EEG Research Based on the Influence of Different Music Effects

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Abstract. Music has become one of the methods for regulating emotions in the daily life of most people. Different concerts bring different emotional changes to people, but the effect of music on the changes of human brain and EEG signals is little known. This paper uses the brain wave (EEG) experiment to study the effect of different musical stimuli on attention, and focuses on comparing the effects of brain wave music and heavy metal music that are widely studied on attention. In this paper, an experiment was designed to collect the EEG signals of 15 students in three states: brainwave music (slow 80BPM), heavy metal music (fast 140BPM) and resting EEG signals. Independent component analysis (ICA) preprocesses the EEG signal, and uses T, T, and T to analyze the characteristics of the α, β and θ wave signals obtained by wavelet transform. Through the experimental analysis of this article, it is found that brain wave music has a significant effect on the alpha wave (P<0.05), and heavy metal concerts have an effect on the power value of the beta wave. The experimental results show that brain wave music, which is the slow board music, can better pay attention. The concentration of force, and heavy metal music (clapper music) will make the attention more distracting.

1. Introduction

There are about hundreds of billions of neuron cells in the human brain. Any neuron cell will connect with the rest of the neurons through its own synapses. Through these connections, neurons will form neural circuits with different functions, thus forming a network with different functions. Highly complex network. The brain is considered to be the most complex and efficient information processing system in nature. Human beings actively explore from the inside of the brain and have obtained many important research progress [1].

Attention has a great impact on daily life. For example, work and study, social interaction, even mood and concentration can complete the precise control of power [2, 3]. Experiments have shown that the degree of concentration of attention has a positive effect on the accuracy of the goal force. Has a significant impact [4]. The current research on attention enhancement is mainly based on vision, touch and hearing. This article mainly focuses on hearing.

In recent years, some researchers have studied the relative comparison between brain waves when listening to classical music and those when not listening to music [5, 6]. All these results show that α waves significantly increase energy when listening to classical music. The classical music section uses Mozart’s “D major two piano sonata, K.448”, in the study of Verrusio Wetal, they use this music and Beethoven’s sonata “Fur Elise” as a comparison, the study found that not all classical music can effectively increase the energy of α waves [7, 8].
Now, the clinical technique of brain wave induction training attention has proved to have remarkable effect, many brain wave inducers have been invented one after another, but there are few instruments related to training attention. This paper mainly focuses on the training of attention [9, 10]. On the one hand, the α and β brain waves are clearly studied, the frequency of brain waves is analyzed by music induction, and then the influence of brain wave music on attention is analyzed. Most of the previous studies used classical music, and no targeted research was carried out on other types of music [11, 12]. This paper focuses on the variance of brain wave music and metal music responses. Heavy metal music and brainwave music are very different in musical instruments, rhythm, style and emotion. So we use metal music as a comparison object [13].

Through the experimental analysis of the following two points:
(1) The first part introduces the specific process of the experiment and the situation of the subjects, and introduces the methods of data preprocessing.
(2) The second part mainly carries on the feature extraction, and carries on the screening to eliminate the useless data, finally uses the single factor analysis method to carry on the statistical analysis to the data, obtains the correlation conclusion.

2. Experimental Analysis Method
The experiment in the article is carried out in four parts: music segment stimulation, EEG data collection, EEG data processing and result analysis. According to previous studies, different music will have great differences in style and emotion, and will have great differences in the influence on brain waves. This article selects two different styles of music as the research materials. In the EEG data collection step, EEG signals will be collected during the music stimulation process. The detailed process will be described below. The experimental data processing is to preprocess the collected data first by pseudo-traction and independent component analysis (ICA) algorithm. Then, the data is further analyzed and processed by Matlab and EEGLAB to convert it into effective analytical data, and the feature extraction of EEG data is carried out by wavelet analysis. Finally, the experimental results were analyzed by statistical method [14].

In this study, we used the t test as a statistical method. P value is the probability of finding the observed result when the original hypothesis (H0) of the research problem is true. hence, we use P values to determine statistical significance in the hypothesis test [15]. In our analysis, p<0.05 indicated that the difference between the two groups of data met the "significant difference" criterion, and p<0.001 indicated that the two groups of data met the "very significant" criterion [16]. The formula for calculating the T test is as follows:

$$ t = \frac{\bar{x} - u_0}{s/\sqrt{n}} $$

where the s is the sample standard deviation and the n is the sample number,

$$ s = \sqrt{\frac{1}{n-1} \left( \sum_{i=1}^{n} x_i^2 - n \bar{x}^2 \right)}.$$

3. Experiment and Discussion
This experiment is divided into two parts: EEG data collection part and preliminary preparations; EEG data processing and feature extraction.

3.1. Selection and Pretreatment of Experimental Materials

3.1.1. Experimental Collection. The experimental recipients were 15 graduate students and undergraduates. Each subject went through three stages: resting state, listening to brainwave music, and listening to heavy metal music. MindWave Mobile instrument [17] was used to collect brain wave signals in the experiment. To prevent student fatigue, the entire experiment time is set to 8 minutes.
The brainwave acquisition time is about 6 minutes. In order to ensure the practicability of the experimental data, we will delete the first 15% and the last 15% of each group of data collected, and package the data collection in the middle part and send it to the computer. Brainwave music has recently been favored by many scientific researchers and has achieved excellent results in research. This is why I chose brainwave as one of the music materials in the experiment. The “delay on empty containers” used to represent the heavy metal music on the subject of the experiment is taken from the DEAP database [18]. Music is divided into high and negative scores, and has the highest average score in this category. Figure 1 is the distribution of all songs in the DEAP database. “Procrastination on the empty ship” is striking in the fourth quadrant [19]. Therefore, we choose it as the experimental material of metal music. Table 1 is the EEG signal frequency classification table.

![Figure 1. DEAP Music distribution (from DEAP database).](image)

3.1.2. EEG Pretreatment. The eeg signal has strong randomness and high incident sensitivity. Noise and interference are mixed in easily to form artifacts. The common artifacts include physiological activities from acquisition equipment and experimental body, eeg artifacts (ocular artifact), emg artifacts (muscle artifact), pulse artifacts (pulse artifact) and so on. In order to eliminate the resistance of artifacts to EEG signals, EEG signals should be preprocessed before extracting the features of EEG signals. Pseudo-subtraction and independent component analysis (ICA) algorithms as well as Matlab and EEGLAB were used to preprocess EEG signals.

The principle of artifact subtraction is very simple and is one of the earlier methods to remove noise. Basic principle: it is assumed that the collected eeg signals are linearly combined by real eeg signals and measurable artifacts, and there is no correlation between the two. By equation (2):

\[ y_i(i) = y(i) - kx(i) \]  

\[ k = \frac{\sum(x(i) - \bar{x})(y(i) - \bar{y})}{\sum(x(i) - \bar{x})^2} \]  

During repeated experiments, each experimenter's data was estimated for k values and corrected using equation (4):

\[ y_i(i) = y(i) - kx(i) - m \]  

The calculation of m is as follows (5):

\[ m = \bar{y(i)} - k \bar{x(i)} \]  

Independent component analysis (ICA) is a calculation method that uses statistical principles to process multiple signals. Its essence is a special blind source separation process. Basic idea of ICA: the observation data or signal are separated into several non-Gaussian signal sources with statistical
independence by optimization algorithm, and then the source signal is obtained by linear combination.
simply, assuming that \( x(t) \) is a \( N \) dimension observation signal, \( s(t) \) is \( M \) source signal, the observed
signal is obtained by linear combination of unknown mixing matrices. The problem to be solved by
the independent component analysis algorithm is to find a demixing matrix \( B \) so that the output signal
is as close as possible to the source signal \( s(t) \). ICA principle is shown in figure 2.

\[
x(t) = As(t) \quad M \times N \quad U(t) = Bx(t) = BAs(t).
\]

**Figure 2.** ICA Schematic diagram.

Independent component analysis (ICA) is a common signal preprocessing method in eeg signal
analysis. the ICA is as follows: (1) it can separate the false trace, with high accuracy and can retain a
large number of useful signals; (2) reference electrode without false trace; (3) there are built-in
independent component analysis algorithms in the supporting software of many eeg acquisition
systems at present, and the collected eeg signal class can remove the noise false trace directly online or
offline. This is also an important reason why this method is often used in EEG preprocessing.

3.2. Feature Extraction from EEG

This experiment uses the wavelet transform analysis method of time-frequency analysis. Wavelet
analysis has the advantage of multi-resolution analysis, which can be used to analyze the frequency
domain at the same time as time-domain analysis. This method makes up for the contradiction
between frequency resolution and time resolution in Fourier transform. The wavelet transform is
defined as follows: when the condition such as formula (6) is satisfied, the \( \psi \) is called a fundamental
wavelet, and the definition of continuous wavelet transform in its domain such as formula (7), formula
(8) is the displacement and scale scaling of the fundamental wavelet, where the \( a \) is the scale factor:
\( \psi \in L^2(\mathbb{R}) \)

\[
C_\psi = \int_{-\infty}^{\infty} \frac{\left| \psi(w) \right|^2}{|w|} dw < \infty \quad (6)
\]

\[
(W_\psi f)(\tau, a) = \frac{1}{|a|^{1/2}} \int_{-\infty}^{\infty} f(t) \psi^* \left( \frac{t-\tau}{a} \right) dt = \langle f, \psi_{\tau,a} \rangle \quad (7)
\]

\[
\psi_{\tau,a}(t) = \frac{1}{\sqrt{|a|}} \psi \left( \frac{t-\tau}{a} \right) \quad (8)
\]

When the duration of the wavelet is limited, the scale factor \( a \) play the role of scaling the basic
wavelet \( \psi(t) \). The \( a \) increases, the analysis period becomes wider and the amplitude decreases; the \( a \)
decreases, the analysis period becomes narrower and the amplitude increases.

Wavelet transform is satisfied in frequency domain (9):

\[
(W_\psi f)(\tau, a) = \sqrt{|a|} \int_{-\infty}^{\infty} F(w) \psi^* (aw)e^{iwr} dw \quad (9)
\]

The wavelet transform multi-resolution and constant Q bit can decompose the signal into different
scales in different ways, and can simultaneously obtain \( \alpha, \beta, \theta \) and \( \delta \) waves with different
characteristics. Furthermore, the wavelet packet overcomes the disadvantage of the wavelet
decomposition in the high frequency resolution difference, and the hierarchical tree method that decomposes each frequency is decomposed and decomposed. The three-layer decomposition tree of the wavelet packet with all the information of the signal is retained as shown in figure 3 below, where the decomposed signal node is $A_{i,j}$ where the $i$ is the number of layers and the $j$ is the node position.

![Figure 3. Three-layer wavelet decomposition tree.](image)

The original EEG signal is converted to a sampling rate of 128 Hz, using the resampling function in the Matlab to decompose and reconstruct the signal. In this chapter, the $\alpha$ wave (7-13 Hz) in the original EEG signal is taken as an example for wavelet packet decomposition. In the experiment, the “bd4” mode is selected to decompose the layer number into 6 layers, with a total of 64 subbands. So the $\alpha$ wave corresponding wavelet node is $A_{5,2}(8-12 \text{ Hz})$, $A_{6,4}(8-10 \text{ Hz})$, $A_{6,5}(10-12 \text{ Hz})$, $A_{6,6}(12-14)$. The $\alpha$ wave of EEG can be obtained by reconstructing the above nodes by preserving the corresponding wavelet coefficients to zero the wavelet coefficients of other nodes. The t algorithm has been mentioned above.

3.3. Results Analysis

Figure 4 is the brain wave map of one of the subjects extracted. $\alpha$ wave intensity increases when listening to brainwave music, conversely, heavy metal music is strong and fast drumming, and squeaking makes $\alpha$ waves less responsive. Tables 1 and 2 show that both the low $\alpha$ wave and the high $\alpha$ wave have obvious $\alpha$ difference. When the $\alpha$ wave increases, the intensity of the $\alpha$ band increases, which will make the subjects' physical and mental relaxation enter the reading state faster. And it can be seen that brain wave music can effectively cause $\alpha$ wave response. And beautiful music melody can make people peace of mind, reduce stress, improve concentration. Conversely, the response of $\alpha$ waves to heavy metal music is not obvious. $\beta$ waves are about high concentration, and intense reactions occur when attention is focused. As can be seen in Table 3, the effect of these two kinds of music on $\beta$ waves is also significantly different. This result is beyond our expectation. In a brief interview after the experiment, most participants said they were not usually exposed to metal music, and the fast and strong drumming of heavy metal music did not allow people to concentrate on listening to music. Instead, brainwave music makes them more relaxed and more focused on reading. And brainwave music also has a significant effect on $\beta$ waves, which also verifies the idea that brainwave music can enhance attention.

![Figure 4. Left and right EEG of frontal lobe (FP1 and Fp2).](image)
Table 1. Comparison of low α waves.

| Number | Brainwave music | Heavy metal music | P T test values |
|--------|----------------|------------------|-----------------|
| 1      | 20767.68       | 11531.49         | 0.013179        |
| 2      | 32350.19       | 13622.37         |                 |
| 3      | 54705.31       | 22727.62         |                 |
| 4      | 39841.20       | 3420.81          |                 |
| 5      | 28167.34       | 18774.26         |                 |
| 6      | 15813.65       | 1987.74          |                 |

* P <0.05* P <0.01* P <0.001*

Table 2. High α wave contrast.

| Number | Brainwave music | Heavy metal music | P T test values |
|--------|----------------|------------------|-----------------|
| 1      | 47654.21       | 11409.06         | 0.013888        |
| 2      | 25479.20       | 3619.45          |                 |
| 3      | 13116.97       | 4139.28          |                 |
| 4      | 10864.59       | 5635.71          |                 |
| 5      | 47254.30       | 16257.04         |                 |
| 6      | 24396.97       | 4824.47          |                 |

* P <0.05* P <0.01* P <0.001*

Table 3. β Wave comparison.

| Number | Brainwave music | Heavy metal music | P T test values |
|--------|----------------|------------------|-----------------|
| 1      | 118311.37      | 56416.57         | 0.01159         |
| 2      | 94133.91       | 46512.30         |                 |
| 3      | 85416.12       | 30784.40         |                 |
| 4      | 122344.20      | 81006.67         |                 |
| 5      | 166930.74      | 66468.15         |                 |
| 6      | 252997.81      | 69897.46         |                 |

* P <0.05* P <0.01* P <0.001*

4. Conclusion
This paper mainly designed the experiment of improving attention through EEG music, which can extract EEG data from human body in real time by EEG instrument, and judge the attention concentration degree of subjects by further analysis of EEG data. Compared with the data in the background of heavy metal music, it can be concluded that EEG music can really improve attention. The effects of music on the brain can not only help people concentrate, but also help people relax and sleep. This is also one of the ways people will improve their lifestyle in the future. In this study, we conducted experiments to realize the correlation between music and brain waves. We compared brainwave music with heavy metal music. Experiments show that brain waves have the effect of relaxing body and mind and concentrating. And heavy metal music with fast and strong beating sound will not have a state of relaxation or concentration. Therefore, the preliminary evaluation of the experiment shows that no music has the purpose of improving attention and relaxing body and mind, while the music beat of brain wave music and classical music is more helpful to improve attention.

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