A Study on Characterization of Alpha Wave Music

Yu-Lung Lo[1], Yi-Lan Deng[2]

Department of Information Management, Chaoyang University of Technology
Taichung City, Taiwan

[1]yllo@cyut.edu.tw

[2]ellendeng0801@gmail.com

***Abstract*— People usually listen music to refresh, relax and help sleep. While humans are in various states of minds, there are different frequencies of brain waves detected. Some music can resonate with human brain waves to achieve the better effect on someone's state of mind. Among brain waves, the alpha wave predominantly appears when people are in wakeful relaxation with closed eyes. There have been several medical reports demonstrated that some specific music, called alpha wave music, can resonate with the alpha wave and strengthen it. Therefore, when people take the rest and listen to the alpha wave music at the same time, it can be very helpful to achieve better relaxing. However, the alpha wave music album is not popular on the market because it only can be classified manually by expertise. Until now, there is still very little research on the automatic identification of alpha wave music. This study analyses the music characterizations and expects to help the categorization of alpha wave music.**

***Keywords*— music classification, alpha wave music, neural network, BPN**

1. INTRODUCTION

Now is a time of fully-competition. Many people have too many pressures which can lead to unintended consequences. Such as anxiety, panic, melancholy, manic depression and other mental illness which may come to the door and even affect the physical health. There are also a numerous regrettable cases in the society caused by excessive pressure. Therefore, it is very important to relieve stress appropriately. People usually listen music to relieve stress and to relax. Some even treat patients with mental or physical illness by music. That is because some music can resonate with human brain waves to achieve the better effect on relaxation [9].

British ambient band Marconi Union has drummed up the world's most relaxing song – Weightless, which was named one of the 50 best inventions of the Year in Time magazine, 2011 [10]. This song was proved to result in a 65 percent reduction in participants' overall anxiety, and a 35 percent reduction in their usual physiological resting rates. The song was composed to be a relaxation inducing sound and was made in collaboration with sound and music therapists. Its carefully arranged harmonies, rhythms, and bass lines help slow a listener's heart rate, reduce blood pressure and lower levels of the stress hormone cortisol. Indeed, "Weightless" is so successful at inducing somnolence that scientists caution drivers not to listen to it while driving [10][23].

While humans are in various states of minds, there are different frequencies of brain waves detected. Among these diverse frequencies, there are four major types of brain waves existed discovered, including Beta (β) wave, Alpha (α) wave, theta (θ) wave, and delta (δ) wave [3][4]. Measured by EEG (Electroencephalography)[2], the frequency between 8Hz and 13Hz of alpha wave was detected when people close their eyes for a short rest [25]. There has been several medical reports demonstrated that some specific music, called alpha wave music, can resonate with the alpha wave and strengthen it [4][9]. Therefore, when people take the rest and listen to the alpha wave music at the same time to enhance the brain wave, it can be very helpful to achieve better relaxing. Until now, the alpha wave music album is not popular on the market because it can only be classified manually by expertise. Due to time-consuming and laborious in classification, it cannot be widespread.

The contents of music provided diverse musical features such as: melody, rhythm and chords, etc., which may represent a music genre. Therefore, content-based music retrieval and classification are important research fields for music databases [6][13][14][15]. In this research, we will investigate the features of the alpha wave music for analyzing and expect to help the categorization of alpha wave music.

2. RELATED WORKS

2.1 Categories of Brain Waves

In 1925, Dr. Hans Beck found that there were four major types of human brain waves generated from the human brain, including beta (β) wave, alpha (α) wave, theta (θ) wave, and delta (δ) wave [3][4]. Usually, one of these brain waves will be relatively stronger presence when people are in a variety of different situations. If the music people listened is synchronized with the frequency of brain wave, it can be enhanced by resonance [4][9].

2.1.1 Beta Brain Wave

The beta wave (>12.5Hz) is more intensely presented, when the person is awake in concentration, thinking, and stress [4][9]. The frequency of beta brain wave measured by EEG (Electroencephalography) is shown in Figure 1.

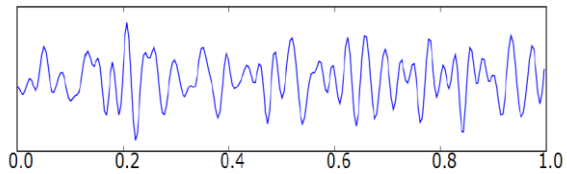

Figure 1. Frequency of beta brain waves detected by EEG [24]

The beta wave music is with similar frequency to beta brain wave. Listening beta waves music can be helpful for longer studying or driving and will help you to maintain a good level of concentration and focus, while also increasing brainwave activity associated with memory and learning. There some beta wave music albums can be found on the market, such as:

(1) Remembrance
(2) Barque Garden for Concentration
(3) Einsten's Dream
(4) Seasons at Roberts Mountain
(5) Water Music

2.1.2 Alpha Brain Wave

The alpha wave (7.5-12.5Hz) predominantly appears when people are in wakeful relaxation with closed eyes [4][9]. The Figure 2 represents alpha brain wave frequency detected by EEG. The frequency is little smoother than beta brain wave.

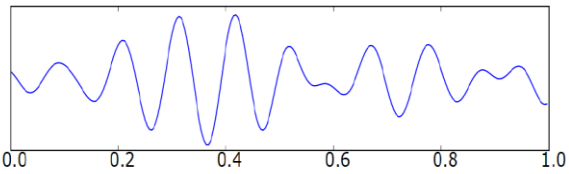

Figure 2. Frequency of alpha brain waves detected by EEG[25]

It has been found that the alpha waves are wave relaxation. Listening alpha wave music is ideal for anti stress relief. We can find some alpha wave music albums on current market, such as:

(1) Masterworks
(2) The Journey Home
(3) Into The Deep
(4) Gaia
(5) Cloudscapes.

2.1.3 Theta Brain Wave

The theta wave (4-7Hz) are the brain states of rapid eye movement sleep, hypnosis, lucid dreaming, and the barely conscious state just before sleeping or just after waking [4][9]. The frequency of theta brain wave measured by EEG (Electroencephalography) is shown in Figure 3.

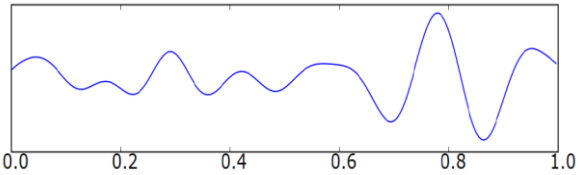

Figure 3. Frequency of theta brain waves detected by EEG[26]

Theta waves are commonly associated with deep relaxation, meditation, intuition and higher consciousness. Listening theta wave music can access the theta state. There are available theta wave music albums as follows:

(1) Out of the Physical Body
(2) Endless Journey
(3) Steal This Album!
(4) Deep Theta: Brainwave Entrainment Music
(5) Theta Wave State

2.1.4 Delta Brain Wave

The delta wave (0.5-4Hz) appears when people are in deep sleep [4][9] The Figure 4 represents delta brain wave frequency detected by EEG.

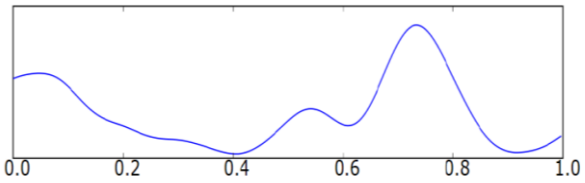

Figure 4. Frequency of delta brain waves detected by EEG[27]

Playing delta wave music when sleeping can help the person reach a deeper sleep. Some delta wave music can be found or download from the internet.

(1) Sounds of Universe
(2) Across the Galaxies
(3) Inner Space
(4) Sleep Music Delta Waves
(5) Beautiful Relaxing Sleep Music

2.2 Alpha Wave Music Classification

2.2.1 Content-based Classification

Lo et al investigated the content-based features of the alpha wave music and develop the distance function for music classification [15]. The music features can be the occurrence frequencies of notes, rhythms, and etc. The n highest occurrences of a feature for a music genre can be the coordinates of the centre as in an n dimensional space. The distance function d(y1, y2,… , yn) for the music to the centre can be derived as equation (1). The yi denotes the features of examined music and xi denotes the centre of a music genre. Thus, the examined music can be identified by the shortest distance.

$$d(y_1, y_2, ..., y_n) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \quad (1)$$

Nevertheless, this study emphasized on analyzing the common features of already identified alpha wave music. It can not substantiate the accuracy for further application on classifying of alpha wave music [16].

2.2.2 Similar Music Genre Discovering

Discovering similar genre for alpha wave music was proposed by Lo et al [16]. This study investigated the content-based features of music and used them to analyze the similarity between alpha wave music and existing music genres. They explored the contents of classical, pop, jazz, folk, blues, and alpha wave music by distance equations and learning machine approaches. In the machine learning algorithm, this study used Support Vector Machine (SVM) through LIBSVM[28] and MATLAB[29] to achieve. They concluded that the notes of alpha wave music are the most similar to classical music as well as the pitch changes of alpha wave music are the most similar to blues music.

2.3 Machine Learning

Machine learning is suitable for prediction or classification [1][5][17][18]. It can be roughly divided into two steps - training and forecasting. The data collected will be trained and adjusted to find its corresponding mathematical model, and verify the results. According to the classification, it can be divided into supervised learning [19], unsupervised learning [12] and semi-supervised learning [7].

Artificial Neural Network (ANN) is also a kind of machine learning [8][22]. It is an algorithm developed by a neural network that imitates creatures. There are many types of neural networks are published and the most representative of them is the back-propagation [20]. The back-propagation trains a multi-layered neural network to learn the appropriate internal representations such that it is allowed to learn any arbitrary mapping of input to output.

3. Research Method

3.1 Music Features

Music, known as the art of sound, makes long history in every culture. In the present life, it is also an indispensable existence. A musical composition consists of three basic elements - melody, rhythm and harmony. Chords are a part of harmony as well. Moreover, the pitch change is also an important characteristic to compose music.

3.1.1 Melody

A melody consists of continuous notes which according to the level, length and strength changes, are arranged in some sequences and compositions. The melody is usually the spindle of musical and the most easily identifiable features. Each note has a different audio frequency. We would like to investigate the notes of alpha wave music to ascertain whether there are specific notes existing most likely to have the harmonic resonance with the brain frequency.

3.1.2 Rhythm

Rhythm is the pattern of musical movement through time. It is formed by a series of notes differing in duration and stress. The rhythm needs to be based on a steady tempo. Different tempos will bring different atmospheres. Generally, slower-paced rhythm is most likely to be able to soothe the emotions and quicker-paced rhythm can boost the human's spirit. The rhythm of alpha wave music will be one of important features in our study.

3.1.3 Chord

A chord in music is any harmonic set of two or more notes that is heard as if sounding simultaneously. People listening to different chords have distinct feelings such as sorrowful for major chords, suddenly enlightened for diminished seventh chords, and unexpectedly flying overhead for major second chords. Chords are more complex and have many variations than other musical features.

3.1.4 Pitch Change

Pitch change is the variation of two adjacent notes. Since the pitch change is not effected by music key up and down, it is one of favourable features for query by example in music retrieval. Usually, the pitch change of hot music is more significant that may inspirit people. On the contrary, the pitch change of lyrical music is smoother that may allow people to relax. The alpha wave music seems to have the same effect as lyrical music does.

Among these music features, the chord is complicate in variety. Therefore, only melody, rhythm and pitch change will be investigated in our studies. We will use them to discriminate alpha wave music from other music genres.

3.2 Categorization *Method*

The categorization method used in this research is BPN (Back Propagation Neural) networks [11]. The BPN is a supervised learning network which provides a set of neural network training data (input) and the corresponding output (output) to learn the relationship between input and output. The structure of BPN network consists of input layer, hidden layer, output layer and weights between layers, as shown in Figure 5. Where, Xi ($1 \leqq i \leqq n$) and Yk ($1 \leqq k \leqq j$) denote the input data and output value, respectively. The weight value between layers will be slightly adjusted in each input data and the adjustment will be affected by the learning rate. After repeated adjustments and trainings, the output value will be closer to the target.

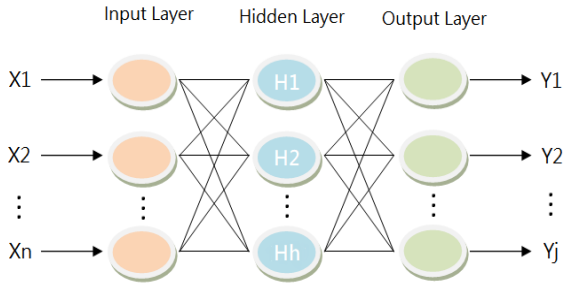

Figure 5. BPN structure diagram [21]

For BPN discussion, the number of hidden nodes increase, the convergence gets slower, however, the errors can be minimized. In general, the concept of designing the number of hidden node used can be:

No. of hidden nodes=

(Input nodes + Output nodes)/2 …..(2)

The software used is MATLAB (MATrix LABoratory) which is a commercial math software produced by the Math Works Company in United States [29]. It provides high-level computing languages and interactive environments for algorithmic development for data visualization, data analysis, and numerical computation. There are many additional tools that can be applied in various areas. The MATLAB version used for our study was R2016a, so does the neural network tools.

4. EXPERIMENTAL DESIGN

The experimental music database used in this study is collected by Lo et al [15][16] including six music genres - blues, classical, folk, jazz, pop and alpha wave music. Among them, there are 150 pieces music for each genre except alpha wave music which has only 87 pieces due to difficult collection. The melodies, rhythms, and pitch changes of music features are also extracted from collected music and analyzed their occurrence frequencies for experimental studies.

In this experiment, we will build a BPN network for each music feature and will discriminate music genres through these BPN networks. Every music feature is split into two portions in which one is for training and the other one is for testing the accuracy of its categorization. Such that each

feature is explored whether there is any special representation of alpha wave music.

4.1 Melody Categorization

The 21 highest occurrence notes (such as Do, Re, Me) in melodies are used for inputs, such as X1.. X21, as shown in the melody BPN structure diagram of Figure 6. In the output layer, Y1, Y2, ..., and Y6 denote the 6 music genres - alpha wave music, blues, classical, folk, jazz and pop, respectively. According to Equation (2), the number of hidden layer nodes in this experiment is 13.

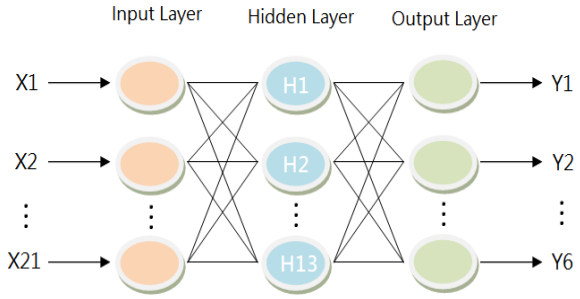

Figure 6. melody BPN structure diagram

4.2 Rhythm Categorization

The 1/8, 1/4, 1/2, 3/4, 1, 1 1/2, 2, 3, and 4 are the most common beats in music. For example, the 3/4 time signature means three quarter-note beats per bar and the beat pattern is strong-weak-weak. These 10 beats will be used for rhythm categorization as the inputs (X1, … , X10) for Rhythm BPN structure diagram as shown in Figure 7. Again, the Y1, Y2, ..., and Y6 denote alpha wave music, blues, classical, folk, jazz and pop, respectively. The number of hidden layer nodes in this experiment is 8.

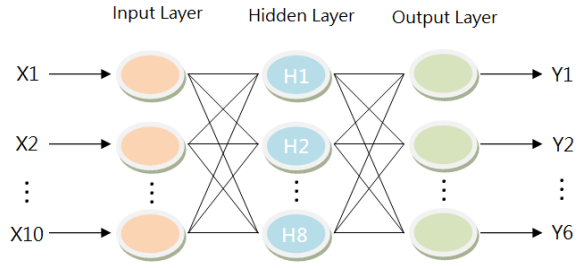

Figure 7. Rhythm BPN structure diagram

4.3 Pitch Change Categorization

For instance, a melody segment of the Little Bee is “So Mi Mi Fa Re Re Do Re Me Fa” such that the pitch changes will be “-2 0 +1 -2 0 -1 1 1 1”. The 24 highest occurrence pitch changes are used as inputs for categorization as shown in Figure 8. The number of hidden layer nodes in this experiment is 15.

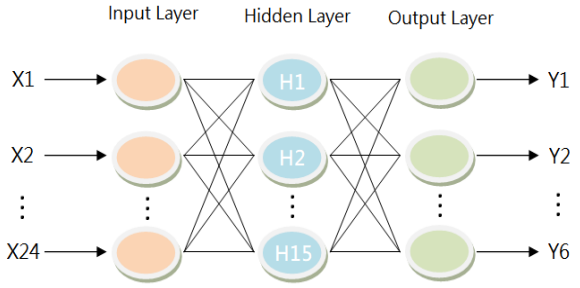

Figure 8. Pitch Change BPN structure diagram

5. EXPERIMENTAL RESULTS

In our experiments, half the amount of each music genre was used for training through the BPN networks and the other half amount of each music genre was used for categorization forecasting.

5.1 Categorization by Melodies

The melody is an important feature of music. We first used melodies for categorization. The half amount melodies of each music genres were trained in BPN networks. Thereafter, the half portion of each music genre is used for categorization forecasting. The experimental result of melody categorization for alpha wave music is shown in Figure 9. The recall is only 43% for alpha wave music. It is obvious that more than 50% of alpha wave music is allocated at the wrong places and most of them were assigned to classical. The classical owns more than 51% of alpha wave music. On the other hand, only 38% of music assigned into alpha wave music was correct placement (precision) as shown in Figure 10. However, 54% of mis-assigned music was from classical. It can be in two reasons. The first one is, due to difficult and less data collection, the number of alpha wave music used to forecast was only half the amount of other music genres. The other one is that alpha wave music and classical music are more similar than other music genres or most alpha wave music are also classical music.

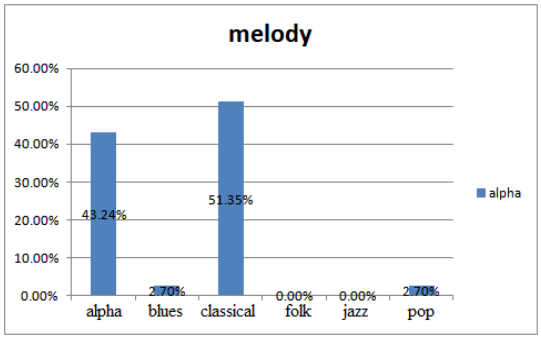

Figure 9. Melody categorization of alpha wave music

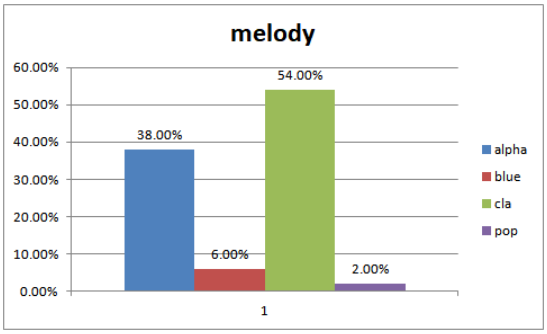

Figure 10. Analysis of melodies in alpha wave music genre assigned

5.2 Categorization by Rhythms

In this study, the rhythms of each music genres are explored for discriminating alpha wave music. After data training and forecasting, the alpha wave music is very inconsistent assigned into every music genres as shown in Figure 11. The most alpha wave music is assigned to classical music however it is only about 35%. The recall is 16% for alpha wave music which is only higher than the amount assigned to folk. Therefore, it seems that rhythm is not a proper feature for discriminating alpha wave music.

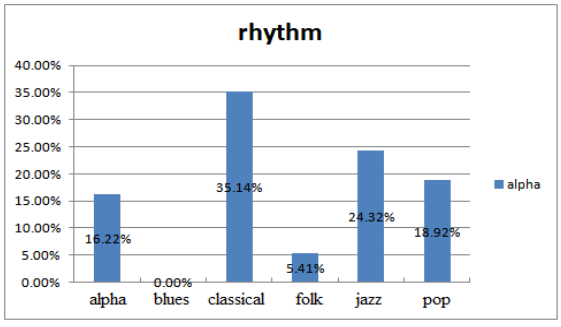

Figure 11. Rhythm categorization of Alpha Wave Music

5.3 Categorization by Pitch Changes

The pitch changes of music features were investigated in this experiment for categorization alpha wave music. The experimental result is shown in Figure 12. Surprisingly, the recall is 94.59% since close to 95% of the alpha wave music was exactly assigned back to its own genre. There were about 5% of alpha wave music assigned to blues and nowhere else. Furthermore, we also examine all music assigned into alpha wave music genre and found that there were 15% blues instead as shown in Figure 13. Therefore, the precision is 85% for alpha wave music in this experiment.

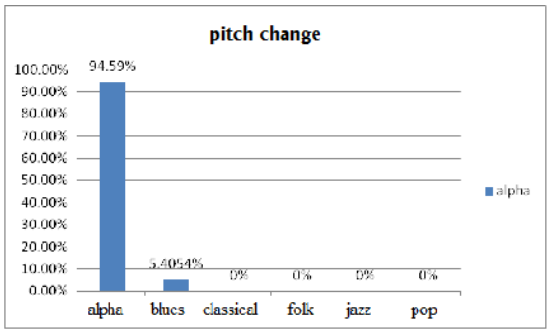

Figure 12. Pitch changes categorization of alpha wave music

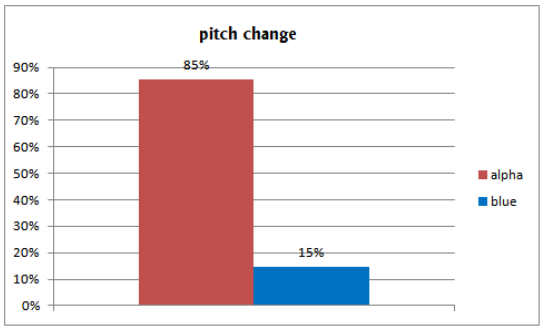

Figure 13. Analysis of pitch changes in alpha wave music genre assigned

6. Conclusion

In this paper, there were three music features (melodies, rhythms, and pitch changes) used as inputs in BPN networks for discriminating alpha wave music. Among them, pitch changes can most distinguish alpha wave music with near 95% recall and 85% precision, while it was only 43% or less for examining by other features. Therefore, pitch change is the key feature for alpha wave music categorization.

Moreover, we also found that more than 50% of alpha wave music was misallocated to classical

music genre in melody categorization. This reflects a similar research conclusion in [16] that alpha wave music and classical are relatively close in melody analysis. Therefore, listening to classical music is helpful for relaxation.

Nowadays, the alpha wave music is relatively rare and more difficult to collect in the market. We still will try to find more samples of alpha wave music for further research. For future work, we will introduce multi-feature classification methods to make alpha music categorization more practical and feasible.

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