulus of ultrasound modulated by the human voice activated the primary auditory cortex and was successfully recognized by people with normal hearing as well as those whose hearing is totally impaired. Recently evidence has accumulated that stimuli outside the frequency and amplitude boundaries of an auditory neuron's receptive field can influence responses to stimuli inside the classical receptive field determined with pure tone stimuli. In our study, high-resolution audio music box sound is considered to benefit brain function with positive hypersonic effects.

This is the first report to describe the effect of high-resolution audio music box sound on EEG. Though we can't conclude the neural mechanisms incorporating high-resolution audio music box sound, in the future, we will study with young and middle subjects whose hearing is totally impaired. And we will clarify the effect of high-resolution audio music box sound on prevention of arteriosclerosis as the possibility of music therapy with middle and elderly subjects. We also will clarify the effect of high-resolution audio music box sound on early-stage Alzheimer disease. If some other factor is dominant, it would be independent of high-resolution sound and so efforts to improve sound quality should be focused on this factor rather than on high-resolution sound. Further study is needed to confirm these problems.

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