STUDIES IN THE BRAIN ALPHA BAND REACTION FROM NONVERBAL SOUND STIMULATION

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Abstract- There are a variety of sounds existing in our environment, and different sounds can cause the human brain different reactivity and responses. In order to understand the reaction of the brain alpha band of nonverbal sound, this study designed three experiments to test ten subjects (their ages between 20 to 28) without mental diseases. Three experiments were given as standard both ears oddball experiment, right ear oddball experiment, and left ear oddball experiment whose standard stimulation was at 1000Hz (80dB) and deviation stimulation was at 1500Hz (80dB). Electroencephalogram (EEG) signals were recorded from 21 scalp electrodes with international standard 10-20 system. The results showed that the ten subjects' average power spectrums of alpha band on T5, T6, O2, OZ and O1 from the right ear oddball experiment were larger than those of the left ear oddball experiment. Thus, that of the nonverbal sound stimulation was more significant in right brain reaction. The average power spectrum of alpha band on T6 was more significant than that on T5. Consequently, the reaction of right hemisphere was greater than that of left hemisphere from nonverbal sound stimulations.

Keywords- Electroencephalogram (EEG), alpha band, nonverbal sound stimulations

I. INTRODUCTION

There are a variety of sounds existing in our environment, and different sounds can cause the human brain different reactivity and responses. The reaction may be known from the brain wave or frequency band. An American neurophysiologist, Dr. Roger Wolcott Sperry, who was awarded the Nobel Prize in Medicine in 1981 [1] proposed a division theory of left and right hemisphere. The human brain is the organ of thinking and conscious activity, the previous studies suggested that left hemisphere specialized in thinking, and the right hemisphere specialized in sensory function [2, 3].

The human brain divides into left and right hemispheres, the two hemispheres are connected and communicate information through nerve fibers, and each hemisphere has its own independent ideological consciousness chains and memories. The human brain is the control center of limb movements and body systems physiological activity, and it is also an organ of controlling thinking and language [4].

Human brain waves also called Electroencephalogram (EEG) are divided into four categories depending on the frequency: α, β, θ, and δ band. The frequency range of α band is 8-12Hz, the frequency range of β band is 12-35Hz, the frequency range of θ band is 4-8Hz, and the frequency range of δ band is 0.1-4Hz. In the one experiment of previous study, the subject's eyes closed without thinking. As human eyes are the most important information channels, a human can close ones eyes to reject 60% to 70% of the information sources [5].
This let the experimental subject imagine a simple thing, and then the subject's brain waves were recorded. The EEG data of the subject exhibited alpha band responses. There was the best learning state while the alpha band wave was larger [6].

The subconscious activities of the right brain have powerful features, and it receive messages quickly. In order to understand the reaction of the brain alpha band of nonverbal sound, this study designed three experiments which were standard both ears oddball, right ear oddball, and left ear oddball experiment to observe whether the nonverbal sound of auditory stimuli was related to the alpha band responses or not.

II. MATERIALS AND METHODS

2.1. Subjects

Ten subjects whose ages were between 20 to 28 years old participated in this study without mental diseases and skin allergies. This study was approved by the Regional Research Ethics Center in Taichung, Taiwan (Protocol No.: cRREC-101-082).

2.2. Experimental Procedure

All these three experiments were executed in a noiseless space and experimental structure as shown in Fig.1, and the subjects seated in front of a LCD monitor during a relaxed state of mind. There are a PC and an EEG acquisition system (Neuron Spectrum-4/EPM) in this space.

There was a brief description of the experimental procedure before the subject conducted every experiment. The subjects tested the experiment according to the instructions of the description to do all the steps of them.

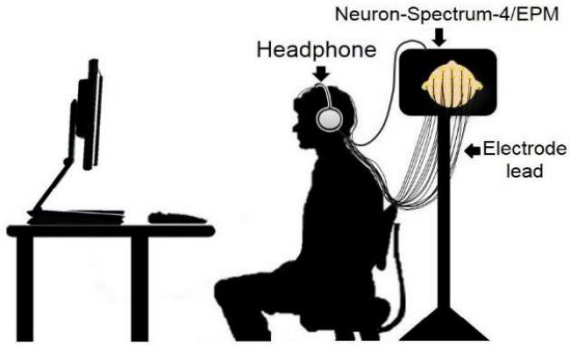


Fig.1 Experimental structure

The experimental flow chart is shown in Fig.2. First, the 21 electrodes were placed on the scalp of the subject, the sound stimulus conditions and other experiment parameters were set in these three experiments, each experiment section is 5 minutes given 300 stimulations (the standard stimuli and the deviation stimuli), and a rest of 5 minutes is between each experiment section. The electrode impedance values were checked before the beginning of experiment. Then, the subject executed these three experiment section and the EEG signals were measured from the 21 electrodes of the subject. EEG data were also recorded simultaneously during executing these three experiments. Finally, the EEG signals were analyzed.

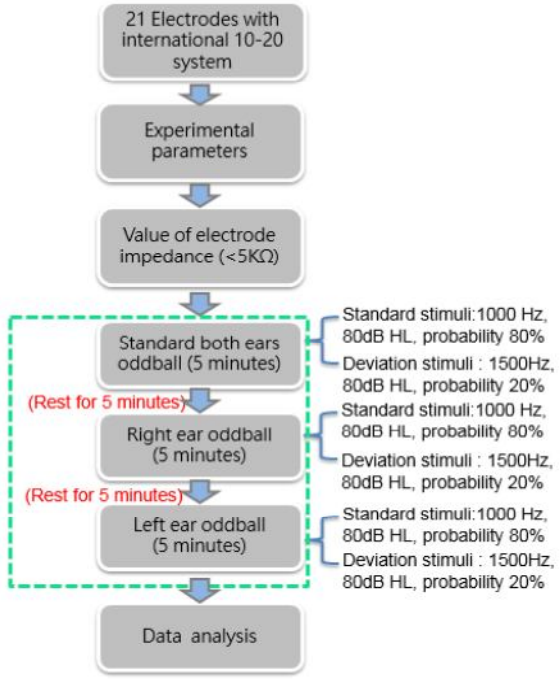


Fig.2. Experimental flow chart

All the parameters of these three experiment sections are:

1. *Standard both ears oddball:*

The standard stimulus is at 1000 Hz, 80dB HL, and probability 80%, the deviation stimulus is at 1500Hz, 80dB HL, probability 20%, the stimulus interval is one second, and the standard stimulus and deviation stimulus appeared randomly. The subject put on the headphone and the sound stimulations existed in both left and right ears.

2. *Right ear oddball:*

The standard stimulus is at 1000 Hz, 80dB HL, and probability 80%, the deviation stimulus is at 1500Hz, 80dB HL, probability 20%, the stimulus interval is one second, and the standard stimulus and deviation stimulus appeared randomly. The subject put on the headphone and the sound stimulations existed in only right ear

3. *Left ear oddball:*

The standard stimulus is at 1000 Hz, 80dB HL, and probability 80%, the deviation stimulus is at 1500Hz, 80dB HL, probability 20%, the stimulus interval is one second, and the standard stimulus and deviation stimulus appeared randomly. The subject put on the headphone and the sound stimulations existed in only left ear.

2.3 EEG Acquisition

EEG signals were acquired with Neuron Spectrum 4 / EPM system by placing 21 electrodes on the scalp of the subject according to international 10-20 system as shown in Fig. 3.

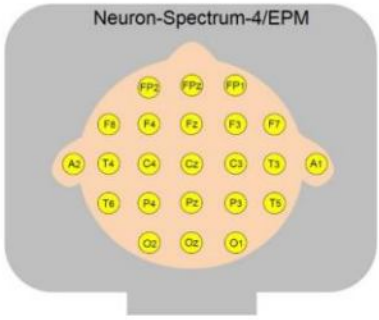


Fig.3. Neuron Spectrum 4/EPM

With an FPz electrode as a reference, the detected impedance is less than 5K Ω, the filter bandwidth is 0.5-75Hz, the band reject filter is 60Hz, and the sampling frequency is 1000Hz.

2.4 Alpha Band Analysis

All the EEG data were analyzed with the EEGLAB 13.43b. All the EEG data were first filtered with a low pass filter of a cut off frequency 40Hz and a high pass filter of a cut off frequency 0.5Hz to reject other noises. Next, every EEG trial of every stimulus event was extracted, and then other noise trial which was too large was rejected. Finally, the time frequency response of EEG trials was analyzed to demonstrate a further observation.

III. RESULTS

In three experiments, and the subject's eyes closed with a relaxed posture without performing any other stimulation (the subject only executed the standard stimuli and deviation stimuli in these three experiments) to do lower operation and memory-related tasks for the establishment of a sound stimulus response model of alpha band. In the standard both

ears oddball experiment, alpha band response appeared more obvious on O1, Oz and O2 (occipital region) as shown in Fig.4. It (a frequency response of 9.8 Hz) also could be seen on occipital region as shown in Fig.5 from the right ear experiment and Fig.6 from the left ear experiment.

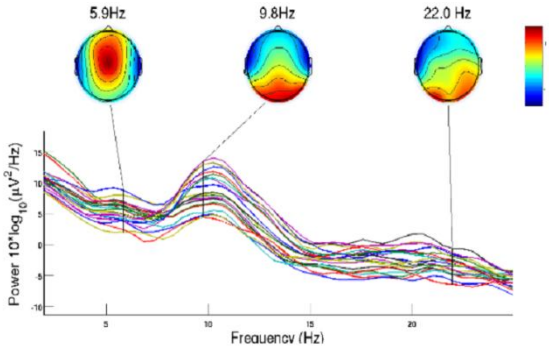


Fig.4. The maps of frequency distribution of the standard both ears oddball experiment

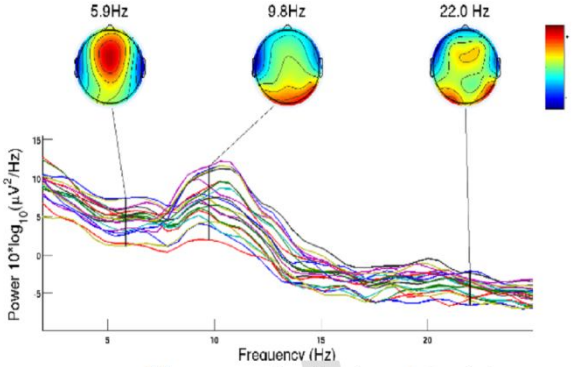


Fig.5. The maps of frequency distribution of the right ear oddball experiment

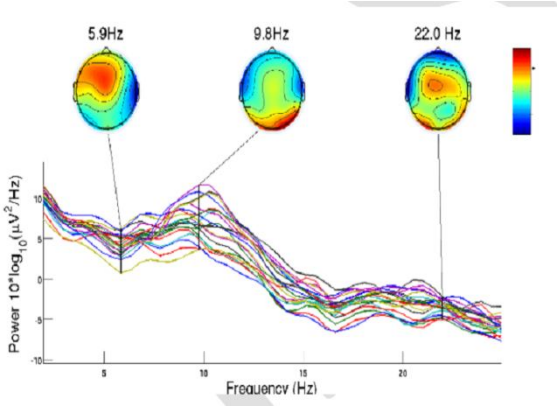


Fig.6. The maps of frequency distribution of the left ear oddball experiment

All the average power spectrums of the alpha band from these three experiments are shown in Fig.7. The average power spectrum of the alpha band on Oz from standard both ears oddball experiment (dotted line) was larger than that on Oz from right ear oddball experiment (solid line). The average power spectrum of the alpha band on Oz from right ear oddball was larger than that on Oz from left ear oddball experiment (cross line).

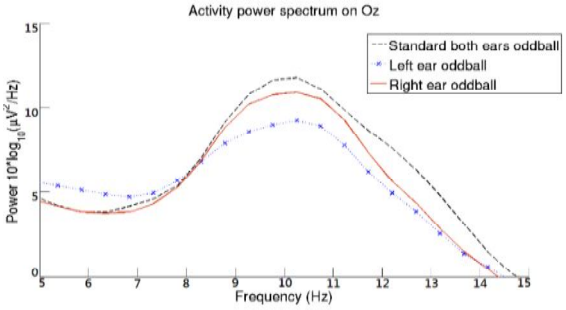


Fig.7. A comparison of alpha band average power on Oz in standard both ears oddball, left ear oddball, and right ear oddball experiment

All the average power spectrums of the alpha band on T5 and T6 from standard both ears oddball experiments are shown in Fig.8. The average power spectrum of the alpha band on T6 (dotted line) was larger than that on T5 (solid line) from standard both ears oddball experiment.

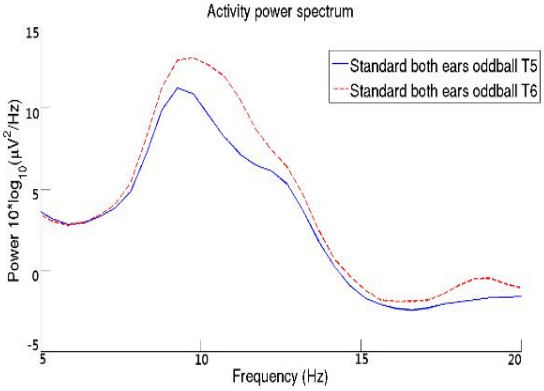


Fig.8. The alpha band average power on T5 and T6 from standard both ears oddball experiment

All the average power spectrums of the alpha band on O2 from right ear oddball experiment and from left ear oddball are shown in Fig.9. The average power spectrum of the alpha band on O2 from right ear oddball experiment (dotted line) was larger than that on O2 from left ear oddball experiment (solid line).

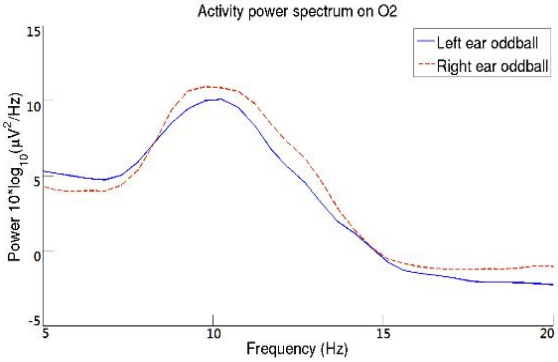


Fig.9. The average power of alpha band on O2 from left ear oddball (solid line) and right ear oddball (dotted line) experiment comparison

All the average power spectrums of the alpha band on OZ from right ear oddball experiment and from left ear oddball are shown in Fig.10. The average power spectrum of the alpha band on OZ from right ear

oddball experiment (dotted line) was larger than that on OZ from left ear oddball experiment (solid line).

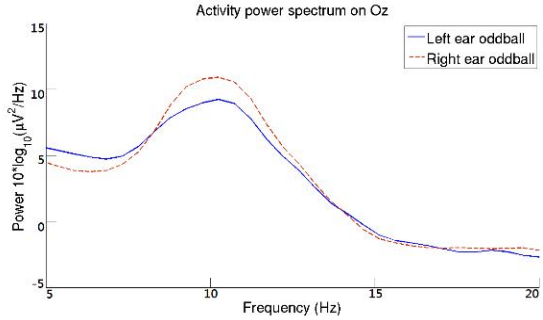


Fig.10. The alpha band average power on Oz from left ear oddball (solid line) and right ear oddball (dotted line) experiment

All the average power spectrums of the alpha band on O1 from right ear oddball experiment and from left ear oddball are shown in Fig.11. The average power spectrum of the alpha band on O1 from right ear oddball experiment (dotted line) was larger than that on O1 from left ear oddball experiment (solid line).

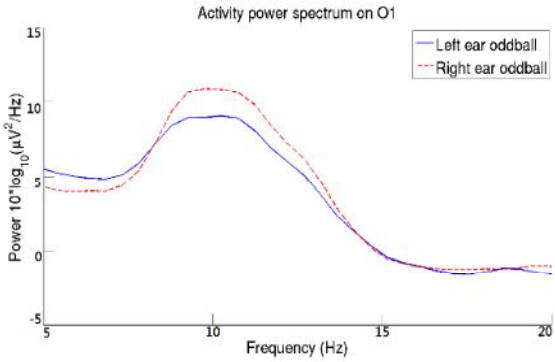


Fig.11. The alpha band average power on O1 from left ear oddball (solid line) and right ear oddball (dotted line) experiment

In comparison of alpha band responses from standard both ears oddball, left ear oddball, and right ear oddball experiment, the average power spectrum of alpha band from standard both ears oddball experiment was the largest. The average power spectrum of the alpha band from right ear oddball experiment was larger than that from left ear oddball experiment. This performed that the reaction of the right hemisphere was larger than that of left hemisphere for nonverbal sound stimulation [7, 8].

CONCLUSIONS

There were more alpha band power responses in the occipital region (O1, Oz and O2) in these three experiments. The alpha band power reaction of the right hemisphere (T6) was more significant than that of the left hemisphere (T5) from standard both ears oddball experiment. The alpha band power response from right ear oddball experiment was more significant than that from left ear oddball experiment. The reaction of the right hemisphere was larger than that of left hemisphere for nonverbal sound stimulation [7, 8].

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