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ARTICLE

Application Research of Music Therapy in Mental Health of Special Children

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ABSTRACT

A healthy psychological state is the premise for children to carry out various activities. Previous surveys have shown that children with special needs are affected by their own obstacles and are more prone to psychological problems such as sensitivity, low self-esteem, and impulsiveness. Therefore, it is necessary to provide more systematic mental health education support for special children. Mental health education programs are an efficient form of maintaining children's mental health. However, in the field of special education, the number of mental health education courses developed according to the physical and mental characteristics and developmental needs of special children is relatively small, and there are many difficulties in the implementation process. Autism disorder (ASD) is a kind of pervasive developmental dysfunction that is relatively common and representative in clinical practice. In recent years, the number of autistic children has continued to surge, and has gradually expanded from a family problem to a serious social problem. At present, the evaluation of the effect of autism intervention mainly relies on various behavioral scales, which are subjective to a certain extent. At the same time, due to the unclear pathogenesis of autism, the treatment of autism cannot be predicated on the right medicine, and can only be intervened in various ways. The purpose of this paper is to explore the difference between the EEG signals of autistic children and typically developing control (TD) children through the analysis method of EEG signals, and based on the analysis of EEG signals from an objective point of view, to study whether the music therapy method of Chinese Zither playing training can effectively Improving the brain functional status of children with autism yields positive therapeutic outcomes. The experimental results show that the complexity of brain electrical signals of ASD children is much lower than that of TD children, and there is a significant difference in the brain functional state between the two. The music therapy method based on Chinese zither playing training can improve the brain function of autistic patients, and there is a positive therapeutic effect. And with the extension of the training period, the effect may be more significant. Chinese zither playing training can provide a new direction for the intervention of autism.

KEYWORDS

Special children; mental health education; brain function state; music therapy; Chinese zither performance training

1 Introduction

Mental state affects people's life experience and quality of life. With the rapid development of national economy and culture, people pay more and more attention to the maintenance of mental health. In September 2016, the state issued the "Healthy China 2030" Planning Outline, which made important arrangements for

building a healthy China, and included "promoting mental health and improving mental quality" among the contents of shaping the health behavior of the whole people. Subsequently, the State Council issued the "Opinions on Implementing the Healthy China Action" in 2019, proposing the implementation of mental health promotion actions and striving to achieve the goal of "raising the level of residents' mental health literacy to 20% and 30% by 2022 and 2030" [1].

Childhood is an important stage of physical and mental development, a critical period for the cultivation of psychological quality, and a stage of frequent occurrence of various psychological problems [2]. If there is no effective education and guidance for children, there may be adverse psychological problems that continue into adulthood, which is affecting their normal social life. The goals of mental health education can be summarized as follows: improve the psychological quality of all students, cultivate their positive, optimistic and healthy psychological quality; fully develop their psychological potential, promote the harmonious and sustainable development of students' body and mind, and lay the foundation for their healthy growth and happy life Foundation [3]. Children's mental health has attracted more and more attention. Scholars have investigated the current situation of students' mental health from different perspectives and explored the factors that affect their mental health [4–7]. Many front-line teachers also pay more attention to the psychological problems of students in their teaching, and some primary and secondary schools also try to develop school-based courses of mental health education suitable for their students [8]. For children with special needs, physical barriers will have a negative impact on the psychology. For example, children with language barriers have difficulty expressing their emotions and emotions, and may take inappropriate forms to express their anxiety and dissatisfaction; children with intellectual disabilities The control ability is poor, and it is difficult to distinguish right from wrong, and it is easy to imitate some wrong behaviors [9]. Paying attention to the mental health of children with special needs, injecting positive psychological energy into them through various forms, and solving psychological distress is not only of great significance to the growth of individuals, but also can reduce the parenting pressure of parents and teachers.

However, at present, the number of studies on mental health education for special children is small, and the objects and research methods are limited. Most of them use the literature method, survey method and single-subject research method, and the research objects are mostly deaf children, blind children and intellectually disabled children. Restricted by many factors, in the actual special education work, teachers and parents mainly focus on rehabilitation training in life skills, language, movements, etc., and students' psychological conditions are often easily ignored. However, once a psychological problem occurs, if it cannot be solved in time, it will hinder and slow down the learning process of other aspects. On the contrary, helping children with special needs to establish positive psychological qualities and cultivate stable emotions can improve their learning and rehabilitation effects. Traditional mental health education shows a heavy meaning of "treatment" and "guidance", and education or intervention is carried out only when students have obvious psychological problems [10]. Nowadays, more and more researchers are aware of the drawbacks of this educational orientation and begin to study the problem of children's mental health education from the perspective of positive psychology and human development [11,12]. Lin [13] believes that mental health education should be oriented to all students, fully develop each student's psychological potential, and promote their overall physical and mental development. Regardless of whether the current special children have psychological problems such as anxiety, depression, and low self-esteem, they may face more pressure than ordinary people in the future. A healthy and positive attitude is the basis and guarantee for special children to adapt to social life and receive education or rehabilitation training. Therefore, both preventive and developmental mental health education and treatment are equally important.

In today's society, there are many factors that lead to the increasing number of children with special needs in my country, such as unhealthy food intake, environmental pollution, genetic factors, and the use

of chemical agents in food production. Today's special children are not limited to physically mentally handicapped children, such as deaf, blind, dumb and so on. Many children with autism, lack of learning ability or children with ADHD are special children. Their psychology will have some bad problems because of their physical or psychological defects.

In this context, this study will focus on the mental health education of autistic children, a special child. The low receptivity of autistic children to external stimuli affects all aspects of the ability of autistic children. Therefore, it is difficult for children with autism to receive intangible influences from the outside world, and it is also difficult for them to interact with others. Long-term positive communication with children is needed to make up for the defect of common attention [14].

Studies have shown that the vast majority of autistic children have a strong interest in music, and their sensitivity to music is higher than ordinary people, and they have a strong ability to imitate, sing, and perform music. Music can bring fun and infection to children with ASD, and its flexible characteristics also bring a new therapeutic experience and effect to children with ASD. Music training therapy can provide a relaxed and happy therapeutic atmosphere for autistic children, and subtly improve their language expression, social interaction, emotional control and other aspects. EEG signal analysis collects scalp electrical signals by contacting the scalp with electrodes to obtain electrical signals generated by the activity of cortical cells in the brain, and then processes and analyzes them in different physiological electrical signal analysis methods [15]. When the nerve cells in the brain discharge, the electrical signals that can be recorded are spontaneous, synchronized and rhythmic. Therefore, extracting and analyzing different features and parameters of EEG signals can fully understand the activity characteristics of cerebral cortex cells, and then reflect brain function. Children with autism often have severe impairments in brain function and severe co-attention deficits. Disorders in brain function affect the physical and mental development of children with autism. If they cannot pay enough attention to external stimuli, they will have difficulty in effective social interaction. Because of the autistic children's preference for music, intervening with music training can significantly improve the common attention of autistic children. Musical stimulation can stimulate the brains of autistic patients, promote the development of music-sensitive areas, and improve their behavioral abnormalities caused by developmental disorders. The clinical manifestations of children with ASD also show that music stimulation has a positive effect on their recovery, and children are more interested in music therapy than other treatments. Therefore, it is of great significance to explore the role of music therapy in autism recovery and to expand the ways of music therapy.

The purpose of this paper is to collect the EEG signals of autistic children and normal children (Typical developing controls, TD), and use the analysis methods of EEG signals to compare the characteristic differences between ASD children and TD children. At the same time, we use Chinese zither playing training as an intervention method to perform music therapy on children with autism. Combined with the analysis results of behavioral data and EEG signals, we explore the effect of music training therapy on the brain function of children with autism, and provide reference for the rehabilitation and mental health education of children with autism.

2 Related Work

2.1 Preliminaries

Autism, the full name of autism spectrum disorders (ASD), is a clinically common and most representative pervasive developmental disorder (PDD) [16]. The incidence of autism is not affected by racial or regional differences, and the incidence is random and the patients are widely distributed. The incidence of autism is not affected by racial or regional differences, and the incidence is random and the patients are widely distributed. Different patients have different onset times due to their own individual differences, but most of them have onset symptoms before the age of three. Autistic patients have social

and language barriers in daily life, cannot express information normally, behave in a rigid and repetitive manner, and have significantly lower growth and development speed and intelligence than normal individuals [17]. The clinical developmental disorders of autistic patients can be divided into communication disorders, social disorders and behavioral disorders, as shown in Fig. 1.

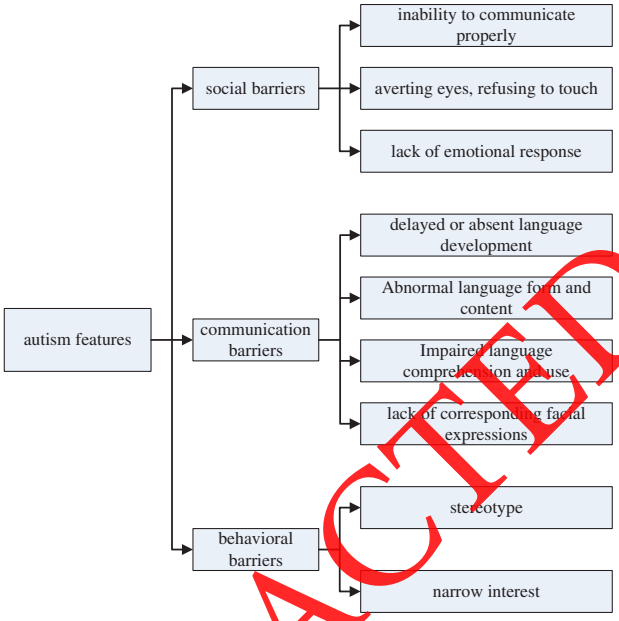

Figure 1: Characteristic manifestations of autism

Communication impairment is manifested as impaired speech expression, slower development of language function than normal children, or no development at all. Some children with ASD develop regular language expression around the age of 2, but their language function degenerates with age, or even completely loses the ability to express language. For children with expressive ability, the way and content of language expression are abnormal, and they cannot express their inner thoughts or transmit information. They have barriers to the process of comprehending the words they receive, to maintain communication, and to make full use of language. Even if they can repeat the lyrics or slogans they have heard, they cannot communicate, ask questions, or start a conversation. They also lack corresponding facial expressions, lack vivid expressive responses, and rarely use body movements such as head and hands to express intent.

Social impairment is manifested as an inability to interact with other partners in an appropriate manner, lack of partnership building, eye aversion, and refusal to contact. People with autism have abnormal expressions and postures, are not interested in the sounds made by others, and lack corresponding responses. They also lack an understanding of conventional social rules and emotions, are unable to perceive and respond to the emotions of social objects, and are unable to adjust social performance in a timely manner as the occasion or situation changes.

Behavioral disorders are characterized by stereotyped and repetitive behaviors and a narrow range of interests. The toys that autistic patients are interested in are obviously different from those of normal children. They prefer round or rotatable objects, such as water bottles and tires. They are not interested in age-appropriate toys and have their own requirements for the location of familiar objects.

From the discovery of autism to the present, the incidence of autism has gradually increased, as shown in Fig. 2. As of 2021, the incidence of autism has reached 2.27%. So far, there are about 76 million autistic patients in the world, a huge number. In China, the number of autism cases has reached 13 million, with a prevalence rate of 0.75%. There are more than 2 million children between the ages of 0 and 14, and this is increasing at an average annual rate of 200,000. This will lead to the gradual conversion of autism from a rare disease to a common disease. The survey results show that the average annual cost of living for children with autism in China is more than 20,000 CNY, excluding the cost of treatment and recovery. Families raising autistic children are under enormous financial pressure. There is no cure for children with autism, only interventions in different ways. There is no cure for children with autism, only interventions in different ways. Most sick children will suffer from mental disability for life. Because they cannot live independently, they need full attention and care from their families and society. Therefore, the sharp increase in the number of autistic children not only imposes a serious economic burden on families, but also becomes a social problem that needs to be solved urgently.

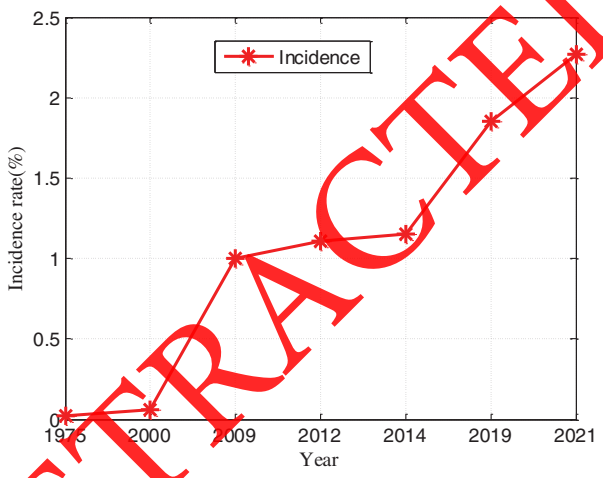

Figure 2: Prevalence of autism

At present, some researchers believe that the cause and pathogenesis of autism may be related to genetic factors, social stimulation, family education and physiological mechanisms, but there is still no clear conclusion on the specific relationship [18]. Studies have shown that the regulation of human gut microbiota can improve the social behavior of mice with neurodevelopmental disorders, suggesting that there may be a relationship between the repetitive behaviors of autistic children and the gut microbiota [19]. Some researchers have also suggested that the cause may be related to genes, and the research results show that it may be related to the environment and susceptibility genes [20]. In addition, the etiology of autism may be related to factors such as gestational hypertension, morning sickness, and male reproductive age, but none of them has been further confirmed.

Therefore, there is no specific plan with significant effect for the treatment of autistic patients, and the treatment effect is still in the stage of incomplete cure. Most of the clinical treatment is based on intervention treatment and various types of training that will not cause damage to the patient. Drugs are only used to treat the health problems that arise during the onset of autism, as well as to control and relieve emotions, and cannot improve their social barriers. At the same time, the diagnosis of autism and the evaluation of the effects of various intervention methods are mostly based on behavioral scales. This requires parents and doctors to fully observe and analyze and calculate the score before evaluation, which is subject to a certain degree of subjectivity, and it is difficult to accurately reflect the condition of the disease.

2.2 Research Status at Home and Abroad

2.2.1 Research Status of Brain Functional State of Autism

Children with autism have different degrees of brain dysfunction, and are accompanied by low attention, severe inattention, which makes them unable to respond to external stimuli. Such children show the characteristics of indifference, non-response, and non-interaction [21]. Therefore, disorders based on brain function have a serious impact on the growth, development and physical and mental health of children with autism. The etiology of ASD is specific, and theoretical models are based primarily on the psychological, weak central, executive, and mirror nervous systems [22].

With the deepening of the research on the pathogenesis of autism, more and more researchers have made a multi-angle and detailed exploration of the brain of autism. They expect to find the pathogenesis of autism from the perspective of the brain and then find accurate and efficient treatment methods. Literature [23] found that all 16 infants with autism had a certain degree of pneumocephalus changes, and their defects were related to language dysfunction. Xu et al. found that the receptor KXRb is missing in ASD patients, which in turn makes the DG part of the hippocampus of the brain defective, which may be the cause of autism [24]. Some researchers used single-photon emission CT to analyze the brain images of children with ASD, and found that the radioactivity in some brain regions was weakened, and the degree of radioactivity in the frontal and temporal lobes was greater, so it was inferred that the pathogenesis may be related to the reduction of the cerebral cortex [25]. Russo et al. found that the activation state of ubiquitin ligase UBE3A in ASD patients is higher than that of normal people, and the excessive activation of ubiquitin ligase UBE3A can affect the synthesis process of retinase and cause autism spectrum disorder [26]. Turner et al. [27] found a direct link between the pathogenesis of ASD in children and the cellular inflammatory response, which was produced by altering the interaction between astrocytes and neurons in the brains of the tested children. This inflammatory response can lead to neuronal dysfunction, resulting in a series of clinical manifestations of autism. The authors concluded that the development of autism is closely related to the natural inflammation of astrocytes [27]. Wang et al. [28] found that new genes due to gene mutations induced the generation of autism spectrum disorders by sequencing the whole genomes of autism patients, and further clarified the genetic characteristics of autism. The findings in [28] provided a new theoretical explanation for pathologies that have previously been unable to be explained by genetics. In recent years, with the continuous breakthrough of gene sequencing technology, the research on intestinal flora has become more and more in-depth. The gut microbiota can directly or indirectly affect the brain-gut axis to varying degrees in various ways, thereby affecting the functional state of the brain [29,30]. Studies have confirmed that the intestinal flora of children with autism is different from that of normal children, and the intestinal microecology is dysregulated to a certain extent [30].

Although a large number of research teams at home and abroad have studied the pathogenesis of autism from different perspectives, there is still no clear conclusion so far. However, it is the consensus of scholars at home and abroad that the brain functional status of autistic patients changes. With the continuous development of medical technology, many scholars have carried out a lot of research on the brain function of autism through continuous means, including MRI analysis, EEG signal stimulation analysis, and analysis of the characteristics of nervous system activity within the brain. Jia et al. [31] performed cerebral perfusion imaging in children with ASD using dual-probe single-photon emission computed tomography and found multiple focal cerebral perfusion areas. Kleinhans et al. analyzed the brain regions that were specifically activated when children recognized different types of images based on brain MRI, and the results showed that multiple cortical and subcortical brain regions in children with autism had functional abnormalities [32]. Uddin et al. found that there were functional connectivity changes in multiple brain regions in the brain salience network in the resting state of children with autism [33]. Literature [34] found that the ability of autistic children to integrate whole-brain network functions is higher than that of normal children, but the ability to distinguish functions is lower than that of normal

children. The dysfunction of this whole-brain network can help us better understand the series of disorders in the functional state of the brain in autism.

The EEG signals emitted by the cerebral cortex can reflect various activities of the brain and are easy to collect. It plays an important role in the diagnosis and detection of mental diseases such as Alzheimer's disease, ADHD, schizophrenia, and manic depression. Therefore, a large number of studies have also detected and analyzed the EEG signals of children with ASD. The authors of [35] compared the EEG coherence between autistic children and normal children, and found that the temporal lobe coherence of ASD children was significantly higher than that of other parts. By analyzing the power spectrum of EEG signals, Han et al. found that the change trend of the power spectral density in the slow wave band of ASD children with age is similar to that of normal children to a certain extent, while the change trend of the alpha frequency band is significantly different [36]. In addition, some research teams also used the power spectrum calculation method to find that the prefrontal lobes of autistic children were oscillated, and the neural connections were abnormal. The prefrontal and temporal power spectral densities of children with autism were lower than normal, and the difference was higher in the left half of the brain than in the right half.

More and more studies have proved that there are certain differences between the EEG signals of ASD patients and normal EEG signals. At the same time, with the development of EEG analysis methods, there will be a more solid theoretical basis for EEG signal analysis. It is more direct and effective to evaluate the effect of intervention therapy in children with ASD based on EEG signals, which has great clinical significance.

2.2.2 Research Status of Music Therapy for Autism

Most children with autism lack sensitivity to the external environment, are unwilling to communicate with the outside world, cannot respond, and try to become immersed in a closed environment constructed by themselves. But a considerable number of these autistic children show a great interest in music, and some even have a very high musical talent. They have an innate musical perception and discernment. Music is different from other methods such as language or action. Music can directly convey different feelings to people, simplifying the process of expression and reaching people's hearts. Therefore, autistic children can and are willing to open their closed hearts and interact in music.

Music therapy for children with autism started earlier in foreign countries, and has gradually formed a therapeutic system with universal application value, which is systematic and practical. In 1950, music therapy became a formal discipline. In 1958, music therapy gradually appeared in the intervention treatment of autism, and many universities began to add music therapy majors [37]. Thaut et al. found that children with ASD are more sensitive to music than animation, and there is no obvious abnormality in their ability to play music [38]. Children with ASD showed a greater sense of pleasure in music therapy, and the duration and frequency of emotional synchronization and spontaneous engagement were longer, and music helped to improve the collective attention and reactive behavior of lonely children [39]. Buday applied music therapy to the improvement of language function in children with ASD, in addition to the improvement of social and behavioral abilities [40].

In China, music therapy for autistic children began in the 1980s. In the beginning, there was a lack of professional treatment system for music therapy for autism, and the hospital or rehabilitation center did not have enough knowledge about the effect of music on children with autism. In recent years, as the strong musical talent shown by autistic children has attracted attention from all walks of life and the effect of music therapy has gradually emerged, more and more parents and students have begun to recognize the practical value of music therapy. Many scholars have also been actively studying the intervention effect of music therapy on children with autism. After entering the 21st century, music therapy began to flourish, and research results continued to emerge. Through case analysis, Wang found that Orff music

therapy can improve the social skills of children with ASD, and their attention spans. At the same time, treated children were responsive to verbal communication and had an increased degree of responsiveness to commands [41]. Liu et al. used a musical game for an attention-item intervention in children with ASD. The results of the study showed that children with ASD had improved attention, improved language function, significantly enhanced learning intent, and reduced abnormal behavior [42]. Although music therapy has received extensive attention from all walks of life, my country still needs a lot of investment in music therapy for children with autism, and the research space is very broad.

In the process of music therapy, due to the strong specificity of autistic patients and the preference for one-to-one individual therapy, it is difficult to select subjects in batches, so it will inevitably lead to a small sample size. The researchers continued to explore the number of people treated and age. Reference [43] determined the number of subjects as 1 to 10 and the age as 3 to 10 years old through the analysis of more than 20 cases. In terms of the classification of treatment purposes, foreign countries mainly focus on the aspects of language expression, social ability and emotional control of children with ASD. Most countries use music as a means of intervention research, and the main treatment methods include acceptance, re-creation and improvisation. In China, it is mainly divided into clinical treatment, individual intervention and centralized intervention.

With further in-depth research, the number of studies on music therapy has increased significantly in recent years. Existing empirical studies have shown that music therapy can significantly enhance the speech function and social ability of ASD patients. It can enhance children's imitative language ability and reduce stubborn and repetitive stereotyped behaviors in children with autism. However, there are still many aspects that have not been covered, such as psychological theory, and more research is needed to explore the impact of this aspect.

3 Data Collection and Analysis of EEG Signals

3.1 Common Analysis Methods of EEG Signals

Dietch first introduced the Fourier transform method when analyzing EEG signals. Since then, EEG signals have opened up an era of rapid development, and analysis methods based on time and frequency domains have gradually emerged. The research method of EEG signal gradually formed a system. After a long-term theoretical accumulation, there are various methods for analyzing EEG signals, which can be divided into the following four types according to the different feature selection:

(1) Frequency domain analysis: The main analysis method of this method is power spectrum analysis. The main idea is to convert the amplitude information into power, and then convert the amplitude-time waveform of the EEG signal into a power-frequency waveform. In this way, the rhythmic changes and distribution of EEG can be directly displayed. Power spectrum estimation can be divided into classical estimation and modern estimation according to the way of finite time series selected in its calculation process. Power spectrum estimation is most suitable for stationary signals, while EEG signals are characterized by non-stationarity and strong randomness, so there are problems of side lobe leakage and poor variance characteristics in the analysis process.

(2) Time domain analysis: The amplitude of the collected EEG signal waveform changes continuously with time, so the time domain analysis method is easy to observe, and the results are intuitive and clear, which is more practical in clinical practice. In the past, the EEG signal analysis was directly judged by the observer through the special waveform on the EEG, which completely depended on the human eye, while the time domain analysis was to extract the characteristics of the signal.

(3) Time-frequency analysis: The EEG signal itself is non-stationary, and is constantly changing, and its frequency also changes with time. The Fourier transform simply combines the time domain and the frequency domain to obtain accurate analysis results. Therefore, for the accuracy of the results, the

time domain and the frequency domain should be fully integrated. Common time-frequency analysis includes wavelet analysis, matching tracking and so on.

(4) Nonlinear dynamics analysis: Studies have shown that the brain has nonlinear dynamics, so researchers apply nonlinear dynamics methods to EEG analysis, such as complexity and fractal dimension. The analysis method of nonlinear dynamics has outstanding application value, which is not disturbed by some special points in the signal, and also overcomes the unrepeatable limitation of previous methods.

3.2 Data Collection

This study selected a total of 8 ASD children, aged 10–14 years, with an average age of 13 years. None of these children had a history of brain tonic injury, epilepsy, or implants. All ASD children were diagnosed as autistic children, which met my country's CCMD-3 diagnostic criteria. The 8 subjects with ASD are all from Xinyi Music Studio in Nanjing City, China, and have received about a year of Chinese zither learning and have a certain foundation. The control group consisted of 8 normal children who mastered a certain guzheng foundation and were able to play music at the same level as children with ASD.

The non-probability sampling method of judgmental sampling was adopted in the selection of children to be tested, and relatively homogeneous and representative children were selected from the recruited population of autistic children as research counterparts, so as to realize the research purpose of knowing the whole from the part. In practice, the selected children are further evaluated to ensure that they are representative, to check the quality and difference of comparisons, and to avoid large sample errors that would affect the results.

For the collection of ASD children's behavior data, the scale method was used, and the scales used were "Childhood Autism Rating Scale, CARS" and "Autism Treatment Evaluation Checklist, ATEC". Before the EEG signal acquisition, CARS and ATEC were distributed to the guardians of 8 subjects with ASD, and appropriate explanations were given to assist the completion of the scale. The EEG signal acquisition uses the g.Nautilus high-precision wireless bioelectrical signal acquisition and analysis system, as shown in Fig. 3. The electrode is fixed on the electrode cap with a certain elasticity, and the electrode has its own impedance detection, which can collect high-quality EEG signals. During the collection, the conductive cap was put on the subject's head according to the electrode position, and the conductive paste was injected along the electrode hole using a special flat-headed syringe to make the electrode fit the scalp well.

Figure 3: g.Nautilus acquisition system

When collecting resting EEG signals, the subjects were provided with a preparation time of 120 s, so that the subjects could keep their bodies relaxed and enter the state. ASD children are assisted by professional teachers during collection and enter a resting state. The entire acquisition environment is kept quiet, indoor personnel are minimized, and the interference of noise in the environment to EEG signals is reduced. EEG signals have low amplitude and weak signals, and are easily interfered by environmental factors and acquisition instrument systems. In view of the unavoidable interference in the acquisition process, it is necessary to perform necessary preprocessing before analysis to obtain accurate signal characteristics. The procedures are as follows:

(1) Remove the unavailable channel data and replace it with the average value of the adjacent channel data.

(2) 20 channels were selected from all 32 channels measured, and they were located in four brain regions of frontal lobe, parietal lobe, temporal lobe and occipital lobe.

(3) Use the adaptive artifact detection method to remove eye movement, respiration, EMG, ECG and other artifact signals, remove baseline drift, sudden slope and outliers, etc., and filter out 50 Hz power frequency interference.

3.3 Analysis of EEG Signals Based on Power Spectrum

The EEG signals collected by the electrodes from the scalp are mixed with signals of different frequencies in various regions of the cerebral cortex, and various features of the EEG signals can be extracted from the perspective of the frequency domain, which can obtain rich spectral information. When abnormal discharge occurs in the brain lesions, the obtained spectral information will also change, and the power spectrum will also change accordingly. Therefore, analyzing the characteristics of EEG signals based on power spectrum can understand the power and energy distribution of different regions of the brain, and find the correlation between them. Power spectrum analysis is an important method in the spectrum analysis of EEG signals. It is a spectrum of the change of signal power with frequency in a unit frequency band. It can retain the amplitude value parameter, so it can directly reflect the change and distribution of EEG rhythm.

In frequency domain analysis, a series of parameters such as absolute power, relative power or power spectral density must be quantified by power spectrum. Power spectrum analysis objectively reflects the changes of various brain regions numerically, overcomes the subjectivity of waveform judgment, and improves the accuracy of EEG in clinical diagnosis. The power spectrum is calculated by integrating the power spectral density in the frequency domain. The specific algorithm is as follows.

There is a random function x(n), find its autocorrelation function r(k), and then we perform a nonparametric Fourier transform on the autocorrelation function to obtain the power spectral density function.

$$P(\omega) = \sum_{k=-\infty}^{+\infty} r(k) e^{-j\omega k} \tag{1}$$

P(w) is the power spectral density function, we use the periodogram method to perform nonparametric spectral estimation analysis, and we obtain

$$\hat{P}(\omega) = \frac{1}{N}\left|\sum_{n=1}^{N} x(n)e^{-j\omega k}\right|^2 \tag{2}$$

Then, we use the Welch method to segment the data on the basis of the periodogram method. Each segment is denoted as x(n), and the length is L. We calculate the power spectral density of each segment and then average as shown below:

$$P(f) = \frac{1}{K}\sum_{i=1}^{K}\frac{1}{LU}\left|\sum_{n=0}^{L-1} X_{i(n)}d(n)e^{-i2nfn}\right| \tag{3}$$

where $U = \frac{1}{M}\sum_{n=0}^{M-1}\omega^2(n)$ is the normalization factor, w(n) is the window function. The power spectral density is the average value of the superposition of the calculation results. The absolute power can be calculated by dividing the signal activity of each frequency band by the average power of each frequency band, and the result is specific. Therefore, when analyzing the EEG signals of ASD children, the error is large, and the accuracy of the results is difficult to guarantee. The relative power is divided by the signal activity of each frequency band by the energy of the whole frequency band, which can reduce the random error.

After preprocessing the collected EEG signals of 8 subjects with ASD and TD children in the control group, the EEG signals of the 20 selected channels were decomposed to obtain 4 frequency bands of EEG signals (Alpha, Beta, Delta, Theta). Then we calculate the energy ratio of each frequency band to the whole frequency band separately, and get the relative power of each frequency band. Referring to existing studies, the resting EEG data of ASD children showed that the power spectrum energy of ASD children in the Alpha band was lower than that of normal children, while the power spectrum energy of Theta band was significantly higher than that of normal children. While Alpha waves are mainly concentrated in the occipital lobe, Theta waves are common in the parietal lobe. Therefore, in the analysis of relative power, this study focused on the Alpha and Theta frequency bands of ASD children and TD children. The calculation results are shown in Figs. 4 and 5. The results showed that the relative power of ASD children in the alpha frequency band of each channel of the occipital lobe was lower than that of TD children in the resting state, which was consistent with the previous research. The results of the significance test showed that in addition to PO8 ($p > 0.05$), the channels P8, PO3, and PO7 had statistical significance ($p < 0.05$), and the significant differences between the channels P7 and PO4 were significant ($p < 0.01$). The relative power of the Alpha frequency band in children with ASD is relatively low. From the perspective of EEG signal power spectrum analysis, it is verified that children with ASD have a lack of attention function, and are often in a state of daze or disorientation. The results of the relative power of the parietal Theta band showed that the relative power of each channel in the parietal lobe was higher in the ASD children than in the TD children. The results of the significance test showed that the channels FC1, C3, C4 and CP2 were all statistically significant ($p < 0.05$), and the channel C4 was significantly different ($p < 0.01$). The higher relative power of the Theta frequency band in ASD children also verifies that they have brain dysfunctions different from those of normal children in terms of memory, mental perception and emotional control.

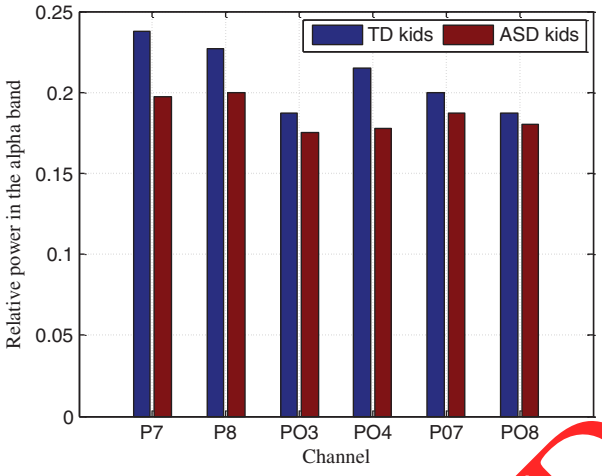

Figure 4: Relative power of occipital lobe Alpha frequency band in resting state

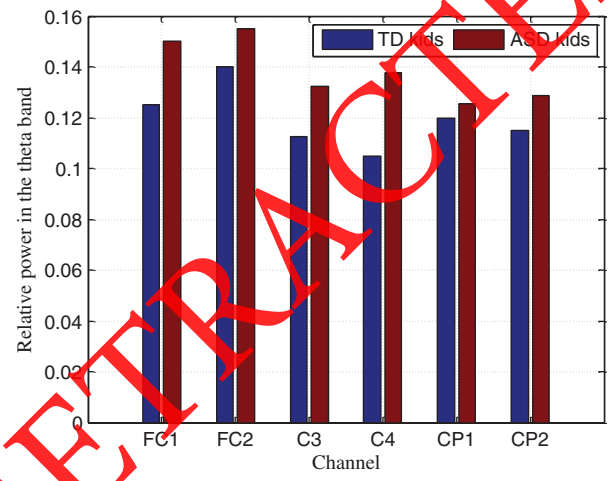

Figure 5: Relative power in Theta band of parietal lobe in resting state

4 The Effect of Music Therapy on Brain Function

4.1 Music Therapy Based on Chinese Zither Playing Training

There are many kinds of music therapy methods. In this paper, the traditional Chinese musical instrument zither is selected. We carry out adaptive music training for autistic children through Chinese zither playing training to achieve the purpose of treatment. Chinese zither playing training makes full use of the low-sensitivity characteristics of the Chinese zither instrument and the adaptive advantages of playing methods, and uses Chinese zither music and its performance as an intervention medium to improve the ability of autistic children to play Chinese zither. Chinese zither playing training associates multiple human sensory channels, so that various regions in the cerebral cortex are coordinated and synchronized to participate in the playing process. Chinese zither playing training can promote the overall development of the brain. At the same time, Chinese zither playing training will also promote changes in other cognitive functions of individuals. Chinese zither training requires long and systematic training. For example, in the auditory domain, children with ASD need to learn to distinguish differences in pitch, volume, rhythm, and timbre. In the motor domain, they must learn to control their arms and fingers, and control different motor responses. For example, adjust fingering, read sheet music, and perform unique

physical responses. When playing the Chinese zither, the player needs to develop asymmetrical finger movements. Through such a complex audio-motion conversion, the therapeutic effect is achieved.

In this paper, the therapeutic method of Chinese zither playing training is used to intervene in children with autism, not only in terms of auditory music perception, but also through a combination of auditory and motor methods. Professional Chinese zither instructors conduct long-term and systematic Chinese zither performance training for autistic children, so that autistic children can play a complete piece of music, so that they can experience the joy and sense of achievement brought by Chinese zither playing, and build self-confidence.

4.2 Experimental Design

Music therapy was performed on 8 selected children with ASD for a period of 4 months. The content of the treatment is Chinese zither adaptive music guidance training, and the whole process is guided by a professional Chinese zither teacher one-on-one. Due to the differences in the playing level and personal preferences of each ASD child tested, in the selection of playing repertoires, the most familiar and preferred music was selected. The treatment time is fixed every Wednesday afternoon, and each training time is 30 min. From the first acquisition of EEG signals, each month was set as a training cycle, and EEG signal acquisition was carried out once. The CARS and ATEC scales were filled out twice at the first and last collection to obtain behavioral data. The whole experimental process is shown in Fig. 6.

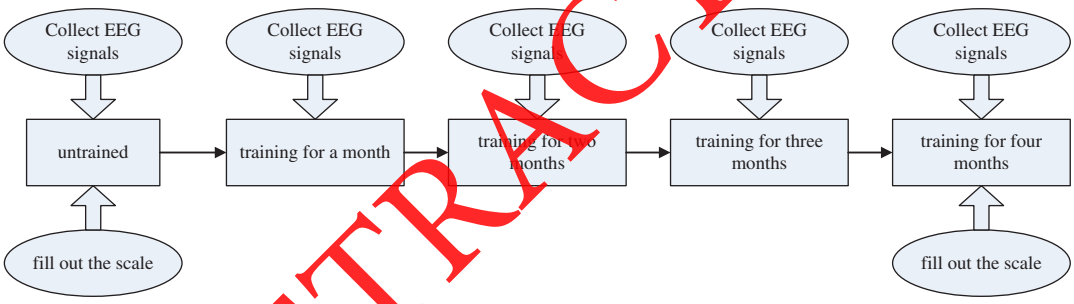

Figure 6: The flowchart of the experiments

4.3 Analysis of the Effect of Music Therapy Based on Chinese Zither Playing Training

The total score was calculated by summing the scores in CARS filled in by the guardians of ASD children before and after training. Table 1 shows the comparison of scores on the CARS scale without Chinese zither playing training treatment and after psychological treatment.

Table 1: Comparison of CARS scores before and after training

Subject number	Score before training	Score after training	Difference in score
1	40	38	−2
2	39	36	−3
3	36	34	−2
4	45	40	−5
5	38	36	−2
6	43	42	−1
7	36	34	−2
8	36	35	−1

In order to facilitate the calculation, this paper assigns scores to each item in ATEC, where N = 1, S = 2, V = 3, M = 2, MO = 3, H = 4. The calculated scores of the ATEC scale before and after Chinese zither training The comparison is shown in Table 2.

Table 2: Comparison of ATEC scores before and after training

Subject number	Score before training	Score after training	Difference in score
1	134	129	−5
2	129	126	−3
3	130	128	−2
4	138	134	−4
5	131	129	−3
6	142	138	−4
7	134	130	−4
8	137	136	−1

It can be seen from the results in Tables 1 and 2 that after the Chinese zither playing training and treatment, the scores of the ASD children's CARS scale and ATEC scale decreased to varying degrees. From the perspective of behavioral data, it can be shown that Chinese zither playing as a new music therapy has a positive effect on children with autism. We use the principles and steps of power spectrum analysis in the resting state to calculate the relative power of each frequency band of the EEG signal of ASD children after 4 months of Chinese zither playing training. By calculation, we obtained the relative power of ASD children without training and after training for 1–4 months, and calculated the average value of all subjects. The relative power in the alpha band of the occipital lobe before and after training in ASD children and TD children is shown in Fig. 7.

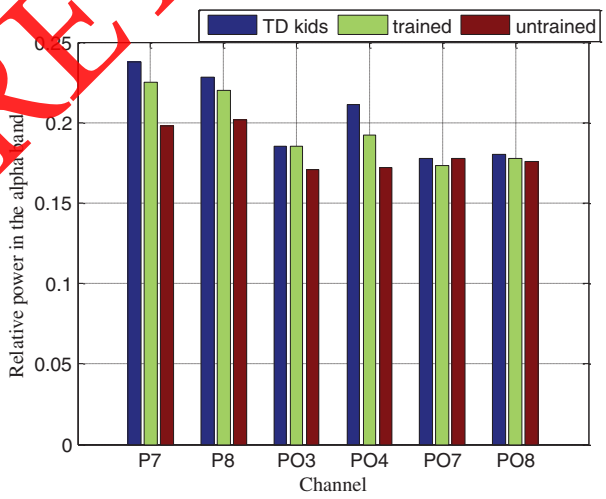

Figure 7: Relative power in alpha band of occipital lobe of children before and after treatment

The results showed that the relative power of the five channels of P7, P8, PO3, PO4, and PO8 in the occipital lobe of the tested ASD children increased significantly after 4 months of Chinese zither playing

training, and the relative power of the alpha frequency band in the occipital lobe was significantly increased, which was significantly close to the relative power of the TD children, but the PO7 channel was not elevated. The results after the significance test showed that there were significant differences in the channels P7, P8, PO3, and PO4 of the occipital lobe of ASD children before and after Chinese zither playing training ($p < 0.01$) (see Table 3).

Table 3: Significance test of relative power in Alpha band of occipital lobe of children before and after treatment

Channel	p value	Channel	p value
P7	0.001	P8	0.001
PO3	0.007	PO4	0.001
PO7	0.086	PO8	0.371

Fig. 8 shows the comparison of the relative power of the parietal Theta band in ASD children before and after training and in TD children. The results showed that the relative power of the Theta frequency band of the six channels of the parietal lobe FC1, FC2, C3, C4, CP1, and CP2 of the ASD children was lower than that before the training after the Chinese zither performance training. Except for the channel FC2, the relative power of the other channels was the same as the TD. The gap between children is decreasing. The significance test of each channel before and after training is shown in Table 4. The results of the significance test showed that the channels FC1, FC2, C3, C4 and CP2 before and after the Chinese zither playing training were all statistically significant and the difference was significant ($p < 0.01$).

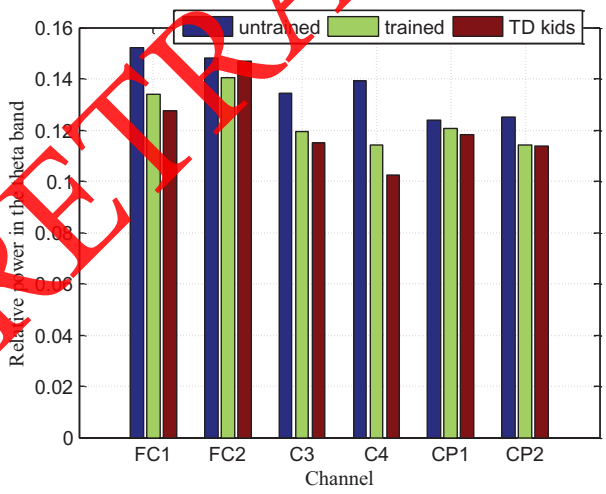

Figure 8: Relative power in Theta band of parietal lobe of children before and after treatment

Table 4: Significance test of relative power in Theta band of parietal lobe of children before and after treatment

Channel	p value	Channel	p value
FC1	0.001	FC2	0.003
C3	0.001	C4	0.001
CP1	0.375	CP2	0.001

Based on the above results, it can be shown from the perspective of power spectrum that Chinese zither playing training, a music therapy method, has a positive effect on improving the brain function of children with ASD.

5 Discussion

Music therapy is a promising early intervention for autistic children and their families, and has been used many times in the treatment and rehabilitation of autistic children at home and abroad. It has important therapeutic significance for the cognitive development, emotion and behavior of children with autism, such as perception and speech. Find out the factors and conditions that make music therapy really work, clarify the neuropsychological mechanism of music therapy's effect on children with autism, and then continuously improve the music therapy model and its methods. Promoting the use of music therapy in more autistic groups and improving the symptom level of autistic children is the ultimate goal and destination of the research. Therefore, how to expand the influence of music therapy and make more autistic children benefit from music therapy is of great significance.

The psychological barriers of children with autism are different from those of normal people. Music can not only promote the balanced development of the brain physiologically and improve intellectual development, but also can directly reach people's hearts psychologically, promoting imagination and creative consciousness. Through rhythm and tune, their brains can be relieved accompanied by music, which helps to adjust their chaotic mental state and coordination of physiological movements. In addition, music can also improve people's emotional activities. Sad music often renders the listener melancholy, while cheerful music renders the listener happy. The author puts the emotion he wants to express in the creation of music, so that children with autism can feel the emotional fluctuations in the music so that they can produce corresponding emotions and stimulate their will.

The mental health problems of autistic children cannot be treated in the same way as normal people. Children with autism are often accompanied by physical impairments resulting in psychological impairments, so it is often not advisable to use language to communicate. For the mental health problems of children with autism, we must first relieve their psychological pressure and let them have trust in the environment, methods and characters of treatment. Appropriate music can change their mentality, thereby reducing their psychological pressure. Even if normal verbal communication is not possible, mental health therapy can achieve significant results through music.

The survey found that children with autism have better hearing and touch than normal children, and their music imitation ability is also higher than normal children. Therefore, they are very interested in music, and citing what they are interested in for treatment must get twice the result with half the effort. One of the most important reasons why most autistic children have psychological problems is that they are affected by their physical defects, surrounding environment and characters, which make them suppress their hearts for a long time. However, the melody and rhythm of music can bring them the enjoyment of hearing and the natural rhythm of the body. Let them try to learn musical instruments, so that they can make the instruments sound and tune through their own abilities, and promote their self-confidence and happiness.

As an effective early intervention method, music therapy can act on the limbic system and other brain regions through hearing, regulate the cerebral cortex, and enhance the level of mood and arousal. It has unique therapeutic effects on cognition, emotion and behavior in children with autism. In order to make music therapy truly benefit the vast majority of autistic children and reduce their physical and mental burden, it is necessary to strengthen large-scale randomized controlled trials of this therapy and further explore the mechanism of the efficacy of music therapy. The neuropsychological mechanism of how it works is deeply rooted, and increasing confidence in treating children with autism is the next step we need to consider.

At present, the evaluation of the effect of autism intervention mainly relies on various behavioral dizziness, which has a certain degree of subjectivity. At the same time, because the etiology of autism has not been clear for a long time, most of the treatment methods are non-invasive interventions. In recent years, music therapy Accepted by more and more patients and their families. In this paper, based on the power spectrum of the EEG signal, the difference of the EEG signal in the resting state between the ASD children and the normal children was analyzed. At the same time, the changes after the treatment of Chinese zither playing training were analyzed, and the intervention effect of Chinese zither playing training, a music therapy method, on ASD children was studied, and the following conclusions were obtained.

The analysis results based on the power spectrum showed that compared with normal children, the relative power of the Alpha frequency band in the occipital lobe of ASD children was lower, and the relative power of the Theta frequency band in the parietal lobe was higher. Although the relative power of the Alpha frequency band in the resting state of ASD children fluctuated after the Chinese zither playing training, it generally showed an upward trend, which was closer to that of normal children, and some channels gradually increased with the increase of the training period. This proves that Chinese zither playing training has a positive intervention effect on improving brain function in children with ASD from the perspective of EEG signal frequency domain.

Therefore, music therapy based on Chinese zither playing training can improve the brain function of patients with autism, and has a positive therapeutic effect. And with the extension of the training period, its effect may be more significant. Music therapy based on Chinese zither playing training can provide a new direction for the intervention of autism.

6 Conclusion

At present, the evaluation of the effect of autism intervention mainly relies on various behavioral scales, which are subjective to a certain extent. At the same time, because the etiology of autism has not been clear, most of the treatment methods are based on non-invasive intervention. Music therapy is accepted by more and more patients and their families. Based on the power spectrum of the EEG signal, this paper analyzes the difference of the EEG signal between the ASD children and the TD children in the resting state, and analyzes the changes after the Chinese zither playing training treatment. Through analysis, we studied the intervention effect of Chinese zither playing training, a music therapy method, on children with ASD, and obtained the following conclusions. The analysis results based on the power spectrum showed that compared with TD children, the relative power of the alpha band in the occipital lobe was lower in the ASD children, and the relative power in the theta band in the parietal lobe was higher. Although the relative power of the Alpha frequency band in the resting state of the ASD children fluctuated after receiving the Chinese zither playing training, it generally showed an upward trend, which was closer to the TD children. The relative power of the Theta frequency band decreases, and some channels have a gradual downward trend, which is close to the normal value. This proves that Chinese zither playing training has a positive intervention effect on improving brain function in children with ASD from the perspective of EEG signal frequency domain.

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Availability of Data and Materials: The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest: The author declares that they have no conflicts of interest to report regarding the present study.

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