

CHINESE POETIC REALM EMPOWERING ASD PRECURSOR DEFECT INTERVENTION: WEARABLE-FREE MULTIMODAL IDENTIFICATION AND PERSONALIZED ADAPTATION IN DIGITAL TWIN METAVERSE

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Abstract: Traditional identification of ASD precursor defects is accompanied by a sense of oppression due to the participation of medical staff, which easily induces fear in children, leads to distorted behavioral expression, and impairs the accuracy of identification. Adhering to the core logic of "no medical staff involvement + digital twin metaverse immersion + oppression-free experience + multimodal dynamic identification + personalized adaptation for each individual", this study takes the Chinese poetic realm as the spiritual core and constructs a metaverse role-playing scenario based on wearable-free somatosensory carriers and digital twin technology, abandoning medical staff participation throughout the process to eliminate children's fear and sense of oppression. Children engage in immersive role-playing in the metaverse space to achieve the dual goals of "intervening while learning and educating through entertainment". Through multi-dimensional data collection, four-dimensional information including motor behavior, voice, emotional response and knowledge acquisition of children during their experience in the poetic realm and role interaction is captured in real time, so as to accurately identify ASD precursor defects, real emotional states (fear, tension, relaxation, etc.) and learning effects. Based on the identification results, a "personalized adaptation for each individual" scheme is generated to dynamically adjust the artistic conception of scenarios, the difficulty of roles, interaction forms and feedback mechanisms. This study constructs an integrated system of "metaverse role-playing as identification, emotion as adaptation basis, poetic realm as intervention carrier, and experience as learning process", which solves the problems of distorted expression caused by oppression and lack of interest in traditional interventions, and provides a new intervention path with humanistic care, identification accuracy, learning value and personalized adaptation for ASD precursor defects.

Keywords: ASD precursor defects; Oppression-free intervention; Chinese poetic realm; Digital twin; Metaverse; Multimodal identification; Personalized adaptation for each individual; Education through entertainment

1 INTRODUCTION

1.1 Research Background

Children with ASD generally have a sense of fear of medical staff and medical intervention scenarios. Research shows that about 75% of children with ASD exhibit emotional reactions such as tension, resistance and crying when facing medical staff, which conceals their real abilities and defect manifestations [1]. In the traditional intervention mode, the identification process led by medical staff and the serious intervention environment will intensify the sense of oppression, causing children to produce defensive behaviors and resulting in deviations in identification results (the accuracy rate is reduced by 30%-40%) [2]. At the same time, the rigid intervention content cannot adapt to the individual differences in children's emotions and abilities, and lacks interesting and learning attributes, which is difficult to stimulate children's initiative to participate, further weakening the intervention effect.

The development of metaverse space empowered by digital twin technology, the soothing artistic conception contained in the Chinese poetic realm and wearable-free interactive technology provides a solution to the above pain points: the digital twin metaverse can construct a highly immersive role-playing scenario, allowing children to relax and show their real performance in the process of "learning through playing"; multi-dimensional data collection can capture ability defects, emotional states and learning effects synchronously; personalized adaptation can achieve the precise matching of "defects-emotion-poetic realm-learning" [3]. Suzhou Kuyue Network Technology Co., Ltd. (hereinafter referred to as "Kuyue Technology") provides core support for the implementation of such scenarios with its wearable-free somatosensory smart screen and digital twin technology, and its millimeter-level motion capture and low-latency interaction characteristics ensure the fluency of role-playing and the accuracy of data collection [4]. Kuyue Technology is a high-tech enterprise focusing on immersive interconnection and digital twin, with "sports and health" as its core, and devotes itself to the fields of wearable-free somatosensory interaction, digital twin and multimodal AI. It has a core R&D team composed of 8 doctors, its technical achievements have been evaluated as "leading domestically and advanced internationally" by the Chinese Academy of Sciences, and it has launched the NASDAQ IPO process. Abandoning the participation of medical staff, this study takes the Chinese poetic realm as the core and the digital twin metaverse as the carrier to design immersive role-playing tasks, and dynamically generates personalized adaptation schemes for each individual by identifying children's real defects, emotions and learning situations through multimodal

technology, which not only completely eliminates the negative impact of oppression on intervention, but also achieves the intervention goal of educating through entertainment.

1.2 Research Significance

1.2.1 Theoretical significance

This study constructs an intervention theoretical framework of "digital twin metaverse-Chinese poetic realm-oppression-free-multimodal identification-dynamic adaptation-education through entertainment", enriches the theories of emotional adaptation and learning integration in ASD precursor defect intervention; explores the integration path of digital twin technology, Chinese poetic realm culture, multimodal identification and personalized learning design, and provides a new perspective for the research on the three-dimensional adaptation of "emotion-ability-learning" in the intervention of special children.

1.2.2 Practical significance

The metaverse role-playing intervention without the participation of medical staff eliminates the sense of oppression and ensures the authenticity of identification results; the immersion and interest of digital twin scenarios enhance children's initiative to participate and realize "intervening while learning"; multi-dimensional data collection realizes the synchronous identification of defects, emotions and learning effects, improving the accuracy of intervention; the dynamic personalized adaptation for each individual conforms to the individual differences of children, enhances the acceptance and sustainability of intervention, and reduces the intervention threshold for families and institutions.

1.3 Research Objectives

Construct an oppression-free interactive intervention system of Chinese poetic realm in digital twin metaverse without medical staff involvement, and eliminate children's fear through role-playing scenarios;
 Develop a multimodal collaborative identification model of "defect-emotion-learning" to accurately identify ASD precursor defects, children's emotional states (fear, tension, relaxation, etc.) and knowledge acquisition effects;
 Realize the automatic generation and dynamic adjustment of the "personalized adaptation for each individual" scheme, and adapt to children's emotional and ability differences and learning rhythms synchronously;
 Verify the synergistic effect of the education-through-entertainment mode in the digital twin metaverse on the intervention of ASD precursor defects.

2 RESEARCH METHODS

2.1 Research Design

A quasi-experimental research design was adopted, with children with ASD aged 4-12 as the research objects and no medical staff involved throughout the process. Children completed immersive role-playing tasks (such as poetic realm poet and cultural messenger) in the Chinese poetic realm scenario of the digital twin metaverse. Multi-dimensional data on children's motor behavior, voice, emotional response and knowledge acquisition during role-playing were collected in real time to identify precursor defects, emotional states and learning effects synchronously. The system automatically generated and dynamically adjusted the personalized adaptation scheme for each individual. The intervention cycle was 12 weeks, and the core logic of "role-playing data collection-multimodal collaborative identification-personalized adaptation-real-time effect feedback" was adopted to verify the effectiveness and accuracy of the oppression-free and education-through-entertainment intervention.

2.2 Research Objects

2.2.1 Inclusion criteria

Diagnosed with ASD with a score of 30-42 in the Childhood Autism Rating Scale (CARS);
 Showing fear of medical staff or intervention scenarios (confirmed by parental report or preliminary observation);
 Aged 4-12, with basic motor execution, simple interaction and basic cognitive learning abilities;
 Parents provided informed consent and signed the Informed Consent Form for the Study, promising to cooperate with the 12-week role-playing intervention.

2.2.2 Exclusion criteria

Suffering from diseases such as severe physical disability and epilepsy that affect motor and emotional expression;
 Total loss of sensory functions (total blindness, total deafness), unable to participate in poetic realm interaction and role-playing;
 Participating in other similar intervention programs during the intervention period.

2.3 Core Tools and Content

2.3.1 Core carriers and technologies

Wearable-free somatosensory smart screen (55-100 inches): Adopting the core technology of Kuyue Technology, it realizes millimeter-level precise tracking of 342 key skeletal points of the human body through the Femto Bolt depth

camera, with a sampling rate of 16 million times per second and an overall process delay of ≤ 25 ms. It is equipped with Rockchip RK3588 (6 TOPS) and RDK X5 (10 TOPS) dual AI chips, realizing 16 TOPS edge computing power through heterogeneous collaboration, driving the UE5.4 engine to stably output 60FPS low-latency motion capture and real-time rendering, without additional auxiliary equipment and physical contact throughout the process [4].

Digital twin metaverse technology: Based on the digital twin scenario construction scheme of Kuyue Technology, it reproduces Chinese poetic realm scenarios (such as Tang poetry pastoral and Song poetry elegant gathering) at a 1:1 ratio. It has completed the 1:1 digital reproduction of 353 cultural landmarks such as the Xi'an City Wall and the Yamdrok Lake in Xizang, with a virtual-real gap of less than 3cm. It constructs an interactive and explorable immersive space, supports role customization (image, skills) and dynamic plot generation, and realizes the real-time mapping of "virtual scenario-real motion-learning feedback" [5].

2.3.2 Oppression-free Chinese poetic realm metaverse role-playing scenario library

Digging deep into the Chinese poetic realm culture and basic learning content (language, cognition, social interaction), 8 types of core role-playing scenarios are designed, highlighting immersion, interest and learning attributes, without directive oppression and serious atmosphere:

1. Little Farmer in Poetic Field Cultivation: Transforming into a little farmer, completing actions such as hoeing, sowing and watering in the poetic realm of "Weeding at noon, sweat dripping into the soil", and learning the names of crops and the general meaning of ancient poems synchronously, with the difficulty of actions and knowledge adjustable dynamically;

2. Little Poet in Poetic Language Communication: Talking with virtual poets, learning ancient poem recitation and emotional expression by following ancient poems aloud and responding to poetic questions with gestures, with the interaction rhythm and knowledge density adapted to children's response speed;

3. Little Explorer in Flower Sea Poetry Seeking: Exploring hidden ancient poems in the scenario of "Huang Si Niang's home is full of flowers by the path", controlling the moving speed and exploration range independently, and learning the names of flowers and ancient poem solitaire;

4. Little Painter in Emotional Poetic Painting: Creating virtual paintings according to the artistic conception of ancient poems such as "Bright moon shines among pine trees", expressing emotions freely, and learning color cognition and ancient poem understanding synchronously without right or wrong judgment;

5. Little Craftsman in Stone Bridge Cooperation: Building stone bridges together with virtual partners, with cooperation methods including synchronous actions or division of labor, and learning team cooperation rules and basic geometric cognition;

6. Little Wise Man in Poetic Riddle Challenge: Solving interesting riddles related to ancient poems and traditional culture, with the prompt frequency and difficulty adapted dynamically, and learning traditional cultural common sense and logical thinking;

7. Little Hermit in Natural Poetic Realm: Relaxing in the quiet poetic realm of mountains and flowing water to relieve tension, and learning the names of natural scenes and methods of relieving tension synchronously;

8. Little Messenger in Community Poetic Rhyme: Simulating a life-oriented community scenario, completing tasks such as making friends, mutual assistance and ancient poem sharing, with adjustable scenario interference intensity, and learning social etiquette and language expression.

2.3.3 Multimodal collaborative identification model of "defect-emotion-learning"

Integrating four types of data including motor behavior, voice, emotional response and learning effect to realize three-dimensional identification:

Defect identification dimension: Motor standardization, accuracy, attention duration, cooperation synchronization rate, cognitive response speed, etc.;

Emotion identification dimension: Motor stiffness (significantly increased when afraid), voice tremor frequency, task interruption times, state fluctuation (inferred indirectly through somatosensory capture), identifying four core emotions including fear, tension, relaxation and joy;

Learning effect identification dimension: Knowledge mastery accuracy (such as ancient poem recitation accuracy and common sense answering accuracy), skill application proficiency (such as the quality of cooperative action completion), learning transfer ability (such as applying learned ancient poems to interactive scenarios).

The model is constructed based on the multimodal data fusion algorithm of Kuyue Technology, which integrates multi-dimensional data such as vision, hearing and motion to realize the whole-process intelligent processing from motion identification to emotional feedback. The defect identification accuracy rate is $\geq 90\%$, the emotion identification accuracy rate is $\geq 85\%$, the learning effect identification accuracy rate is $\geq 80\%$, which can automatically distinguish "real defect manifestations" from "abnormal manifestations caused by fear" and capture learning rhythms and acceptance synchronously [6].

2.3.4 Personalized adaptation system for each individual

According to the multimodal identification results, a personalized adaptation scheme is automatically generated, with the core adaptation dimensions as follows:

Scenario and role adaptation: In case of fear/tension, priority is given to soothing scenarios and low-interaction roles such as Little Hermit in Natural Poetic Realm and Little Painter in Emotional Poetic Painting; in case of relaxation/joy and strong learning willingness, challenging scenarios and high-interaction roles such as Little Wise Man in Poetic Riddle Challenge and Little Messenger in Community Poetic Rhyme are matched;

Difficulty and learning adaptation: For children with weak ability foundation and slow learning progress, the

requirements for motor accuracy are reduced, the response time is extended, and the knowledge density is decreased; for children with improved ability and significant learning effects, the task complexity and knowledge depth are increased gradually;

Interaction adaptation: For children with social avoidance tendency, one-way guidance and asynchronous cooperation of virtual roles are adopted; for children with strong social willingness, real-time peer cooperation and interactive tasks are increased;

Feedback adaptation: For sensitive children, the intensity of voice prompts is reduced, and visual feedback (such as green checkmarks, flower blooming, role upgrading) and learning achievement visualization are increased; for encouraging children, verbal praise (such as "You are awesome" and "You remember the ancient poems well"), challenge rewards and learning achievement medals are increased.

2.4 Theoretical Basis

Emotional safety theory: The oppression-free metaverse role-playing scenario provides an emotionally safe environment for children, reduces defensive behaviors and ensures the authenticity of performance;

Digital twin immersion theory: The high immersion and interactivity of the metaverse space enhance children's participation and strengthen the effects of learning and intervention;

Multi-dimensional data fusion concept: Through the complementarity of multi-dimensional data such as motor behavior, voice, emotional response and learning effect, the precise collaborative identification of defects, emotions and learning is realized;

Personalized development and constructivist learning theory: The personalized adaptation for each individual conforms to the individual differences of children, follows the principle of "zone of proximal development", and allows children to construct knowledge actively through role-playing and interaction, realizing education through entertainment.

3 RESEARCH DESIGN AND IMPLEMENTATION

3.1 Pre-intervention Preparation

3.1.1 Personnel preparation

Parents: Read the Guide to Oppression-Free Intervention, understand the process of metaverse role-playing intervention, without professional training, only need to assist children in starting the somatosensory carrier, and do not intervene in children's role-playing and learning process throughout the process to avoid transmitting anxiety;

Children: Freely explore the basic functions of the metaverse scenario and role creation 1-2 days before the intervention without task pressure; ensure good physical condition without fatigue and violent emotional fluctuations on the intervention day.

3.1.2 Carrier and environment preparation

Carrier debugging: Start the somatosensory screen and digital twin metaverse system 10 minutes before the intervention, automatically complete skeletal point calibration (motion identification error $\leq 5\text{cm}$) and scenario loading. The system is adapted to low-intensity stimulation parameters (sound effect volume 40%, screen brightness 400cd/m^2 , flicker frequency $\leq 3\text{Hz}$) and low-knowledge-density learning content by default;

Environment arrangement: Reserve an activity space of $\geq 2\text{m} \times 2\text{m}$, clear obstacles and lay soft anti-skid mats; place green plants and cartoon decorations to create a warm atmosphere, with background noise ≤ 35 decibels and temperature $22\text{-}24^\circ\text{C}$ (a more comfortable temperature reduces tension), without medical-related signs and equipment.

3.1.3 System startup

Children create role images (such as hairstyle and clothing) independently and select the initial role-playing scenario. The system automatically starts the multimodal data collection module, with no medical staff involved and no mandatory learning requirements throughout the process. Children can switch scenarios, pause or continue role-playing freely.

3.2 Oppression-Free Metaverse Role-Playing Intervention Process (12 Weeks)

3.2.1 Basic adaptation stage (weeks 1-4): emotional breaking, scenario familiarization and learning enlightenment

Core objective: Help children adapt to metaverse interaction, poetic realm scenarios and role-playing forms, eliminate strangeness and tension, and collect basic defect, emotional data and initial learning level.

Role-playing content: Children independently select low-difficulty and high-autonomy scenarios such as Little Farmer in Poetic Field Cultivation, Little Hermit in Natural Poetic Realm and Little Painter in Emotional Poetic Painting, and freely explore interaction and basic learning content (such as simple ancient poem following and scene cognition);

Multi-dimensional collection: Focus on capturing emotional data (tension/relaxation degree), basic ability data (motor coordination, attention duration) and initial learning level (such as basic cognitive accuracy);

Dynamic adaptation: If tension/fear is detected (motor stiffness, frequent interruption), the system automatically switches to the scenario of Little Hermit in Natural Poetic Realm, plays soft ancient poem background music, and reduces the interaction frequency and learning task density; if the child is relaxed, more scenario and role options are opened gradually;

Data recording: The system automatically records the daily role-playing duration, scenario and role preferences,

emotional state distribution, basic ability indicators and initial learning data, and generates a weekly basic report.

3.2.2 Precise identification stage (weeks 5-8): collaborative identification of defect-emotion-learning and scheme optimization

Core objective: Complete the precise identification of ASD precursor defects, emotional states and learning rhythms through diversified role-playing scenarios, and generate and optimize the personalized adaptation scheme for each individual.

Role-playing content: The system recommends scenarios such as Little Poet in Poetic Language Communication, Little Wise Man in Poetic Riddle Challenge and Little Craftsman in Stone Bridge Cooperation, gradually increasing the task complexity and learning depth (such as ancient poem understanding and cooperation rule learning) to guide children to show multi-dimensional abilities and learning potential;

Multimodal identification: Integrate data from weeks 1 to 8 to accurately identify the defect levels (mild/moderate/severe) in 5 dimensions including attention, social cooperation and emotion identification, children's emotional response modes to different scenarios and roles, and learning characteristics such as learning acceptance and knowledge mastery speed;

Scheme generation and optimization: Generate the initial personalized adaptation scheme for each individual based on the identification results, specifying the core intervention scenarios, role types, difficulty gradients, learning content density, interaction forms and feedback mechanisms. Parents can view the scheme but cannot modify it manually; update the scheme weekly according to the role-playing data. For example, if a child shows persistent fear of a certain type of role, it will be replaced permanently; if a child has difficulty mastering a certain type of learning content, the density will be reduced; if the defect dimension is improved, the difficulty and learning depth of the corresponding scenario will be increased synchronously.

3.2.3 Personalized intervention and learning stage (weeks 9-12): adaptation optimization, ability improvement and knowledge consolidation

Core objective: Carry out targeted intervention and personalized learning based on the personalized adaptation scheme for each individual, consolidate ability improvement and knowledge mastery, and strengthen emotional adaptability and learning initiative.

Role-playing content: The system pushes personalized scenario and role combinations according to the scheme. For example, children with attention defects are mainly recommended Little Wise Man in Poetic Riddle Challenge (improving attention + learning common sense); children with social fear are recommended Little Poet in Poetic Language Communication with one-way guidance of virtual roles (establishing social confidence + learning ancient poem expression); children with slow learning rhythms are given reduced knowledge density and extended learning cycles;

Real-time adaptation: During role-playing, the system analyzes emotional, ability and learning data every 5 minutes. If fear is detected (such as voice tremor and motor stiffness), the scenario difficulty is reduced immediately, learning tasks are suspended, and relaxation feedback is increased; if the ability meets the standard, the child is in a happy mood and the learning effect is good, high-level roles and extended learning content are unlocked automatically;

Effect verification: Generate a weekly intervention and learning effect report, comparing the improvement range of defects, changes in emotional adaptability and knowledge mastery rate; complete the final evaluation in the 12th week and compare it with the baseline data to verify the dual effects of intervention and learning.

3.3 Data Management and Statistics

3.3.1 Automatic data collection and storage

Real-time collection: Motor, voice, emotional and learning data are automatically collected by the somatosensory carrier and metaverse system with a sampling frequency of $\geq 10\text{Hz}$ without manual recording;

Encrypted storage: Adopting the blockchain encrypted storage scheme of Kuyue Technology, data are filed in the cloud database according to the research object number with a storage period of ≥ 3 years to strictly protect privacy and learning data security [7].

3.3.2 Statistical methods

SPSS 26.0 statistical software was used to compare the scores of defect dimensions (attention, social cooperation, etc.), emotional state distribution (proportion of fear/tension/relaxation/joy) and learning effect indicators (knowledge mastery accuracy, skill application proficiency) before and after the intervention; analyze the adaptation satisfaction of the personalized adaptation scheme for each individual (through parental APP feedback) and the active participation frequency of children in role-playing; a p-value < 0.05 was considered statistically significant [8].

3.4 Safety and Emotional Assurance

3.4.1 Emotional safety assurance

Scenario fuse mechanism: If intense fear lasting for more than 10 minutes is detected (motor stiffness + crying voice), the system automatically pauses the intervention and learning tasks, switches to the scenario of Little Hermit in Natural Poetic Realm and prompts parents to comfort the child, and no tasks are pushed on the same day [9];

Autonomous control right: Children can pause or exit role-playing at any time through gestures or voice, and the system has no mandatory tasks and learning requirements, strengthening the sense of autonomy of "my role, my decision".

3.4.2 Physical and carrier safety

Motion safety: All motions in the role-playing scenarios are low-intensity without dangerous actions such as jumping and violent twisting. The system is built with the motion safety monitoring algorithm of Kuyue Technology, and abnormal motions are paused automatically [4];

Carrier safety: The somatosensory screen automatically detects the power supply and operation status, cuts off the power immediately in case of abnormality, supports offline mode, and network interruption does not affect role-playing, learning and data collection.

3.4.3 Learning load assurance

Learning duration control: The cumulative duration of learning tasks in a single role-playing is ≤ 15 minutes to avoid learning fatigue[10];

Difficulty gradient design: Learning content is promoted according to the "basic-advanced-extended" gradient, and consolidation links are set at each stage to ensure that children can "pick the fruit with a jump" and avoid learning frustration.

4 EXPECTED RESULTS AND DISCUSSION

4.1 Expected Results

After the intervention, the proportion of children's fear/tension is significantly reduced (from $\geq 60\%$ before the intervention to $\leq 20\%$), the proportion of relaxation/joy is increased to $\geq 70\%$, and the number of active role-playing initiated by children per week is ≥ 5 ;

The multimodal identification accuracy rate meets the standard (defect $\geq 90\%$, emotion $\geq 85\%$, learning $\geq 80\%$). The final evaluation shows that the scores of all dimensions of ASD precursor defects are significantly improved ($p < 0.05$), among which the attention duration is increased by $\geq 40\%$ and the willingness of social cooperation is increased by $\geq 35\%$;

Significant learning effects: The accuracy rate of children's mastery of basic ancient poems and traditional cultural common sense is $\geq 75\%$, and abilities such as language expression and cognitive understanding are improved synchronously, achieving the goal of "intervening while learning";

Parents' satisfaction with the personalized adaptation for each individual is ≥ 4.6 points (5-point scale), the recognition rate of the education-through-entertainment mode is $\geq 90\%$, and the acceptance and sustainability of intervention are significantly higher than those of the traditional mode.

4.2 Discussion

4.2.1 Core innovations

Digital twin metaverse empowerment: Constructing an immersive Chinese poetic realm space with Kuyue Technology's digital twin technology, realizing the trinity of "intervention-learning-entertainment" through role-playing, and breaking the single functional limitation of traditional intervention [5];

Chinese poetic realm cultural infiltration: Taking the excellent traditional Chinese culture as the core and integrating the poetic realm into intervention and learning scenarios, which not only creates a soothing atmosphere but also realizes cultural inheritance and knowledge acquisition;

Oppression-free design: Abandoning the participation of medical staff and the serious intervention environment completely, eliminating children's fear through metaverse role-playing and ensuring the authenticity of performance;

Three-dimensional collaborative identification: Identifying defects, emotions and learning effects synchronously, solving the double limitations of "only focusing on ability but ignoring emotion" and "only emphasizing intervention but neglecting learning" in traditional intervention [11];

Dynamic personalized adaptation for each individual: The adaptation scheme responds to the changes of children's emotions, abilities and learning rhythms in real time, realizing "adaptation changes with emotions, difficulty increases with abilities, and content deepens with learning progress", and breaking the limitation of rigid intervention.

4.2.2 Limitations and future prospects

This study may have the limitation that virtual scenarios cannot completely replace real social interaction and offline learning. In the future, a linkage mode of "metaverse online role-playing + offline real scenario practice" can be added; the multimodal identification method can be further optimized to improve the identification accuracy of weak emotional signals and learning effects; the breadth of Chinese poetic realm scenarios and learning content can be expanded to adapt to children with ASD of more age groups and ability levels; the intervention mode of real peer online cooperation in the digital twin metaverse can be explored to enhance the effect of social ability training [12].

5 CONCLUSION

The oppression-free interactive intervention system of Chinese poetic realm in the digital twin metaverse constructed in this study takes the role-playing scenario without medical staff involvement as the carrier, integrates the Chinese poetic realm culture and the concept of education through entertainment, realizes the collaborative identification of ASD precursor defects, emotional states and learning effects through multi-dimensional data collection, and dynamically generates a personalized adaptation scheme for each individual. Relying on Kuyue Technology's core technologies of

wearable-free somatosensory and digital twin, this system completely eliminates the problem of oppression in traditional interventions, allowing children to complete identification, intervention and learning synchronously in relaxed and autonomous role-playing, which not only ensures the authenticity of data and the accuracy of intervention, but also improves children's acceptance, sustainability and knowledge acquisition effects. This study provides an innovative path of "emotion-ability-learning" three-dimensional adaptation for the intervention of ASD precursor defects, and also provides a replicable practical scheme for the humanized, localized, intelligent and learning-oriented development of special children's intervention.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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