Analysis of the Characteristics of Thinking Control during Basketball Free Throw Based on Electroencephalogram

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ABSTRACT

There are important features about the simultaneous exchange of information among different regions of the brain. Synchronization of Electroencephalogram (EEG) signals in different frequency bands is one of the important means to understand the brain. EEG can help discover many unknown details and explain some human behaviours. In addition, it can provide help and theoretical basis for other information research. In order to explore what affects the basketball players' free-throw percentage, this paper conducts a statistical survey of the free throws by college basketball players. By observing the brain waves which reflect the happy and sad moods of the test subjects in the cerebral cortex, this paper analyses the relationship between brain waves and free throw performance. It discusses the factors that affect the psychological changes of basketball players and the general psychological training methods for them. By learning about the psychological characteristics of basketball players, it analyses the psychological adjustment methods for basketball players in various movements. In summary, this paper analyses the factors that affect the free throw percentage from the psychological, physical and technical perspectives, which provides a better reference for future scientific training.

Key Words: Electroencephalogram (EEG), Human Behaviour, Free Throw, Basketball Players

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Introduction

Basketball is a competitive, confrontational and highly motivated team sport. Only when the players work together and be both offensive and defensive can they win the game. As players become proficient and the game gets more competitive, the two sides often go neck and neck and need to shoot in the final stage of the game to decide who the winner is. This requires basketball players to adjust and control their mentality by themselves. Modern scientific research shows that the potential of human movement lies in the combination of physical, technical and psychological factors (Hobson *et al*., 2016; Song *et al*., 2016). A lot of practices in modern competitive sports also prove that a player may not perform well in the game even if he has great physical, technical and tactical skills. This shows that performance is influenced not only by physical and technical factors, but also by psychological factors (Guo *et al*., 2014; Vickers, 2016). Therefore, in the basketball game, athletes are required not only to have good physical quality such as speed, strength, stamina and flexibility and high technical and tactical level, but also to have the best competitive state of mind to obtain a better Score.

Currently, research on human brain tends to be diversified. In recent years, there have been

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new studies on various aspects of the brain, such as brain repair, role of glial cells, how the brain learns to form memory and relationship between dreaming and brain structure. The results provide important scientific basis for clinical research. From the brain research history which lasted for nearly a century, it can be seen that the research method based on EEG has become one of the common methods in brain research (Grushko *et al*., 2015). The most important reason for this is that it is a non-invasive research method that focuses on temporal information transfer and processing. This EEG-based research method has such merits as high temporal resolution and multi-modal assessment, including amplitude, time continuity, frequency domain, correlation, time-frequency analysis, high-order spectral analysis and nonlinear dynamics analysis (Du *et al*., 2016; Laouer *et al*., 2016). Its cost is also lower than those of others and it is a non-invasive test on the brain. However, the existing EEG-based research method still has its limitations. On one hand, it is impossible to record signals of higher temporal resolution in real time and effectively, mainly due to the limitation of the signal acquisition system; on the other hand, the velocity at which the computer processes large amount of collected real-time EEG data is far from enough to satisfy real-world needs. Luckily, the development of the microelectronics computer technology will break these limitations (Pates, 2013; Sun *et al*., 2016). And how to use computer to process large amount of high-velocity and real-time EEG data more efficiently needs further study in the future. This experiment is designed mainly to stimulate the brain with different events to result in different emotional changes in the brain, and then study the EEG signals generated accordingly. The EEG signals are analysed and processed by the principal component analysis method. At last, with the help of computer, scientific and effective analysis results are obtained (Bigliassi, 2017; Lo, 2015). EEG-based analysis of the characteristics of basketball free throws is to analyse changes in EEG activity in the cerebral cortex regions by detecting and analysing players' pleasant and unpleasant emotions caused by sound changes (Hodges, 2017). Different events stimulate the brain differently. The discussion results help provide basic analysis for EEG data analysis and clinical EEG studies.

The introduction of virtual reality in the course of the analysis to improve the design can implement through the virtual reality technology, the establishment of appropriate virtual scene, designers and visitors can enter the scene with a variety of auxiliary equipment, a full range of time and space feeling design. Through a series of experiments summary of the data, the design of the lack of places, and constantly improve the design. Design of digital technology is playing an unprecedented role in landscape planning. In-depth study on the impact of virtual reality technology landscape planning and design, landscape planning and design of further development has an extremely important role.

Research content and analysis

Basketball player's psychological characteristics

In a basketball game, both sides always confront each other according to their competition strategy. Their task is to gain control of the ball, and then complete various offensive and tactical actions and try to rule out the interference by the defensive midfielders so as to hit the basket. The defenders are trying to prevent the attackers from hitting the basket and try to shift from the defensive to the offensive. Therefore, both sides have the same psychological characteristics.

(1): Good sense of ball. In a game, basketball players take "ball" as the centre, so their sense of ball is really important, which includes hand-to-ball control and the velocity, height and direction of the ball. An excellent basketball player can feel the subtle changes of the ball, so in a game, he/she can pass the ball, dribble and shoot. in a timely, accurate and skillfully. Therefore, a good sense of ball is very essential to winning the game (Roberts, 2017). Athlete in the psychological state of the game has often reflected in changes in mood. Such as the impatience of the score temporarily behind, want to win the fear of losing tension, resentment when the injustice of the referee, rage when opponents rough action, the companion complain about the key moment mistakes, the audience when the enraging irritation and coaches emotions on athletes wait. In the game, the rapid changes of factors lead to changes in tactics and tactics, the need for timely adjustment.

(2): Good concentration and distribution of energy. Before the game, players are very concentrated under the stress state, but in the course of the game concentration and excitement will gradually decrease and become even worse. Therefore, attention is very important in basketball games, athletes in the fierce confrontation, but also it has better distribution of

their attention ability. It is necessary to focus on the ball, but also timely and effective allocation of attention to take care of dynamic changes within the audience to play with his teammates technical and tactical.

(3): Good willpower. Willpower is very important, to winning a game which includes initiative, courage, independence, perseverance and self-confidence. In summary, willpower means a basketball player consciously sets the goal, and then adjusts his/her actions according to the goal, overcomes the difficulties and at last achieves the goal. Basketball players's good willpower is of very special significance to the game.

Thinking control methods for basketball players

Thinking control is an important part of basketball training, which can be divided into general thinking and pre-game thinking. It is of great significance to cultivating the players' stable and moderate state of mind in both training and game, promoting training and exerting better skills in the game. Relaxation training is achieved through self-suggestion by players, indicating that language influence is a strong psychological adjustment tool. It allows the tired bodies to get a quick and sufficient rest, so that players' mood can be adjusted, and their confidence can be increased to prepare for the next round. The practice is to let the players sit or lie down, imagine their own relaxation scenarios and use language to imply relaxation. Concentration training is important to attention adjustment. Concentration of attention refers to a state in which a person's body and mind tend to be concentrated on one goal and not distracted or interfered by various external factors. In fact, attention adjustment is an important psychological quality of players. This ability not only has something to do with the characteristics of the innate nervous system, but is also related to the systematic conscious training.

Willpower training for basketball is important. When one side is left behind by the other, or a key player needs to stay in the game after getting injured, they all need the willpower to go on. Therefore, training of willpower plays a very important part in the daily training. This kind of training is also known as imaginary training (Zhang, 2014), which is a method of thinking and control. Players complete the training by imagining or recalling some kind of technical movements, including the key points of movement, order of movements, method and time, causing corresponding neuromuscular changes. Meditation is one of the forms, or it can be combined with reading and watching technical pictures. The purpose is to strengthen the correct concept of technical actions, and improve skills and the accuracy of technical actions. For example, when training is over, take five minutes to let the player stand on the free throw line and make imaginary free-throw attempts, and then take five minutes to imagine shooting. Psychological self-adjustment is mainly a way of adjusting an individual's psychological imbalance through thinking activities in the brain If due to the tension caused by participating in important competitions, the athletes should think more about the better scenes they have in mind activities and calm themselves down. Through repeated ideas and activities to control, reduce the tension in the mind. If the athletes to participate in the competition less opportunities, poor experience, the game as a burden, lack of correct evaluation of their own, did not appear on the battle cowardly, loss of fighting spirit. Encourage their morale and increase the confidence to win. Adopted the concept of "I just use their usual technology to play out, they will certainly be able to play a good game," "This race will win our team," and so on. Supercharged method for those who are timid before the game, there is a lack of fighting spirit, do not believe their own strength athletes before the game to take supercharged methods to stimulate their fighting spirit to arouse their enthusiasm for the game to establish the confidence and win of the game Faith. Cooling method, for those who appear before the game of psychological stress and uncontrollable excitement, take pre-cooling and cold treatment, through the "do not expect too high," the media-oriented, so that their emotions calm down, psychologically stay calm and have a positive effect. Elimination of obstruction law never forget "track mistakes.". Self-blame athletes themselves affirm their strength, emphasizing their strengths, to eliminate their psychological pressure, so that they lay down their baggage, light on the go, boldly give play to their strengths.

Model construction and description

Experimental purposes

According to different characteristics of EEG signals in different basketball free throws, the degrees of electrical activities caused by stimuli in different parts of the brain under the same feeling

are different, and different types of sensory stimuli result in different patterns of brain formation. The main purpose of this experiment is to set up some specific media as external changes, such as listening to free throw commands, different free-throw lines, and other different ways to stimulate. Stimulation needs to make the brain in different states under the EEG figure data and information, and through the method of principal component analysis, the obtained data can help determine several suitable variables, and the sum of these variables need to reflect the original variable information as much as possible to reduce the original variable dimensions. The extracted variables are analysed, and the relationship between changes of EEG signals and emotional changes is further studied.

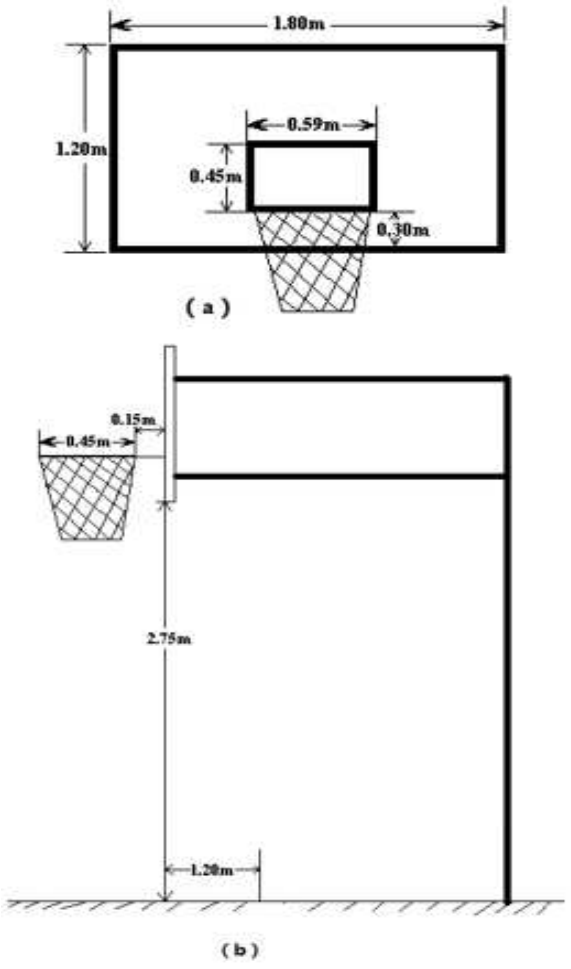

Figure 1. Structure of basketball frame

Free throw is the simplest and most important way of shooting among various shooting styles. Suppose free-throw shooting does not take into account the rotation of the ball after the ball has been shot and the situation in which the ball touches the backboard or the rim, then the penalty is high on the free throw line. Considering the situation of the basketball banking into the basket, this paper tries to discuss the relationship between the shooting angle (30°, 45° and 90°) and shooting velocity and hit rate. Structure of basketball frame as shown in figure 1.

Experimental environment and equipment

The experimental site has selected in a medical school affiliated hospital as far as possible without intensity light; the temperature is suitable, no external noise interference room. Experiments using a series of different events to stimulate the brain induced experimental data through EEG instrumentation. The EEG apparatus of this experiment is an electroencephalograph (EEG-9200K) manufactured by Nihon Kohden Kogyo Co., Ltd. The main features of the electroencephalograph include the following tips.

(1): Type 10-20 JE-920A/AG Electrode Input Box. In the electrode position layout board, there are 25 electrode jacks, 4 multi-purpose input jacks, 3 breathing jacks, 6 bipolar jacks (3 pairs) 4 DC input interface.

(2): Easy skin electrode contact impedance is checked by pressing the impedance check button on the electrode input box, and clicks the impedance check button on the screen to check all the electrodes for the skin electrode. The impedance test result is displayed on the electrode input box and the layout of the electrode on the screen.

(3): Selectable measurement settings

Different preset 36 lead modes. A lead pattern contains preset lead configuration, amplifier settings, and waveform display settings. Waveform display settings locate the waveform, showing on/off, colour, amplitude limits, and comments. We can select different lead modes to set the desired measurement settings quickly and easily.

(4): A variety of unipolar induction measurement function

It is possible to easily switch between the monopolar induction methods of the earlobe reference electrodes (A1-, A2, A1-2, A1A2, A1+A2), overhead reference electrode (VX) average reference electrode (AV), source reference electrode, and the original reference electrode (Org).

(5): Simultaneous display of 64 channel EEG waveforms

High-resolution colour display can display up to 64 channels of 5, 10, 30, 60 seconds or 5

minutes waveform. The screen also shows the time stamp, time scale, marker channel, lead configuration name and event. In addition, you can change the waveform color and amplitude values for some channels, or on/off waveform display.

(6): Waveform amplitude and time interval measurement

When the waveform is frozen, the EEG waveform amplitude, frequency, and time interval are automatically measured through the cursors.

(7): EEG filter

Filters can be used to reduce artifacts on overlapping EEG waveforms. In addition, for waveform acquisition and playback, with accurate signal acquisition, flexible operation and so on. Conductive adhesive commonly used in the experiment is a special conductive adhesive, good performance.

Experimental object

The subjects were from a basketball college and a science and engineering university. There were a total of more than 20 people (20-27 years old), all of whom were right-handed except that two males and one female were left-handed. The average age was 25.5 years old. After investigation, it was found that more than 20 people had not received any regular free throw training. They were all in good health without any record of serious nervous system disease and psychiatric medication. The study performed more than 30 EEG experiments, each of which included two CCTs, one noise incident and one free-throw listening. Relevant parameters of the basketball free throw model are as follows:

d: basketball diameter

D: basket diameter

L :horizontal distance between the free-throw line and the centre of the basket

H: height of the basket centre

h: shooting height of the basketball player

v: shooting velocity of the basketball player

α: shooting angle of the basketball player;

β: angle at which the basketball enters the basket.

In terms of size, L=4.375m, H=3.05m, d=0.246m and D=0.45m. Figure 2 shows the basketball free throw model.

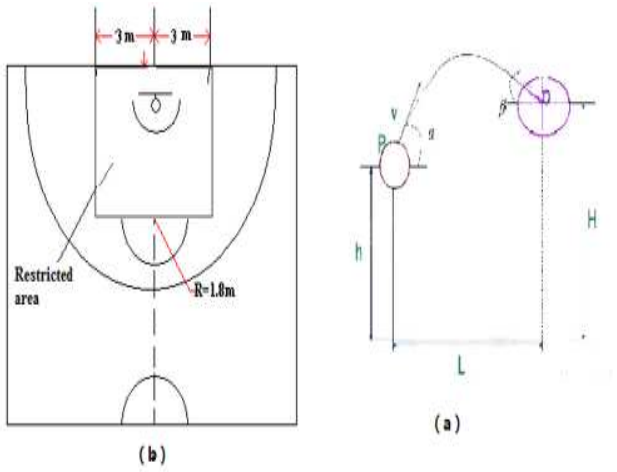

Figure 2. Basketball free throw model

Mathematical model for basketball free throw

There are n samples, each of which observed at p positions on the free throw line $x_1,...,x_p$, and then we can get the original data matrix of free throw line.

$$X=\begin{pmatrix} x_{11} & \cdots & x_{1p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{pmatrix}$$

$$x_i=(x_{1i},x_{2i},\cdots,x_{ni})^T, i=1,2,\cdots,p \quad (1)$$

The sample covariance matrix S and the basketball player correlation R are respectively as follows.

$$S=\frac{1}{n-1}\sum_{i-1}^{n}(X_i-\overline{X})(\overline{X}-X_i)', \quad (2)$$

$$\overline{X}=\frac{1}{n}\sum_{i=1}^{n}X_i=(\overline{x_1},\cdots,\overline{x_p})' \quad (3)$$

$$r_{ij}=\frac{s_{ij}}{\sqrt{s_{ii}s_{jj}}}(i,j=1,2,\cdots,p), s_{ij}=\frac{1}{n-1}\sum_{i-1}^{n}(x_{it}-\overline{x_t})(x_{ij}-\overline{x_j}) \quad (4)$$

Use the P vectors $x_1,...,x_p$ of the data matrix X to make a linear combination as follows.

$$F_i=a_{1i}x_1+a_{2i}x_2+\cdots+a_{pi}x_p, i=1,2,\cdots,p \quad (5)$$

The above equation requires the following.

$$a_{1i}^2+a_{2i}^2+\cdots+a_{pi}^2=1, i=1,2,\cdots,p \quad (6)$$

In addition, the coefficient is determined by the following principles.

I. F_i and $Fj(i \neq j, i, j = 1, \ldots, p)$ are not relevant.

II. F_1 is the largest variance among all the linear combinations x_1,..., x_p (the coefficients satisfy the above equation), and F_2 is the largest variance x_1,..., x_p among all the linear combinations that are irrelevant.

PCA calculation of basketball free throw

1. Steps of principal component analysis

(1) Observe the free throw line position: $X = (X_{ij})_{nxp}$;

(2) Calculate the mean and standard deviation of the free throw line (position) and various indices of the basketball players:

$$\overline{X_j} = \frac{i}{n}\sum_{i=1}^{n} X_{ij} \quad S_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(X_{ij} - \overline{X_j})^2}, j = 1,2,\cdots,p \qquad (7)$$

(3) Standardize X_{ij} and calculate the free throw line (position) correlation matrix:

$$Y_{ij} = \frac{X_{ij} - \overline{X_j}}{S_j}, i = 1,2,\cdots,n, \; j = 1,2,\cdots,p \qquad (8)$$

Then we have the standardized data matrix

$$Y = (Y_{ij})_{nxp}$$

$$r_{ij} = \frac{1}{n-1}\sum_{i=1}^{n} Y_{ij} \bullet Y_{ik}$$

$$= \frac{1}{n-1}\sum_{i=1}^{n} \frac{(X_{ij} - \overline{X_j})}{S_j} \cdot \frac{(X_{ik} - \overline{X_k})}{S_k} \qquad (9)$$

$$R = (r_{ij})_{pxp}$$

If $r_{ij}=1$, $r_{jk}=r_{kj}$

R is a symmetric matrix, where all diagonal elements are 1. It only needs to calculate and output $\begin{pmatrix} r_{21} & & \\ \cdots & & \\ r_{p1} & \cdots & r_{p,p-1} \end{pmatrix}$

(4) Find the eigenvalues and eigenvectors of R.

If we can transform Q by orthogonalizing $Q'RQ = \begin{Bmatrix} \lambda_1 & & \\ & \cdots & \\ & & \lambda_p \end{Bmatrix}$, then $\lambda_1, \lambda_2, \ldots, \lambda_p$ is the p characteristics of R.

We can set $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p > 0$, and then the Q columns are $l_j = \begin{pmatrix} l_{ij} \\ \cdots \\ l_{pj} \end{pmatrix}, j = 1,2,\ldots,p$. λ_j is the corresponding orthogonalized eigenvector.

(5) Establish the principal components

According to the criteria for cumulative variance contribution rate $\sum_{j=1}^{k}\lambda_{ij} / \sum_{j=1}^{p} r_{jj} > 85\%$, we can determine K, and establish the first K principal components.

$$F_j = l_j' F = l_{1j}Y_1 + \cdots + l_{1j}Y_1, \; j = 1,2,\cdots,k \qquad (10)$$

where, $Y_1, Y_2, \ldots, Y_p$ are the standardized index variables.

(6) Calculate the free throw line (position) values of the first K principal components.

$$F_{ij} = \sum_{t=1}^{p} Y_{it} l_{tj}, i = 1,2,\cdots,n, \; j = 1,2,\cdots,k \qquad (11)$$

The above can be obtained by substituting the principal free throw line (position) value $(F_{ij})_{nxk}$ for the original player value $(X_{ij})_{nxp}$ for statistical analysis. It can be said that the problem is simplified.

Results and discussion

The EEG Analysis System Tool is an EEG data analysis system written in MATLAB, which includes reading EEG data files, displaying, converting and processing EEG data, analysing parameter settings and setting data display. Another advantage of the system is that a large number of EEG signals are stored in the computer in a matrix form, thereby reducing the time required for data calculation, improving calculation efficiency and saving storage space, Different shot height of the minimum shot speed and the corresponding shot angle as shown in table 1.

Table 1. Different shot height of the minimum shot speed and the corresponding shot angle

h(m)	Vmin(m/s)	α(angle)	Shot rate
1.8	6.6789	71.565	0.758
1.9	6.5985	71.060	0.803
2.0	6.5186	70.430	0.895
2.1	6.4392	69.830	0.925

The shooting angles α1 and α2 are calculated from the equation (3) at a shooting velocity v=8.0-9.0 (m/s) and a shoot height of 1.8-2.1(m), and the

incident angles β1 and β2 are calculated according to the following table 2.

Table 2. Angle of attack on the different shot speed and shot height of the shot angle

V(m/s)	h(m)	α1	α2	β1	β2
8.0	1.9	71.565	54.321	63.796	30.9213
	2.0	71.570	54.330	63.695	30.1431
	2.1	71.575	54.345	63.540	29.6478
		71.580	54.360	63.430	29.3698
8.5	1.8	73.697	53.900	64.890	22.6250
	1.9	73.705	53.935	64.732	22.7753
	2.0	73.725	53.012	64.792	23.0240
	2.1	73.730	53.133	64.332	23.3583
9.0	1.8	75.320	51.895	65.720	15.6550
	1.9	75.335	51.796	65.670	16.1663
	2.0	75.340	51.605	56.540	17.7321
	2.1	75.355	51.540	64.630	17.9542

Regarding the above α1, we calculate the maximum deviation of hand the angle Δα and Δα/α, and then we calculate the maximum deviation of the hand velocity Δv and Δv/v when only h=1.8,2.0 (m). The results are included in table 3.

Table3. Shot angle and shot the maximum deviation speed.

H (m)	α	v(m/s)	Δα	Δv	Δα/α	Δv/v
1.8	59.4099	8.0	0.6562	0.0432	1.2060	0.6687
	61.6975	8.5	0.6303	0.0576	0.9275	0.8165
	63.0697	9.0	0.5770	0.0698	0.5432	0.8835
2.0	60.7281	8.0	0.7238	0.0691	1.1241	0.7321
	64.3367	8.5	0.6544	0.0745	0.7818	0.8541
	67.4700	9.0	0.5377	0.0900	0.6432	0.9543

Software analysis of basketball free throw

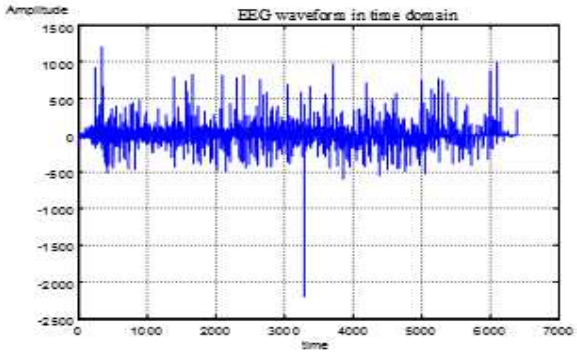

Figure 3. EEG waveform of basketball free throw in time domain

Through the time-domain waveform of the basketball free throw signals,, we can draw the signal amplitude range and signal fluctuations and find the signal mean equation and other eigenvalues. Based on MATLAB data extraction, the load function can extract the sampled EEG signal data. The time-domain mapping EEG waveform is shown in Figure 3.

As can be seen from Figure 3, there are 6,400 data volumes. The amplitude of the selected EEG fluctuates within the range of 0. However, the signals are not stable, with large peak signals. The signals need to be spectrum converted.

The original EEG fast Fourier transform of basketball free throw is shown in Figure4. After the Fourier transform, the data show a curve with frequency conversion as shown in Figure 4.

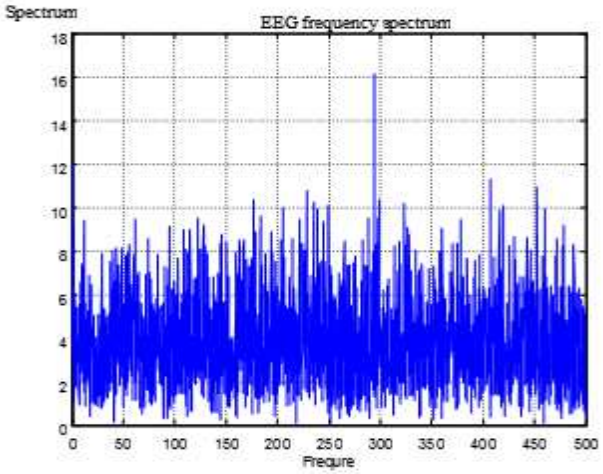

Figure 4. EEG frequency spectrum of basketball free throw

It can be seen from the figure 5 that there are many high-frequency signals in the basketball free throw, indicating that there are many external interference signals among the original signals. Therefore, in practical applications, the signals need to be preprocessed and filtered to remove the signal noise interferences. The filtered ones are more practical EEG signals of basketball free throw.

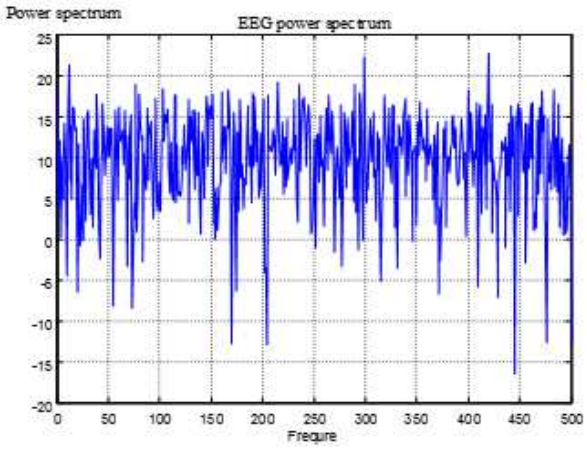

Figure 5. EEG power spectrum of basketball free throw

EEG wavelet decomposition of basketball free throw prediction

The experiment selected db8 wavelet decomposition of basketball free throw orders collected above, call wavelet_dec.m file. The decomposition of the signals obtained by layer is shown in Figure 6 below.

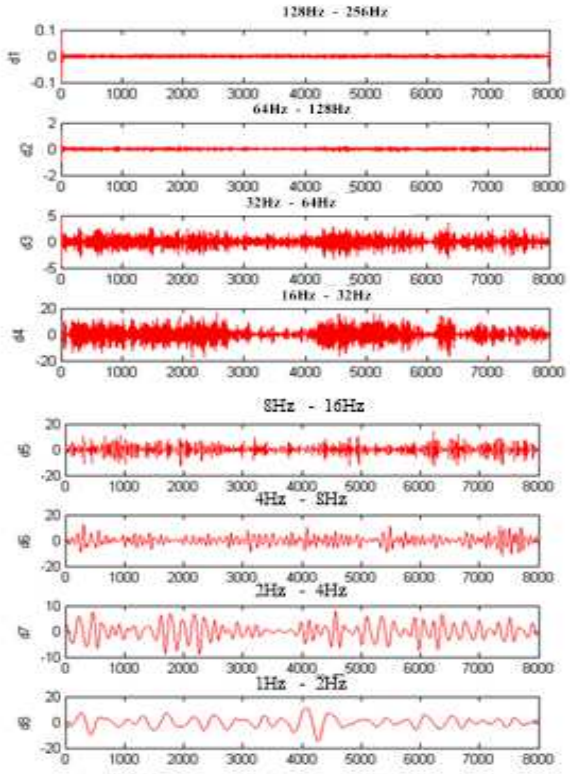

Figure 6. EEG signal of basketball free throw after wavelet decomposition

The sampling frequency of basketball free throw orders is 256Hz, so the built-in frequency range is as follows:

$$[0,\frac{f_s}{2^8}],[\frac{f_s}{2^8},\frac{f_s}{2^7}],[\frac{f_s}{2^7},\frac{f_s}{2^6}],[\frac{f_s}{2^6},\frac{f_s}{2^5}],[\frac{f_s}{2^5},\frac{f_s}{2^4}],[\frac{f_s}{2^4},\frac{f_s}{2^3}],[\frac{f_s}{2^3},\frac{f_s}{2^2}],[\frac{f_s}{2^2},$$

The corresponding frequency components of each sub-band are shown in the following table 4. Under normal circumstances, a8 sub-band is the low-frequency interference, d3, d2 and d1 sub-bands are high-frequency noise, and d8, d7, d6, d5 and d4 sub-bands are the EEG signals, but they may also be mixed with certain noise, which needs to be analysed according to the actual situation.

The α-wave of basketball free throw orders is the most noticeable wave in rhythmic brain waves. Through analysis of each layer obtained by the above wavelet decomposition, it is found that the α wave is mainly concentrated in the d5 subband. So we choose the d5 sub-band between 5500~8000 which contains 2500 data points to draw the signal diagram, as shown in Figure 7

Table 4. Wavelet decomposition of basketball free throw orders

Sub-band signals	Frequency Range	Main signal of basketball free throw orders
a8	0Hz~1Hz	Low-frequency interference
d8	1Hz~2Hz	δsignal
d7	2Hz~4H	δsignal
d6	4Hz~8Hz	θsignal
d5	8Hz~16Hz	αsignal
d4	16Hz~32Hz	βsignal
d3	32Hz~64Hz	High-frequency noise
d2	64Hz~128Hz	High-frequency noise
d1	128Hz~256Hz	High-frequency noise

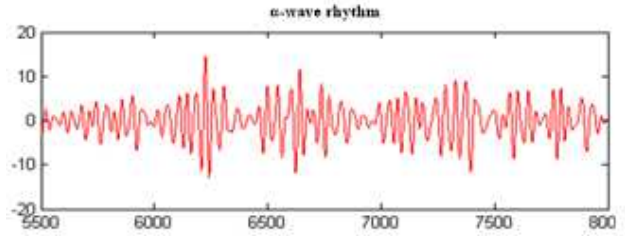

Figure 7. The extracted α-wave rhythm of basketball free throws orders

As can be clearly seen from the figure 7, the α-wave amplitude of basketball free throw orders takes on a prism-like pattern, which is from small to large and then from large to small.

Conclusions

This paper uses the measured original EEG signals of basketball free throw orders to analyse and evaluate the methods and results, hoping to provide some theoretical reference and analysis basis for EEG signal processing and feature extraction. At present, people also try to process EEG by modern methods such as non-linear processing, neural network, and time-frequency combination. We believe these methods will contribute to better brain cognition and promoting the learning and control of motor skills. EEG signals of basketball free throw orders are non-stable random signals. The wavelet analysis method can help directly observe certain frequency components of the signals or extract useful characteristic signals, which provide a very good prospect for the measurement and analysis of EEG signals. The research on the relationship between free throws and emotions has very important theoretical and practical significance. Free throws can induce various kinds of emotions

and play an outstanding role in the treatment of neurological diseases. In this experiment, the EEG data were collected and analysed by the principal component analysis. The purpose is to analyse changes in EEG activity in the cerebral cortex region by detecting and analysing emotions, in order to find out the inner relationship between human brain and the emotions induced by free throws.

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