Effects of Different Musical Wave Types on the EEG: A Pilot Case Study

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For a selected subject, we chose music with 3 wave types (square wave, triangular wave, and serrated wave), and set constant values for the length, pitch, and volume of the music. When the patient was asked to listen to these 3 types of music, we recorded changes of her brain waves with an EEG and compared them to the ordinary state from her brain waves to determine the effect of stimulation by these 3 types of music. The results of the study found that α-brain waves increased in occurrence with triangular and square wave-type music, and that β-brain waves increased with the serrated wave-type music. Those preliminary findings are similar to the principle of composing music, however, the results of this study need to be duplicated with larger sample sizes and the use of statistics. (*FJJM 2004；2(3)：213-217*)

Key words: music therapy, tone color of music, triangle wave, serrated wave, square wave, EEG

INTRODUCTION

Music therapy is a newly developed clinical technique in occupational therapy. Music therapy is defined by the Canadian Association for Music Therapy as "...the planned use of music to achieve therapeutic aims with people who have special needs because of social, emotional, physical or intellectual problems"[1]. Many occupational therapists and nursing professionals have suggested applying music to the medical treatment arena and have endorsed the therapeutic effects and experiences with research data[2-5].

Based on the results of research by foreign scholars, music therapy has been scientifically proved to have therapeutic effects on people undergoing rehabilitation due to brain damage. Previously, researchers thought that musical stimuli might be transmitted to the cerebral cortex though the optic thalamus. As the optic thalamus controls human emotions, musical stimuli received by the optic thalamus improves the function of appeasing or exciting emotions[6,7]. Some scholars found that when a patient listened to hi/her favorite music, the secretion of β-endorphins was increased[8], and that his/her pain was relieved or even that he/she experienced a joyful feeling. Some scholars believe that Western classical music is helpful in increasing a listener's α-brain waves and thus helps the listener relax[9,10]. Such research is valuable evidence of the clinical utility of music therapy.

According to a research report entitled "Tone color of music and inappropriate behavior of schizophrenia" published in 2003 by Shih[11], an

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occupational therapist, several tests were given to 38 inpatients of the psychiatry department in a medical center in Taipei City, Taiwan. The researcher chose Mozart's K448 Piano Sonata as the background music, which was created by computer synthesis to determine which of 3 wave types (square wave, serrated wave, and triangular wave) was best for changing background music into therapeutic music which can efficaciously alleviate the 4 typical inappropriate behaviors (leaving the group; attacking other people with the body; and being in a trance, laughing euphorically, or falling asleep) of patients participating in a static occupational therapeutic activity. Results indicated that the triangular wave type was the best at reducing patients' inappropriate behaviors; that the square wave-type, which was similar to the triangle wave-type in efficacy, and was apt to make patients fall into a trance or fall asleep; but that the serrated wave type largely increased patients' arousal level and made patients clinically manic[11]. The critical issue still remained, i.e., for researchers to determine the actual effects of these 3 wave types (tone color) on the human brain.

Presently, major research on music therapy in Taiwan is focused on the behavioral sciences, and little research is being conducted using an EEG to determine the effect of music on human brain waves. The aims of current study were (1) to test the effect of wave types of music on human brains using an EEG, and (2) to determine differences in brain waves produced by 3 types of music formed by square waves, triangular waves, and serrated waves.

METHODS

The Music

We selected Mozart's K448 Piano Sonata (the first movement) which has been suggested to be useful in healthcare settings[5,12] and used it as a positive control. In this research, the violin, piano, and clarinet were chosen, and the music was performed using 3 types of music with serrated waves, triangular waves, and square waves. We ensured that the 3 types of music had identical pitch, volume, and length, and the tone color was altered using Finale (a kind of music-making computer program, CODA MUSIC, USA).

EEG Measurements

We used an EEG 2100 (NHON KOHDEN, Japan) for recording brain waves in this research.

Procedures

In the first step, we asked the subject to close her eyes and to rest silently for 6 min before asking her to listen to each of the 3 types of music for 6 min. Then, we compared the patient's brain waves when she rested and listened to each of the 3 types of music. The order in which the music was presented was the serrated wave, triangle wave, then square wave, and there was a 3-min resting time between administration of the 3 types of music.

Subject

In order to avoid using a subject who might have a prejudice for or against any of the 3 wave types, we selected a patient who had never learned to play a musical instrument. This was a 26-year-old woman, who neither suffered from brain damage nor previously had listened to the music prepared by the researcher.

RESULTS

We observed changes in the patient's brain waves when listening to music of a specified wave type. Results of the study indicated that when the patient heard the serrated wave type of music, her β-brain waves in the central line of her brain (F3-C3) and in her occipital lobe (P3-01) increased

slightly compared to her brain waves with no sound, and that the brain waves in other parts of her brain remained almost unchanged. Results also showed that when the patient listened to the triangular wave type of music, the α-brain waves in her parietal lobe (P4-02) slightly increased, and that when she listened to the square wave type of music, the α-brain waves in her parietal lobe (P4-02) and occipital lobe (P3-01) slightly increased.

DISCUSSION

Results of this study are similar to those in the article "Tone color of music and inappropriate behavior of schizophrenia" published by the principal author of the present study in 2003[11]. According to the conclusions of that experiment, the serrated wave-type background music more easily made patients manic, while the music with the triangular or square wave more easily made patients calm down in a group therapeutic activity. The EEG findings of the present study showed that β-brain waves occurred more prominently with the serrated wave-type music than under a soundless condition or with the triangular- or square wave-type music. But with the sound of the triangular or square wave-type music, α-brain waves were found to increase in the parietal lobe, a motor area. Preliminary results of this study are similar to the findings of the 2003 study, in which either the triangular wave or the square wave-type background music lessened mania and inappropriate behaviors of the patients in a group therapeutic activity. The preliminary results of this study agree with the principle of composing music.

In music composition, the serrated wave type (e.g., performance by stringed instruments) is more frequently used in for marches than the triangle or square wave type (e.g., performance by piano or clarinet), since marches can more easily excite human emotions. On the contrary, the triangular wave or square wave type (e.g., performance by piano or clarinet) are often used for relaxing music or opera than the serrated wave type (e.g., performance by stringed instruments).

This study has some limitations, such as: there were only 1 case, who was studied only 1 time, and the sequence in which the music was presented may have affected the results. Furthermore, the results of this study need to be duplicated with a bigger sample size and the use of statistics. Furthermore study is needed to determine the occurrences of both α- and β-brain waves under each of the 4 conditions.

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不同波形的音樂介入時，在腦波圖中所顯示的差異——一個前趨個案研究

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研究者嘗試將方形波、三角形波、鋸齒狀波三種不同波形的音樂給一個個案聽，並將三種音樂的音長、音高、音強控制為定值，與沒有音樂時做比較，比較這三種音樂介入時腦波在 EEG 內的改變。結果發現相對於無音樂時，三角形波與方形波介入時，個案的α腦波會增加；相對於無音樂時，鋸齒狀波介入時，個案的β腦波會增加。這個初步的發現跟音樂學的作曲學原理類似，期待往後能有更明確的數據，還需藉由腦波統計儀器來分別算出α腦波與β腦波在四種情況下所分別出現的次數，並多收集更大量的樣本資料，才能做出更確切的推論。(輔仁醫學期刊 *2004*；*2(3)*：*213-217*)

關鍵詞：音樂治療，音色，三角型波，鋸齒狀波，方形波，腦電波圖

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