

# *Application and Prospect of Immersive Virtual Reality Technology in Rehabilitation Practice of Autistic Children*

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**Abstract:** The treatment of autism spectrum disorders has always been the focus and difficulty in special education. Immersive virtual reality technology has brought new technology and hope to break through this difficulty. In recent years, the research of immersive virtual reality technology in autism correction has shown the gradual advancement and deepening of research tasks and the renewal and iteration of instruments and equipment. The horizontal research focuses on specific fear, social and life skills, emotion recognition and expression, and nonverbal communication. In order to give full play to the role of immersive virtual reality technology in the treatment of autism, it is more necessary to pay attention to the research and development of equipment and technology upgrading, enhance the universality of the technology platform, and conduct more in-depth and effective rehabilitation measures research in combination with the latest neurophysiological science and technology.

## 1. Introduction

Autism spectrum disorder (ASD), also known as autism, often leads to serious social disorders in young children, and presents a certain degree of intellectual disability. The incidence rate has been increasing in recent years. In 1975, the incidence of autism in the world was about 1 /5000, and has risen to 1 /68 in 2014. Autism education and rehabilitation has become a major topic in the field of special education. There are many ways to correct autism. Most of the traditional psychotherapy is a concentrated behavioral rehabilitation training, such as game oriented therapy. The most popular “floor time” is psychological intervention through symbolic games, so as to improve children's emotional recognition and expression ability. However, this method has high requirements for teachers. All links should be guided. The intervention cost is very high and the effect is very limited. It is not feasible for most autistic patients. Therefore, there is an urgent need for new methods to treat autism in this field.<sup>[1]</sup>

In 1996, Strickland et al. Applied immersive virtual reality (IVR) technology to the correction of autistic students, creating this new research field. Compared with ordinary virtualreality (VR) technology, immersive virtual reality technology makes the scene more believable and the stimulation to students more natural and profound. It allows users to track all movements (position, direction, facial expression, etc.) in the virtual environment and realize real-time communication

and interaction with virtual objects. It can also adjust or specially “make” a certain environment to meet some special learning requirements, Allow students to learn from their mistakes without being affected by the real world. Therefore, immersive virtual reality technology has greatly enhanced the effect and application potential of behavior correction. It can be used as an educational tool to help autistic students overcome some problems that are very simple for ordinary people but very difficult for them.

## **2. Application of Immersive Virtual Reality Technology in the Rehabilitation of Autistic Children**

At present, immersive virtual reality technology is still in the preliminary stage in the field of education, especially in the field of special education, and has not been introduced into education and teaching on a large scale. However, because of its “immersion” and “interaction” characteristics, it can create a variety of realistic learning environments, especially simulate the things that are difficult to touch in real life, so it has a wide application prospect in autism rehabilitation training.

At present, the intervention training of virtual reality technology for autism mainly focuses on the following aspects:

### **2.1 Training of Life Skills**

Life skills are the necessary ability for autistic children to enter the society and live a normal life in the future. Autism is a developmental disorder that affects their social communication, communication, learning and adaptive behavior. The research of virtual reality technology in the field of life adaptation mainly focuses on daily life and traffic safety. Self et al. Used virtual reality technology to build a virtual environment of fire and tornado to teach autistic children safety skills. Josman et al. Carried out research on the teaching effect of safe crossing skills. The application of computer in the field of special education in China started late, and there is little research and application. Facing the increasingly prominent demand, it is very important to design and implement a training system.<sup>[2]</sup>

In view of the above problems, China has designed a public transport training system based on virtual reality. The innovations of the system are as follows: ① in combination with the necessity for autistic children to master the skills of taking the bus in China and the difficulties of the current skill training, a perfect and personalized virtual reality training system has been designed and implemented on the basis of the lack of a perfect virtual reality training system for this skill at home and abroad. ② In the process of design, the system combines the current international advanced Autism Training Method - critical response training (PRT), scientifically and reasonably designs the training process, and uses support vector machine (SVM) to intelligently realize the judgment and jump of the training process. ③ The system adopts somatosensory technology, and uses multiple sets of somatosensory solutions such as Kinect, leap motion and oculus touch to enable participants to interact with the virtual environment in the most natural way, greatly reducing the difficulty of training and effectively improving the fidelity of the simulated environment.<sup>[3]</sup>

This system is a virtual reality training system that simulates the bus environment for autistic children, including three training modules: skill points, overall skills and skill generalization. The skill point training module divides the process of taking the bus into four key parts, including waiting for the bus and queuing to get on, getting on the bus and buying tickets, finding a seat to sit down or grasping the handrail, sitting or standing well and getting off at the right station. Each part is designed as an independent training unit to form the training content. This module is the first one to receive training. Through the training of this module, you can master the key points in the

process of taking the bus step by step and have a basic understanding of the process of taking the bus. As the core module of the ride training system, the skill generalization module is a module for training the flexible use of ride basic skills. By analyzing the possible changes in the ride process, the classification change factors are extracted and applied to the virtual training scenarios to realize the simulation of the constantly changing ride environment in reality. Factors include bus shape color, bus route, departure and destination, number of people on board, number of people getting on and off the bus, etc. The module includes 6 training units, which correspond to the training unit with single change of each change factor and the training unit with change of all factors. After completing the training of this module, the system training ends.<sup>[4]</sup>

During the training, participants can gradually master the ability to take the bus from easy to difficult, from simple to complex. In order to further refine the step-by-step training process, the system also has three difficult training modes in the basic skill training module, namely, the simple training mode using voice and text prompts, the understanding training mode using voice prompts using words that need to be understood, and the common training mode without any prompts simulating the riding situation.

Due to the particularity of autistic children, there are differences in each individual. The traditional grouping control method for experimental design and data analysis is not feasible, and there are large deviations in data analysis. Therefore, it is more suitable to adopt the single subject experimental design which is the most common in autism research. The design divides the experimental process into five stages, including baseline period (a), dry expectation period (b), maintenance period (c), generalization period (d) and tracking period (E). Through visual analysis of the ability changes of the subjects in the five stages, the intervention effect is studied. The baseline period refers to the period in which the subjects are placed in the actual riding environment to test their riding ability before the system intervention, so as to master the situation before the intervention. The tests are generally conducted 2-3 times, with an interval of more than 2 days; Intervention expectation refers to the systematic intervention stage in which the subjects receive systematic training; Maintenance period refers to the test phase of skill maintenance status, which is generally carried out in the form of virtual environment test 2 weeks after the end of the intervention expectation, and the test times and intervals are similar to the baseline period; The generalization period refers to the stage of testing the ability trained in the virtual environment to the riding ability in the actual environment, which is carried out after the test effect in the maintenance period meets the expectation, and the test times and intervals are similar to the baseline period; The follow-up period refers to the period in which the actual riding ability of the subjects is tested again after the completion of the intervention training for a period of time (generally more than 2 months), so as to track whether the subjects really master the relevant abilities. This period is also generally 2-3 actual riding tests, with an interval of about 1 week.<sup>[5]</sup>

## 2.2 Training for Language Skills Deficiencies

Language retardation is common in autistic children, and different patients show different language defects. Many researchers have applied virtual reality technology to the language skills training of autistic children, and achieved remarkable results.

Hetzroni and tannous also used multimedia software to conduct intervention training on language communication skills for autistic children. In the experiment, the subjects carried out daily activities such as playing, eating, health and hygiene in the virtual environment with the classroom as the background, so as to carry out the intervention training of language skills. The experimental evaluation is to evaluate and analyze the subjects' language skills before and after the intervention through the multi baseline setting. The results show that from the baseline period to the expectation

period, the subjects' language function is improving, and they can transfer their acquired skills to the real classroom.

Compared with the traditional intervention training of language skills for autistic children, in the dual-mode virtual environment, patients learn faster and have better memory effect. It is worth noting that in the virtual reality intervention training, multi-mode feedback and stimulation also have different significance on the training effect. In the study, Hailpern et al. Used two feedback modes of vision and hearing to train the vocal autonomy and active expression ability of four autistic individuals. The experimental results show that different modes of virtual reality feedback have different effects on improving patients' active expression ability. Therefore, in the intervention training, patients with different language development characteristics need to be treated differently. Researchers should create a training feedback system to adapt to different language abilities.

### **2.3 Emotion Recognition and Self Emotion Expression Training**

Autistic children generally have the core defect of emotional understanding, which directly affects their normal social communication ability. Compared with traditional intervention training methods, the immersion and reality provided by virtual environment are more helpful to improve the emotional understanding ability of autistic children.

Emotional recognition and self emotional expression disorders affect the development of a series of abilities of autistic children, such as social interaction and communication. Most studies have proved that virtual reality technology can not only improve autistic children's emotional cognition of others, but also improve their self emotional expression, and the emotional expression trained by virtual reality technology is more conducive to generalization into real scenes. For example, Lorenzo used the immersive virtual reality technology to train and improve the emotional expression ability of autism. The research designed 10 virtual scenes according to the ability defects in the real life of autism, including going to a friend's birthday party, listening to a teacher's story in the classroom, seeing the annual physical examination, playing hide and seek with friends, etc. The design of these scenes takes into account the emotional expression of autistic children, such as happiness, sadness, fear and disappointment. The robot camera was used to record the participants' expressions. The results show that, compared with desktop virtual reality, immersive virtual environment has more appropriate emotional performance for autistic children. On the other hand, during the intervention training, the emotional behavior of autistic children in the immersive virtual scene training group in the real school environment has been improved. This shows that immersive virtual reality technology can enable autistic children to generalize the skills learned in the virtual environment to the real environment.

### **2.4 Social and Communication Skills Training**

The deficiency of social communication and social interaction is one of the core symptoms of autistic children. Virtual reality technology can improve the psychological theory ability of autistic patients. It is a very effective auxiliary technology in the social skill training of autistic individuals.

Charitos et al. Used virtual reality technology to make a "home" Scene software in the experiment. The experiment has two training modes: (1) autistic patients follow the virtual characters to carry out a series of basic daily activities training; (2) In the experiment, the subjects control and guide the activities of the virtual character through the input device. After training, the subjects' life skills were significantly improved, and the patients could apply the acquired skills to real life. Later, Josman and others created a virtual reality scene of "crossing the road" in the computer to train 12 autistic children in crossing the road skills. According to the comparison before and after the training, it shows that the subjects have acquired the skills of crossing the road after

the training, and the acquired skills are transferable. In another study, matsentidou et al. Also proved the effectiveness of immersive virtual reality technology in the intervention training of life skills of autistic children. Immersive road crossing demonstration, waiting for the green light and road crossing training.

### **3. Problems and Countermeasures of the Application of Immersive Virtual Reality Technology in the Rehabilitation Practice of Autistic Children in China**

It can be found from the relevant studies described above that the advantages of virtual reality technology in environment creation and instant feedback can not only effectively rehabilitate the physical and mental health of autistic children, but also help them learn knowledge and skills, better play their potential and integrate into the mainstream society with the goal of returning to the mainstream society.

Many researches on virtual reality technology in the intervention training of autistic children have proved the effectiveness of virtual reality technology in the intervention training of autistic children, but there are still some deficiencies. The article will put forward some problems in the autistic intervention training from the following aspects: (1) in the virtual reality intervention training, the virtual environment generally needs to be created by the computer, head mounted display, projection wall and other facilities, so the training location is fixed and inflexible. This results in the high cost of autism intervention training, and hinders the popularization of virtual reality intervention training. (2) many researchers only use a single input mode when designing training systems. This reduces the interaction between patients and virtual characters, patients and patients; At the same time, it reduces the interest of the training process and gives patients a bad sense of experience, which to some extent affects the effect of autism intervention training. (3) In most of the autism intervention training, researchers use the task-based virtual reality intervention training. However, compared with task-based intervention training, play training is more attractive to autistic children. In order to pursue success in the game, patients often ignore the changes of the environment, thus reducing their discomfort. (4) In many previous intervention training under virtual reality technology, autistic children mainly achieved the effect of skill training by interacting with virtual characters. On the one hand, it reduces the interaction between patients and the real world and weakens the transfer of patients' acquired skills; On the other hand, repeated procedural training has no obvious effect on the improvement of patients' flexible coping ability, and patients will even feel tired and bored in the face of repeated training.<sup>[6]</sup>

Combined with the actual needs of the development and education of autistic children in China, this paper believes that the application of virtual reality technology in autistic rehabilitation training in China can start from the following aspects.

#### **3.1 Application of Immersive Virtual Reality Technology in the Establishment of Virtual Classroom**

Integrating virtual reality technology into autism learning classes. For example, in terms of safety education, self and others developed a training course on fire and tornado safety education, and tested 8 autistic children aged 6 to 12. The project was successful. For the teaching content that cannot be demonstrated on the spot in the traditional teaching, considering the safety and other factors, virtual reality technology can be used to provide a realistic learning environment for children. In terms of adapting to the society, combined with the characteristics of imitation learning of autism, we can provide more opportunities for imitation learning for autism by designing the behavior of virtual peers, which can make them better acquire life skills. Virtual characters can provide more social communication methods for autism, including verbal and nonverbal

communication. Verbal communication can be realized through real-time text chat. Autistic children with weak language ability can also communicate through nonverbal information such as dynamic expression and gesture of virtual characters. In terms of recognizing the world and feeling the culture, autistic children can observe various underwater creatures in the virtual underwater world, interact with underwater creatures in combination with the interactive characteristics of virtual reality, roam among the planets in the virtual universe, feel the “real” planets, constellations and milky way, observe Mars closely, and even land on Mars for “field” investigation. Virtual reality technology can also present some long-lasting changes in a short time, such as the growth process of plants from seeds to trees. In addition, virtual reality technology can overcome the limitation of physical space distance and provide a space for social learning activities for teachers and students. Through the multi-user virtual platform, students can participate in real-time classroom interaction, feel as if they are really in the virtual environment, and can stimulate the learning interest of autistic children and improve their attention and participation. Therefore, a virtual reality classroom should be built to enable autistic children in different physical environments to enter the virtual scene for interaction, connect home and school, and establish a classroom where parents, teachers and autistic children interact together. Similarly, virtual learning classrooms for autistic children can be established nationwide or even globally. The realization of virtual classroom can enable autistic children from different countries to learn in the same classroom and have a sense of belonging to their own groups.

### **3.2 Organic Combination of Immersive Virtual Reality Technology and Medical Rehabilitation System**

Under the guidance of the idea of “combination of medicine and education”, autistic rehabilitation refers to the use of modern rehabilitation medicine to rehabilitate autistic children with speech, language, emotion and other dysfunction, and to rehabilitate autistic children with various means or compensate for their defects through the development of other potential, so as to maximize their potential. It is the first time to use virtual reality technology for pathological treatment and intervention of autistic children from the perspective of medical application. For autistic children, the principles of early detection, early intervention and early treatment should be adhered to. The early treatment of autism mostly carries out project-based rehabilitation training in hospitals, such as cognitive training, multi sensory training, motor skills training, etc. Some autistic children in regular classes also receive compensation training in hospitals while studying in schools. Doctors arrange rehabilitation training programs according to their clinical characteristics. Based on the research and analysis of the application of the existing virtual reality technology in the rehabilitation training of autism, it involves the language cognition, life skills, social interaction, emotional cognition and other aspects of autism. Therefore, the virtual reality rehabilitation system can be developed according to the rehabilitation project of autism, and the rehabilitation training module can be systematically developed from the aspects of cognition, social skills and life ability improvement by combining the virtual reality technology with rehabilitation means. The virtual reality technology is not only used in school curriculum teaching, but also used in hospital autism rehabilitation training.<sup>[7]</sup>

### **3.3 Close Combination of Immersive Virtual Reality Technology and Other Treatment Methods**

The combination of Internet technology and virtual reality technology enables users from different physical locations to interact in one scene, and even play games with users on the other side of the ocean. The combination with modern technology makes the application of virtual reality

technology have a broader prospect. For example, virtual reality technology can be combined with robot technology to create a living scene by using virtual reality technology to stimulate multiple senses such as sight, hearing and touch. The humanoid robot can be used as a rehabilitation assistant to complete repetitive teaching and demonstration actions, so that children can imitate and learn. In the practical application of virtual reality technology, it can be combined with social story method, picture interaction system, play therapy and other autism training methods. For example, Austin and others tried to combine virtual reality technology and hypnotherapy into virtualreality hypnosis (VRH) to treat two autistic adolescents. Their parents believed that this special treatment mode had therapeutic potential. The application of virtual reality technology does not mean the negation of other intervention technologies and the replacement of existing treatment methods, but enriches and expands the technologies and methods for autism. It is a new development direction of autism treatment to combine the existing technology and treatment methods with virtual reality technology.<sup>[8]</sup>

#### **4. Reflection on Application in Practice**

##### **4.1 Based on the Actual Situation in China, Immersive Virtual Reality Technology Shall Be Used Appropriately and Timely According to Specific Conditions**

With the development and penetration of technology, the application of modern technology in the intervention of autistic children has become an inevitable trend, but the ultimate goal of any intervention technology is to improve the skills of autistic children in social life. Therefore, when virtual reality enters the classroom, we must pay attention to that virtual reality technology cannot become a substitute tool for autism to interact with others, and the use of virtual reality technology cannot reduce or even stop the teaching activities of autism to interact with others.<sup>[9]</sup> Moreover, the education and treatment of autism is a complex process involving multiple links, factors and personnel, which requires teachers, parents and rehabilitation doctors to communicate and cooperate with each other when using virtual reality technology. In addition, as an auxiliary equipment for teaching, virtual reality also has entertainment function. On the one hand, it can reduce the pressure of teachers.<sup>[10]</sup> On the other hand, it should not pay too much attention to the entertainment function while ignoring the teaching.

##### **4.2 Provide More Scientific Treatment and Complete Evaluation System According to Individual and Social Needs**

In application, we should pay attention to the pertinence of software development, conform to the general law of children's cognitive development, and consider the needs of parents. Before developing the software, investigate the evaluation results and characteristics of autistic children, and refer to the reports of teachers and parents to understand the current target skills that need priority intervention. In addition, the developed software needs to conform to the general rules of cognitive development, such as from easy to difficult, following the characteristics that autistic children tend to pay attention to parts and ignore the whole, etc. In the future, when developing a virtual reality software system suitable for autistic children, we should work with autistic assessment experts to formulate corresponding treatment and assessment standards, scientifically identify the initial level of children, judge their physical and mental development changes in the training process, and assess their changes and improvement at the end of the training.<sup>[11]</sup>

### 4.3 Carry out Multi-Party Cooperation with Social Forces and Take the Localization of Technology as an Important Research Direction

Compared with foreign countries, the research on the application of virtual reality technology in autism rehabilitation in China mostly stays at the research level, and the actual application is not extensive. If the foreign virtual reality scenes are directly quoted, due to the differences in cultural background and language, the positive role in promoting the rehabilitation of autism in China may be very limited. Therefore, in order to truly benefit autistic children in China, virtual reality technology needs to be combined with the needs of autistic children in China and the actual situation of autistic rehabilitation education, such as combining with school-based curriculum of special education, integrating into rehabilitation projects, etc., which requires special educators to strengthen contacts with government departments, scientific and technical personnel, carry out interdisciplinary cooperation, and learn from relevant foreign research, Do more research on localization. On the one hand, it can enrich the course content and rehabilitation projects of autism. On the other hand, with the maturity of virtual scene development, it can also reduce the rehabilitation cost and achieve a broader rehabilitation.

Virtual reality intervention, with its advantages of low cost, high efficiency, universality and personal customization, will effectively make up for the shortcomings of traditional intervention and become a new hope for autistic children and adults. With the further upgrading and development of virtual reality technology, the application of VR, AR and MR will play a greater and broader role in intervention, fitness and entertainment.<sup>[12]</sup> In the future, virtual reality intervention is likely to pay more attention to the combination of physiological indicators and psychological indicators, and the causal connection between intervention effect and physiological mechanism. Artificial intelligence makes machines learn the ability of human like thinking and behavioral response, and even have a certain degree of induction and comprehensive ability. This not only shortens the diagnosis time of visual motor perception defect of autism, but also increases the accuracy of diagnosis. Therefore, the future virtual reality intervention is expected to develop in the direction of meeting the needs of personal customization and universality, so as to pay more attention to and be closer to the current life of special people. However, there is still a lack of tests for visual motor perception defects in autism, which still needs to be continuously developed and improved, supplemented by operational, normative and clinically effective intervention strategies.<sup>[13]</sup> At the same time, special attention should be paid to the early identification of visual motor perception ability of autistic children, which will be a scientific problem that needs to be solved urgently in the recent research in this field.

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