INVESTIGATE THE EFFECT OF EEG FOR RELAXATION USING BINAURAL BEATS

Chao-Wang Young[1], Chun-Yu Tsai[2], Sheng-Ren Zheng[3], Liang-Pu Wang[3], Hsiao-Wen Chen[3], Chyung Ay[4*]

[1]Assistant Professor, [2]Research assistant, [3]Student, [4]Professor, Department of Biomechatronics Engineering, National Chiayi University, Chiayi, Taiwan, R.O.C
*Corresponding Author: +886-5-2755211, Email:cay@mail.ncyu.edu.tw

Abstract: In this fast-paced society, "tension" and "Insomnia" have become annoying problems for white-collar student populations. In the most severe circumstance, these problems will affect common mental disorders, such as depression, anxiety and others. This study used the Audacity music editing software to compile binaural beats music, ten test subjects then wore headphones to listen to the music for the experiment. On the other hand, the Mindwave wireless electroencephalogram (EEG) device developed by Neurosky is used to measure EEG signals, and Bluetooth connection to the brain-computer interface written with Microsoft Visual C# software is used to measure the four different brainwave frequency signals α, β, θ, δ, through the eSense brain chip algorithms are used to calculate the context of the attention and meditation parameters, subjects' brainwave context is observed and the stored data is counted and analyzed, to evaluate whether binaural beats technology is effective in improving the body's relaxation. Currently preliminary findings in experiment's statistics found that, compared to more general situations, listening to binaural beats music can effectively enhance meditation parameters. In the future, using binaural beats technology to improve context will no longer have drug therapy as the only way.
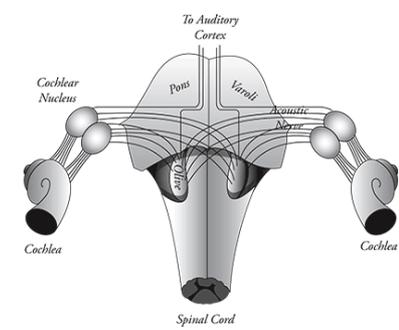
Key Words: Binaural beats, Brain-computer interface, Relaxation

INTRODUCTION

Due to the busy pace of modern life, many diseases of civilization problems will emerge endlessly. Stress causes memory loss and inability to concentrate in human brains, and when reflected in the mood, it causes depression, irritability, sleep disorders and other conditions. Medicine also confirmed that pressure will interfere with or even destroy the body's hormones, brain neurotransmitters, immune function and metabolism (Hsu, 2009). When the body functions slowly weakened ability to resist fading, coupled with drug abuse, increased side effects, in order to solve the root of the problem, this study whereby explore the use of technology to improve poor binaural wave EEG signals to see if alleviating pressure had a significant effect.

Hemi-Sync includes many procedures, and binaural beats are only one element of in the procedures. In the fields of medical treatment and self-help, binaural beats have been studied for more than 30 years, in the past scientific evidences explained that it might be a unique science, which can be used in medical treatment procedures. The process involves breathing exercises, relaxation guidance, positive discourse and visual

projection. Many studies have also shown audio frequency stimulus can generate reaction records on the top of the head at the Baihui acupoint, and this reaction can be measured by EEG (Smith, 1975). Human psychology, physical force, or some kind of homeostasis, all will resist the effects of binaural beats. This inner equilibrium of the body is generally controlled by life status and will's action, as consciousness and the subconscious. The subjective experience of the human body's to the binaural beats stimulation will also be affected by some other media factors. According to the Monroe Institute, U.S. years of research, using binaural beats to effectively stimulate the lateral auditory processing areas in the so called superior olivary nucleus of the brain stem (as shown in Figure 1), and in coordination with brainwave measurement technology, after various topic tests, found that most of the large-scale and specific binaural beats mixes were similar. Reports indicate that a complex combination of binaural beats is more effective than other combinations or single-frequency sine wave binaural beats.
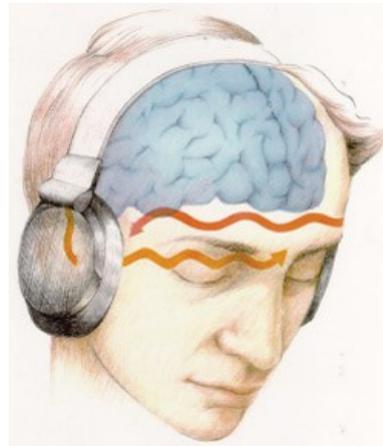

Figure 1. Brain auditory area (Oster, 1973a) Figure 2. Schematics of listening to binaural beats

Sittapong Settapat et al (2008) designed a self-relaxation real-time control systems, test subjects' EEG signals can be measured, and then the system determines and gives the appropriate beat music to the subject for adjustment and relaxation. Jiang Zhao-Xu et al (2012) used a traditional voice-based, secure, and targeted binaural beats to affect the brain auditory system, to explore the brainwaves characteristics and the general law of mental reactions, and then find the correlation between these two.

According to the provisions of the International Brainwaves Association, the potential reaction of the cerebral cortex measured by brainwave measuring instruments, according to their different frequencies can be divided into four brainwave types waves, respectively named α, β, θ and δ waves. According this classification each different brainwave frequency has different significance and characteristics, as shown in Table 1. In recent years the γ wave with an even higher frequency has been discovered. (Lin, 2005)

Table 1. Situational status of brainwave types (Guðmundsdóttir，2011)

Brainwave types		Frequency range	Reactions
δ	Delta	0.1 Hz—3 Hz	Deep sleep, non-REM sleep, unconsciousness

| wave			
θ wave	Theta	4 Hz—7 Hz	Intuition, creativity, memories of fantasy, imagination, light sleep
α wave	Low Alpha	8 Hz—9 Hz	Conscious, quiet
	High Alpha	10 Hz—12 Hz	Relaxed but not sleepy
β wave	Low Beta	13 Hz—17 Hz	Motor and sensory rhythm, relaxed but can still focus, attention, has coordination
	High Beta	18 Hz—30 Hz	Alert, excited

MATERIALS AND METHODS

System Design

This study is mainly divided into a 2 parts design, as shown in Figure 3, one is a brain-computer measuring interface that used Microsoft Visual C # software design and the Mindset wireless electroencephalogram with Bluetooth connection, to conduct the situational status value measurement of brainwave signals according to α, β, θ, δ wave values and the two parameters of attention and meditation calculated through the ThinkGear ™ technology and eSense patented algorithms, the other design is to let test subject listen to binaural tones music with different frequencies produced by a music editing software. The 2 designs are coordinated, brainwave values are then analyzed, to evaluate the effectiveness of the binaural tone music technology.

Attention and meditation context

Neurosky used specific values from 1-100 to indicate the test subject's attention and meditation levels, these two parameter are without a unit of measure. The attention characteristic describes the intensity of the user's concentration or attention, for example, when you are able to enter in a highly focused state and can steadily control your mental activities, the value of this parameter will be very high. When mental state is being upset, in a trance, inattention and anxiety, these states will reduce the value of the attention parameter, as shown in Figure 4.
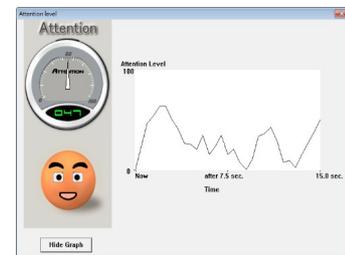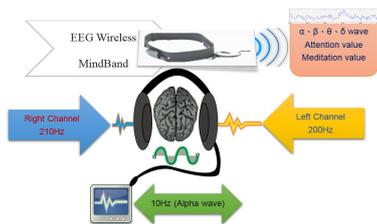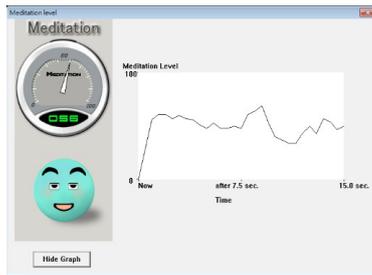
Fig. 3. System design   Fig. 4. Measurement of   Fig.5. Measurement of the
                        the attention parameter values   meditation parameter values

The meditation characteristic describes the user's mental stability or relaxation. This parameter's value also ranges from 0-100. In particular, the meditation parameter reflects the user's mental state rather than their physical state, therefore, to simply relax the whole body's muscles is not a way to quickly increase relaxation. For most people, under normal circumstances, whole body relaxation usually can help mental relaxation. Increase in relaxation has a significant relation with decrease in brain activity. Long-term experiments found that closing your eyes can reduce the brain's mental activity. So, closing eyes is often an effective way to increase meditation value. Being in mental status such as upset, in a trance, inattentive, anxious, agitated and sensory stimulations all contribute to decreasing the value of the meditation parameter, as shown in Figure 5. Table 2 explains the measurement parameter values and the test subject's state in the moment.

Table 2 The status of eSense value (Neurosky, 2010)

eSense value	Status Description
1-20	States of distraction, agitation, or abnormality
20-40	
40-60	"Neutral" and is similar in notion to "baseline" that are established in conventional brainwave measurement techniques
60-80	"Slight elevated" may be interpreted as levels tending to be higher than normal （ levels of attention or meditation that may be higher than normal for a given person）
80-100	"Elevated", meaning they are strongly indicative of heightened levels of that eSense

Music software design

This study, in order to investigate the binding relationship between binaural beats and music, used the Audacity music editing software, which is a set of open software with functions like editing, copy, remix and others, to design effects for different frequency waves, in coordination with relaxation music, as background. Using self-designed music for the experiment and using wireless EEG to measure the test subjects' brainwave signals, the EEG data is used to analyze whether the designed binaural beats music has
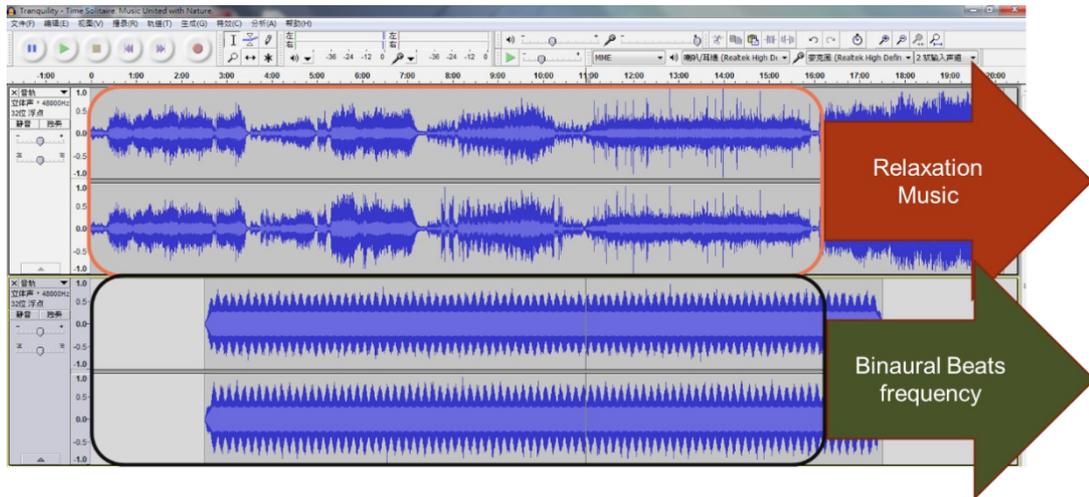
a significant effect for relieving stress.

Figure 6. Binaural beats music production

The music editing software design is as shown in Figure 6. The upper block is the stress-relieving music for background, the lower block is self-designed Alpha wave with a 10Hz wave difference between right and left channels, designed for the purpose of improving brain relaxation. Then the upper block's stress relieving music, in coordination with the lower block's beat technology is converted into wav music files, becoming treatable binaural beats music to use in the experiments.

Experiment design process

The experiment process is designed to be divided in two parts, as shown in Figure 7, one experiment condition is without listening to binaural beats music, and recording the attention and meditation parameter data. The other experiment condition is listening to binaural beats music, and then recording the parameter data. After the data is analyzed, the effects of binaural beats music are compared to see if there is any effect on the brainwaves.

4.5 Brain-computer interface software design

With the rise of biomedical technology, BCI has been applied in many different control areas. Ganguly and Carmena (2009) mentioned that electrophysiological activity or nervous system metabolic rate of organs can be converted into recognizable signals. As time passes humanity currently can use neural activity to communicate directly with electrical equipments. In this study, Microsoft Visual C # software is used to design the brain-computer interface, to mainly measure the brainwave signals when listening to binaural beats music, and the data for different frequency bands (α, β, θ and δ-wave) can be observe in real-time from the interface, as well as obtain the attention and meditation parameter data through the eSense algorithms. In addition, when measuring brainwave data, real-time brainwave data can be recorded in excel files for data analysis, as shown in Figure 8.
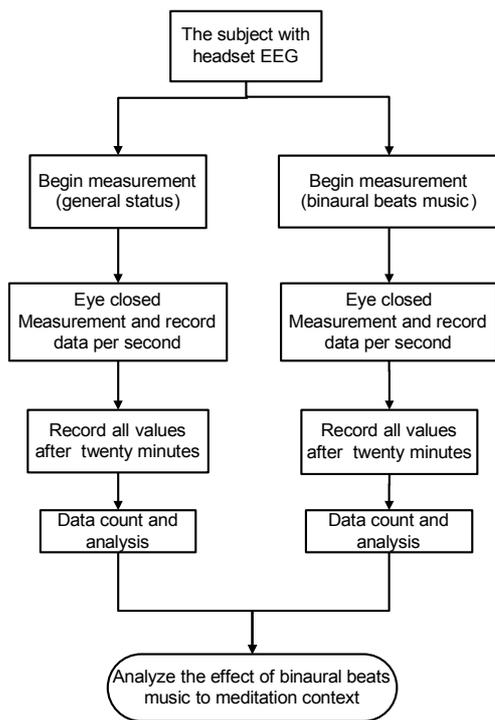
Figure 7. Binaural beats experiment flowchart Figure 8. Brain-computer measuring interface

4.6 Neurosky MindBand EEG

This study uses the MindBand electroencephalogram developed by Neurosky (as in Figure 9). This is an electroencephalogram that uses non-invasive Bluetooth technology for detecting the electrical activity triggered by neurons.

RESULTS & DISCUSSION

This experiment used the brain-computer interface written with Microsoft Visual C# to measure the brainwaves' attention and meditation parameters and stored the value per second in an excel file, to be then analyzed. Data presentation is as shown in (1).

$$A = \frac{S}{t}$$

where:
    A = The average of data (1/s)
    S = The sum of the data parameter per second
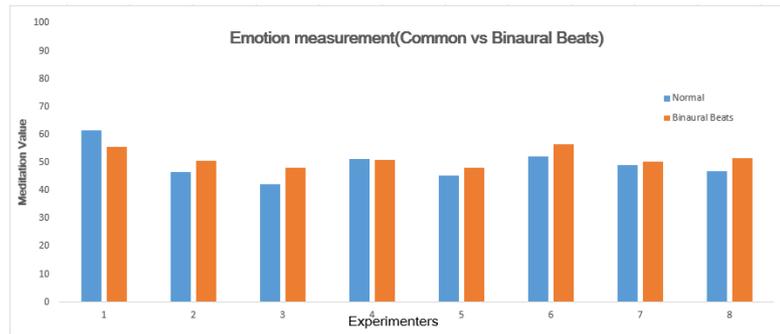 t = Total second(s)

Fig. 9. MindBand headset   Fig 10 Medication parameters (under normal
electroencephalogram   circumstances and binaural beats)

Preliminary experiment findings showed that, with eight subjects observed for meditation parameter data, the effect for the six listening to binaural beats music was indeed improved, as shown in Figure 10. Although the amount of effect change before and after the measurement was not significant. However, during the experiment, subjects clearly fell asleep, as shown in Figure 11.

Fig. 11. Measuring situation of test subjects

CONCLUSIONS

Preliminary results from the experiment found that compared to past studies in the literature, the use of binaural beats technology to improve brainwave impact is effective. However, since there is no significant difference from the effect of the change, this problem will be a reason to observe the changes in the different musical elements, or the long period of measurements observation, or with the help of many other physiological measurement reactions as verification, to be so that binaural beats technology will have significant efficacy for the treatment of the human brain.

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