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Research Article

Practice of Music Therapy for Autistic Children Based on Music Data Mining

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For children with autism, music therapy has aroused great concern with its novelty and better influence. Music therapy, as one of the effective treatment methods, has an important influence on the social interaction, behavior, and emotion of autistic children. This study attempts to explore a form of applying highly specialized impromptu music therapy to the personal treatment of autistic children in schools for the disabled, as well as the design method of specific music activities. Based on music data mining, the machine learning method is introduced to model music emotion features, and various algorithms are compared to find a model with higher recognition rate, and, at the same time, the antinoise ability and generalization ability of the model are further improved. Finally, a music emotion cognitive model with better performance is established. The results show that the model can effectively promote the overall development of autistic children's cognitive movement, social communication, language communication, and cognition.

1. Introduction

Autism is a syndrome caused by the pathological changes of brain, nerves, and genes. Although autistic children refuse to communicate with others through language, music is a pleasant experience for them, and most of them have good musical sensibility. Some autistic children are timid and self-abased and are ashamed to communicate with and talk to other children; some are self-closed, refusing to communicate and contact with other children [1–3]. Some behaviors are abnormal, such as aggressive behavior, self-injury behavior, or abnormal addiction. Some are indifferent to the surrounding environment. In practice, through various music experiences and music forms, music therapists can improve the physiological, social, communication, emotional, intellectual, spiritual, and other aspects of the treated object and restore or improve their psychological and physiological health [4].

At home, the development of autistic children in the field of music therapy is gradually being studied. Most of them focus on case studies, and there is not much research on the combination of several major music teaching methods abroad. In the specific implementation plan of music therapy for autistic children, there is a lack of professional and systematic music auxiliary teaching materials, which often makes it difficult for music therapists to get started in the course. Due to the lack of all-round construction of the course system, the selection and application of music cannot be well connected and applied, which leads to the failure to achieve the maximum optimization of the course effect [5, 6]. Impromptu music therapy can provide patients with a nonverbal or preverbal interactive mode, which can help patients with weak language ability to establish nonverbal communication and interaction and, more importantly, can arouse patients' positive emotions about communication [7]. It is found in the study that the music ability of autistic children is almost universal [8, 9]. Although they are indifferent to the outside world, and some even have no language, most of them show great interest in music, and some children even have extraordinary music perception

and super sound discrimination ability. There are many expositions and research achievements about music therapy, but there is limited research on the feasibility analysis of combining it with local clinic and based on foreign music education system.

Music therapy is divided into group therapy and individual therapy [10]. Individual therapy can project the patient's inner feelings and psychological problems through the patient's performance, and collective performance can increase the communication among group members and improve the patient's interpersonal problems. Music can express emotions, stimulate emotional experience, have an impact on people's mind, trigger brain physiological activities, and then influence people's behavior and decision-making. In addition to the well-known effects of relieving anxiety and calming mood, music can also relieve pain, influence purchase decisions, and promote the development of children's prosocial ability and reading ability. This paper focuses on the practical research of music therapy for autistic children, hoping to make a little contribution to the treatment of autistic children in China.

The innovations of this paper are summarized as follows:

(1) Based on the analysis of predecessors' research results, this study puts forward the theoretical model of impromptu music therapy for autistic children and the intervention model of impromptu structure, with a view to providing some instructive suggestions for the educational practice of autistic children in secondary schools

(2) Machine learning method is used to build music emotional cognitive model and explore effective music emotional cognitive model, dig into music information resources, and apply music emotion cognitive methods and theories to more application fields

The content structure of this paper is summarized as follows: Section 1 mainly introduces the background of the topic selection, the research status at home and abroad, and the significance and purpose of the research. Section 2 introduces the theoretical basis of music therapy for autistic children. Section 3 mainly introduces the cognitive model of music emotion, which provides the experimental basis for the following discussion. In Section 4, the method of this paper is realized through experiments. Section 5 is devoted to the conclusion and prospect of this paper.

2. Related Work

2.1. Research Progress of Music Therapy for Children with Autism. The initial model of using music therapy to intervene in autistic patients comes from the study of maternal-infant relationship. In-depth study of the musical dialogue between the baby's mother and the baby shows that when the baby is very young, it can react differently to different tones and melodies of the mother's voice [11]. Rachael et al. found that music therapy had an effective effect on the common attention of autistic children [12]. The research report of Khowaja et al. shows that music therapy is more effective than game situational therapy in the influence of persistent attention of autistic children by measuring the duration of eye gaze and the duration of turning head orientation of two groups of children [13]. Nicholas et al. used music therapy to intervene in autistic children. Research shows that music therapy can improve autistic children's communicative language response, concentration, following instructions, physical contact, participating in activities, and making eye contact, which have significant effects [14]. Oztan et al. pointed out that, in the music environment, children with autism tend to be happy or stable [15]. Shuai and Lin think that it is easier for children to memorize and retell lyrics in the music situation, so as to induce the corresponding language. The induction of children's language by music therapy may be similar to that of infants [16]. Trzmiel et al. pointed out that although many research reports have pointed out the effectiveness of music therapy for autistic patients, there are many differences in the music therapy methods and research design of these studies [17]. Lecavalier et al. reported several cases of autistic boys with significant musical response. These children have a high melody memory ability, can recognize classical music, and show interest in piano performance, singing activities, and music appreciation [18]. Sun et al. compared and analyzed the diversity of colors displayed by autistic children using xylophone accidentally and color cards and found that using music can trigger more complex and diversified reactions of autistic children [19].

2.2. Research Status of Music Data Mining. With the advent of the information age, information from all walks of life is stored in the form of data, and the data stock increases exponentially. How to find valuable rules in the vast amount of data has been extensively and deeply studied by scholars at home and abroad. Kania et al. proposed the emotional classification of music electronic database by combining lyrics with audio-visual data [20]. Kama and Kanla proposed classifying music by linear discriminant analysis and SVM (support vector machine) and extracted audio feature vectors from each piece of music by Fourier transform and other methods and then formed high vectors [21]. Karydis et al. used dyadic wavelet transform to classify speech and proposed a speech classification algorithm based on dyadic wavelet transform [22]. Panwar et al. adopted an improved K-nearest neighbor method to find out K-nearest distance points from the test vector in the training set and then classified them by taking the average distance [23]. Niitsuma et al. can not only recommend music that is similar to the user's interest but also discover new potential interests for users [24]. However, because the sampling and interception of music pieces are random, it is easy to produce periodic deviation, which will reduce the representativeness of samples and thus affect the quality of statistical results.

3. Methodology

3.1. Application of Data Mining Technology. Data mining technology has various functions, including data classification, data estimation, data prediction, and data association

grouping, which play a distinctive role in different fields. Because data mining has such functions, it will be applied in various fields.

Data mining technology not only involves various fields but also better promotes the unprecedented development of these fields. Nowadays, data mining technology brings people into a new era of big data. The Internet provides students with various and rich knowledge resources, and data mining technology provides a larger and better development space for the education field. This big data information brings very convenient learning resources to scholars. It successfully crosses the limitation of time and space, and scholars can learn anytime and anywhere, saving more learning time and space.

Data mining analysis and sorting can be carried out on music resources and user experience. On the one hand, it can better analyze the most popular music types and songs at present and improve the overall click-through rate of online music platform. On the other hand, it can better provide similar songs and singers with similar genres for the audience through data analysis of songs and singers that the audience often listens to and can also update the performance time of singers' concerts at any time to provide more opportunities for fans [4]. Through the application of data mining technology in the field of music, it not only promotes the all-round development of online music platform but also brings rich sources of funds to individuals and economic companies by selling singers' albums, thus better and more effectively promoting the development of music.

PSO (particle swarm optimization) assumes that an example without mass or volume is an individual, defines the rules of each particle, and then optimizes the search through individual cooperation and competition among populations. The algorithm has the advantages of fast convergence, few parameters, and easy realization and can effectively solve more complex optimization problems.

Consider the D-dimensional case, assuming that the population consists of N particles, where the ith particle is represented by a D-dimensional vector:

$$X_i = (x_{i1}, x_{i2}, \ldots, x_{iD}), \quad i = 1, 2, \ldots, N. \tag{1}$$

We use a D-dimensional vector to express the flying speed of particles:

$$V_i = (v_{i1}, v_{i2}, \ldots, v_{iD}) \quad i = 1, 2, \ldots, N. \tag{2}$$

Stop searching when the number of iterations reaches the maximum or the fitness function reaches the optimum.

SVM can not only solve linear problems but also be applied to nonlinear fields such as polynomial, interpolation problem, radial basis function neural network, and multilayer perceptron. Because it is based on the structural minimum principle, its quality and complexity are independent of the dimension of the input space.

There is a classification hyperplane such that

$$\begin{cases} w \cdot x_j + b \geq 1, & y_i = 1, \\ w \cdot x_i + b \leq -1, & y_i = -1. \end{cases} \tag{3}$$

Then the training set is linearly separable, where ωx represents the inner product of $\omega \in R^{(N)}$ vector and $x \in R^{(N)}$.

It can also be written in the following form:

$$y_i (\omega \cdot x_i + b) \geq 1. \tag{4}$$

By minimizing $1/2\|\omega\|^2$, only the following quadratic programming problems need to be solved:

$$\begin{cases} \min & \dfrac{1}{2} 2\|\omega\|^2, \\ s.t. & y_t (\omega \cdot x_t + b) \geq 1. \end{cases} \tag{5}$$

According to the statistical theory, the optimal hyperplane is defined as the classification plane that maximizes the distance between the nearest sample data of hyperplane.

The data storage capacity of the Internet is getting stronger and stronger. Facing the massive digital information, people can quickly get rich resources through the Internet, but these resources are also full of complicated information, which makes us at a loss. Therefore, how to extract music melody and display different music as different digital signal forms is a key problem to be solved in music recommendation system, and music classification is such a process in which digital signals are classified through data learning rules.

Specific steps of PSO optimization SVM are as follows (Figure 1):

(1) Coding the sum of parameters to be optimized into the initial population.

(2) Random population and speed.

(3) Calculating the fitness by training for each iteration of particles.

(4) Finding global extremum and individual extremum.

(5) Updating speed and population.

(6) Setting the termination condition, and the fitness function converges. The optimal individual is output.

3.2. Model of Impromptu Music Therapy for Children with Autism. Music therapy is to influence people's thoughts and behaviors through their instinctive reaction, so as to achieve the purpose of therapy. There are many ways of music therapy, which are mainly divided into receptive, active, and impromptu.

For accept type, it mainly emphasizes various physiological and psychological experiences caused by listening to music and includes music recall, song discussion, music synchronization, music imagination, and music guidance imagination. For active, participatory music therapy mainly includes musical instrument playing, song singing, melody development exercises, rhythm exercises, music games, piano playing therapy, and singing therapy. As regards improvisation, as the name implies, patients improvise their ability to play simple musical instruments, including various percussion instruments, such as drums, triangle irons, cymbals, bells, and xylophone. Improvisation method

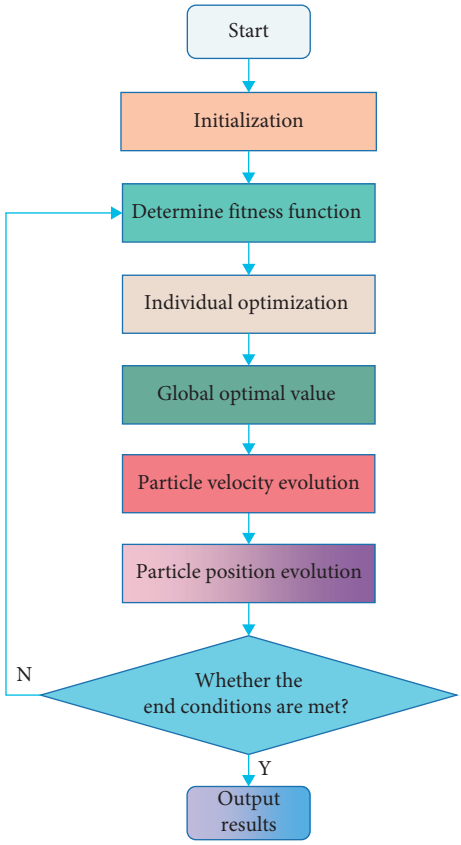

Figure 1: Optimization of SVM process with PSO.

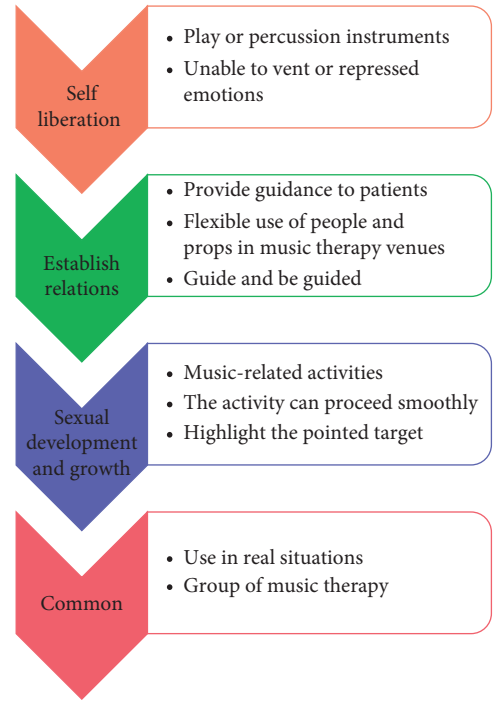

Figure 2: The whole treatment process.

includes music psychodrama, Orff's improvisation method, and improvisation evaluation.

The basic characteristics of improvisation experience are its spontaneity, creativity, free expression, extensiveness, and independence, and it includes interpersonal skills. Therefore, for autistic children, impromptu music therapy can be said to be one of the most appropriate treatment methods. By communicating with patients, therapists can help children express emotions that are difficult to express in words. At the same time, improvisation is the safest means to try new behaviors and new methods and develop determination.

The model of impromptu music therapy for autistic children is a mobile developmental model. Aiming at the overall goal, taking the development of children's communication awareness and autonomy as the specific goal, combined with the specific situation of children (including the degree of severity, specific symptoms and preferences, etc.), the whole treatment process can be divided into four stages in the name of the main goal of stages (Figure 2).

Many clinical observations and experiments on autistic children have confirmed that autistic children have special response and unusual interest in music stimulation. Some researchers have also applied structured music therapy technology to autistic children and found that it has positive effects on the development of autistic children in the following aspects: presocial behavior, attention duration, self-expression, psychological age, spontaneous speech, voice imitation skills, interpersonal relationships, accuracy of task completion, shopping skills, and so forth.

Different autistic children are in different stages in the flow model of impromptu music therapy because of their different intelligence, autistic degree, and development level in various fields; that is to say, if we want to implement improvisational music therapy intervention for different autistic children, we need to start from different stages, and the stage goals are also different.

Based on the overall evaluation results in the baseline period, the researchers worked with parents and teachers to formulate treatment plans, including the formulation of long-term and short-term goals, treatment plans, materials used, and participants, and predicted the possible behavior trends according to the actual ability level of children, with different emphasis on treatment contents and forms at different stages.

Researchers follow up the children's behavior after treatment and observe and record the children's life and learning state in natural situations. The data of the tracking phase is collected twice a week for 45 minutes, totally 4 times. At the same time, the researcher interviewed parents and teachers again to understand the changes and development of children before and after treatment and to supplement and support the research results.

According to the previous evaluation results, the subjects' sports field developed best, which is their advantage field. Therefore, it will be used when making treatment plan, thus driving the development of other fields. Through interviews with parents and teachers, combined with the actual ability level of the subjects, the goal of treatment focuses on the following points:

(1) Increase the time of sustained attention, eye contact, and common attention

(2) Improve the way of speaking and singing, and increase the volume

(3) Expand the concept of cognitive structure, and master the concept and usage of life words

(4) Increase social behavior with others, express needs and wishes simply, and master basic social etiquette

3.3. Music Emotion Feature Extraction. Most autistic children are reluctant to speak, but some children still have good language imitation ability. In this case, therapists or social workers can choose to sing songs. Through the interactive singing experience, the negative emotions of autistic children can be released, and they can express their thoughts after receiving the positive influence of music on the emotional system, thus stimulating their hearing and oral expression ability. The long-term nature of experiments is limited because a large number of experiments are observed. Therefore, most observation research methods should be changed to experimental research methods, which can not only save manpower and time better but also provide a more applicable way to prove persistence.

First, extract the main melody fragment from the music, extract the musical features of this fragment, and obtain a series of feature vectors. At the same time, manually annotate the sentiment categories of the main melody segments to obtain a set of sentiment vectors. Finally, establish a music emotion database based on emotion vector data and feature vector data, and then build a prediction model according to this database to find the functional relationship between music emotion and music features.

K-means algorithm is based on centroid, that is, considering the average value of objects. Because of its high efficiency and simplicity, it has been widely used in data mining and big data. Using the objective function as the square error, the formula is as follows:

$$\mathrm{SSE} = \sum_{i=1}^{k} \sum_{x \in G_i} \mathrm{disc}\left(g_i, x\right)^2, \tag{6}$$

where k is the number of clusters, x is each object, G_i is the ith cluster, and g_i is the centroid of cluster G_i. The criterion first calculates the error, the distance from each point to the centroid, and then calculates the sum of the distances as the total error square.

K-means algorithm has the characteristics of simple implementation and fast operation and can efficiently process massive data.

Split hierarchical clustering is a top-down hierarchical clustering. Firstly, all objects are regarded as a cluster and then gradually subdivided layer by layer to get more and more clusters with smaller and smaller range. When the subdivided clusters meet certain conditions, for example, they are divided into a certain number of clusters or subdivided to the lowest level, and so on.

In the aggregation or splitting algorithm of hierarchical clustering algorithm, there are four widely used intercluster distance measures:

Minimum distance:

$$D_{\min}\left(M_i, M_j\right) = \min_{p \in M_i, p' M_i} \left|p - p'\right|. \tag{7}$$

Maximum distance:

$$D_{\max}\left(M_i, M_j\right) = \max_{p \in M_i, p' \in M_i} \left|p - p'\right|. \tag{8}$$

Mean distance:

$$D_{\mathrm{mean}}\left(M_i, M_j\right) = \left|x_i - x_j\right|. \tag{9}$$

Average distance:

$$D_{\mathrm{avg}}\left(M_i, M_j\right) = \frac{1}{n_i n_j} \sum_{p \in M_i} \sum_{p' \in M_i} \left|p - p'\right|, \tag{10}$$

where $|p - p'|$ is the distance between two objects p, p', x_i is the average value of cluster M_i, and n_j is the number of objects in cluster M_i.

Using the normalized pieces of music, the experiment of manually annotating music inertia was carried out, and the construction process is summarized as follows:

(1) Collection methods include online music and music albums.

(2) From each piece of music, a 30-second piece of music is intercepted by experts in the field of music. The principle of interception is that this piece of music reflects the main melody of the music, the melody is complete, and it reflects the obvious music emotion of a single category.

(3) Finally, 300 valid music pieces were randomly selected as the final experimental music resources.

(4) Each 30-second piece of music is marked with artificial emotion.

(5) Use Maryas tool to extract music feature information, extract 64-dimensional feature parameters from each music segment, and obtain music feature data information of music.

(6) Establish a music emotion feature database by using the above-mentioned artificial emotion annotation data and music feature data extracted by Maryas.

After obtaining the music emotional feature library, the data prediction model can be established by machine learning algorithm to realize the automatic recognition of the emotional characteristics of music by computer. The modeling process is shown in Figure 3.

The core idea is that, for each object in a cluster, the amount of data in the neighborhood of a given object must be greater than the radius of a given value; that is, it must exceed a certain threshold density nearby.

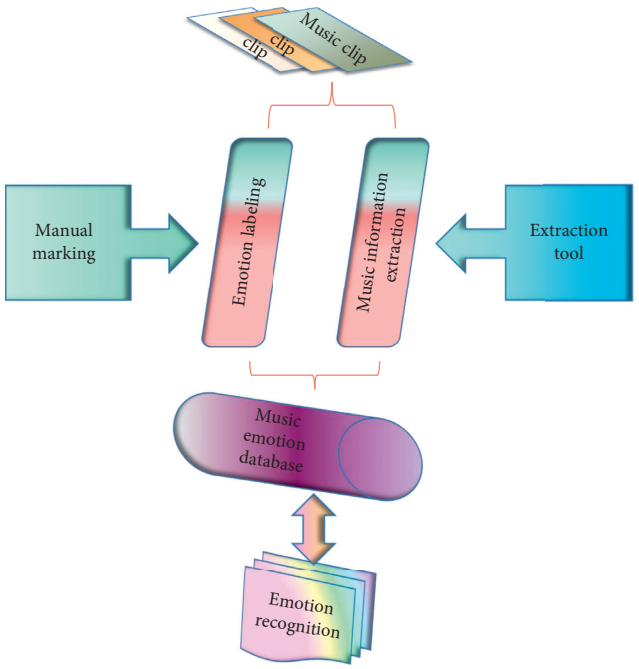

Figure 3: Construction process of emotional cognitive model of music.

Based on this convention, a cluster can be uniquely determined by any basic object. When the number of rectangular spaces in the bottom layer is more, the clustering results will be better, and the computational complexity will also increase. When the number of rectangular spaces in the bottom layer is less, the clustering results will get worse, and the computational complexity and time consumption will be reduced.

4. Results Analysis and Discussion

According to the research plan, the researchers divided the intervention period into three stages and, after each stage, made an overall evaluation on the subjects using the Autistic Children Assessment Form and got feedback on the treatment effect, so as to make timely and effective adjustments to the treatment plan and strategy. The result of perception evaluation is shown in Figure 4.

Through the treatment of multidimensional music activities, the therapist purposefully makes the subjects feel the changes of music elements such as pitch, rhythm, speed, and intensity, and the chances for the subjects to listen to music and feel music are greatly increased, which also improves their sensitivity to sound, which is embodied in the items of auditory response, auditory attention, auditory discrimination, and so forth.

At the same time, the simultaneous processing of vision and hearing also promoted other senses' perception of the external environment, and the identification and memory items of touch, taste, and arousal changed from no perception to awareness.

The social interaction field is the most lagging field of subjects' development, and it is also the key field of

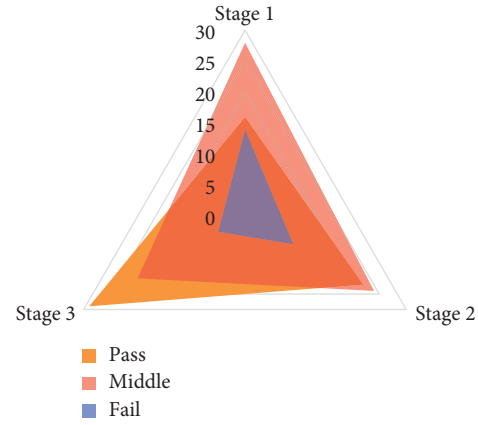

Figure 4: Perception evaluation results.

treatment target. Mother also put forward the hope that, through treatment, the subjects can master basic social etiquette, try to integrate into the group, and play with their peers. The researchers have been aiming at this goal throughout the whole treatment stage.

In this study, during each treatment, the researchers set eye contact, following instructions and active communication as the target behaviors, and observed and recorded the number of behaviors, so as to evaluate the development of subjects in the fields of social communication and language communication. The results are shown in Figure 5.

As shown in the figure, after receiving music therapy, the eye contact behavior obviously increased, and, after removing the therapy, the eye contact behavior declined, but it was significantly higher than the ability level before treatment. Therefore, music therapy is effective for the subjects and has a certain delay effect.

After receiving music therapy, the subjects' behavior of following instructions increased significantly. After the therapy was removed, the behavior of following instructions decreased, but it was significantly higher than the ability level before the treatment. Therefore, music therapy is effective for the subjects and has a certain delay effect.

After receiving music therapy, the participants' active communication behavior increased significantly. After removing the therapy, although the active communication behavior decreased, it was significantly higher than the ability level before the treatment. Therefore, music therapy is effective for the subjects and has a certain delay effect.

Figure 6 is obtained by separating the two activities from the structured activities.

It can be seen from Figure 6 that the eye contact rate of the subjects is greatly influenced by the replacement of the assistant teacher, whether in the activity of human-human interaction or in the activity of human-musical instrument-human interaction. The starting point of the eye contact rate between the subjects and teachers in the human-musical instrument-human-interaction activities is slightly higher than the starting point of the broken line of human-human interaction activities. This shows that it is also a structured activity. Structured activities with musical instruments as the interactive media between the subjects and teachers at the

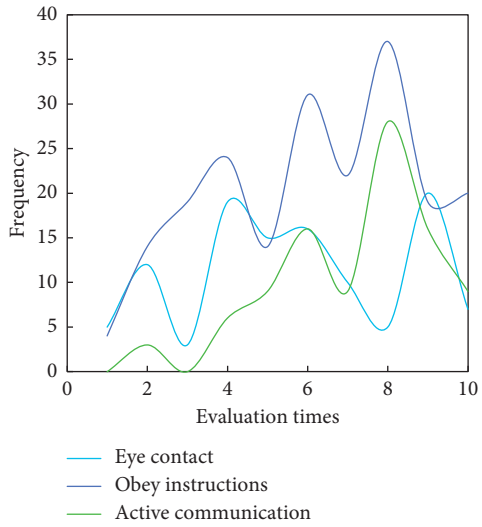

Figure 5: Behavior change.

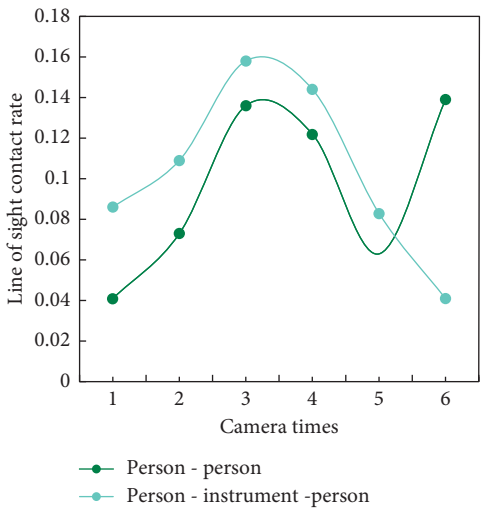

Figure 6: Changes of subjects' eye contact frequency in two structured activities.

Table 1: Loss matrix of the training set.

Class	Test		
	1	2	3
1	0	30	0
2	380	0	0
3	0	0	366

Table 2: Loss matrix of the test set.

Class	Test		
	1	2	3
1	0	21	0
2	116	106	0
3	0	0	133

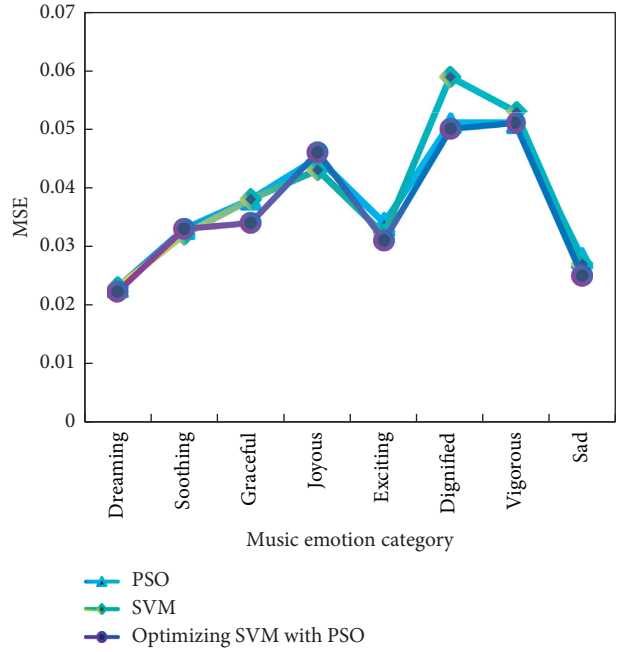

Figure 7: MSE test results of the music emotion cognitive model.

initial activity can cause the subjects to make eye contact with the outside world.

In this experiment, MATLAB libsvm toolbox is used to select parameters to verify SVM algorithm. 1,500 groups of data were selected as training samples, and the remaining 500 groups were used as test samples. The data were normalized to the [0, 1] interval by data preprocessing. Then, the best parameters were used to train SVM network. In this experiment, RBF kernel function is selected to verify the analysis.

The loss matrix of the training set is shown in Table 1.

The loss matrix of the test set is shown in Table 2.

Finding the best parameters through grid division ensures the best classification of training set without test set, while PSO algorithm can save a lot of time and space by heuristic search without traversing the whole grid. From the above results, it can be seen that the classification preparation rate is greatly improved by PSO algorithm.

In the model construction, we compared the prediction performances of three models (SVM, PSO, and Optimizing SVM with PSO). When SVM is used, cross-validation method is used for the training set to obtain the optimal values of the parameters in the model. Finally, the model was tested, and the specific results of the model comparison are shown in Figures 7 and 8, respectively.

Criteria of model performance are as follows: Generally speaking, the correlation coefficient is above 90%, and MSE (Mean Squared Error) of the model is below 0.01, which means that the model has higher control power and smaller model error. It can be seen that the music emotion cognition performance of the Optimizing SVM with PSO algorithm is better.

Children with autism have great individual differences, and the variation of emotion and behavior influenced by situation is significantly greater than that of other children with disabilities, which increases the difficulty of discussing

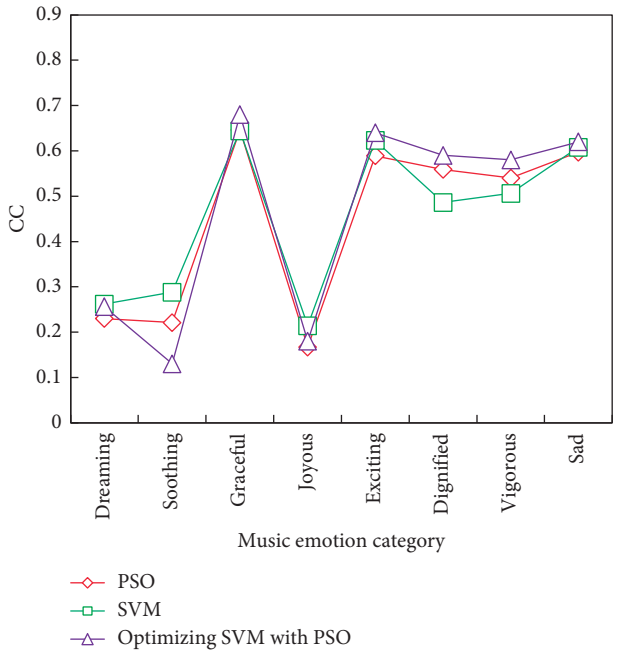

Figure 8: CC test results of the music emotional cognitive model.

the details of intervention effect of children with autism. However, according to the above analysis of existing music therapy intervention research from four aspects, such as research methods, feasibility, intervention targets, and types of music therapy, it is entirely possible for music therapy intervention to be an effective intervention for autism, so it is necessary to pay attention to the whole treatment process of children with autism.

Children with autism are generally sensitive to music, and some even have different talents. The accumulation of music knowledge and skills is likely to provide opportunities for children's future development. Ignoring the training of music technology is likely to stifle the foundation of children's sustainable development. Therefore, in the intervention of autistic children, their musical potential should be explored and cultivated.

5. Conclusions

Music is a kind of diversified nonverbal communication tool, which can help children to vent their psychological negative emotions, relax their body and mind, and get a sense of pleasure. Structured activities can make autistic children feel at ease in an unfamiliar environment as soon as possible and can quickly experience the fun and success of the activities, which can be the basis and adjustment for improvisation. Improvisation activities provide opportunities for autistic children to discover and explore and verify various relationships through their own behaviors and provide opportunities for developing their cognitive abilities and other higher-level abilities. The active participation and cooperation between parents and teachers of autistic children play an important role in the treatment process. Machine learning method is used to model data, and the performances of the models are compared. Finally, a music emotion cognitive model based on the Optimizing SVM with PSO algorithm is obtained, which can predict music emotion with high accuracy and can be used in a wider range of applications.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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