

Research on Healing Product Design for Autistic Children with Language Barriers Based on Audio-Visual Synesthesia

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Abstract: *Objective:* To design a healing tool compatible with multiple types of autistic language disorders, which can dynamically adjust according to feedback to match children's individual mental states. This design adopts Augmented Reality (AR) scanning technology to promote autistic children's language development and emotional expression through object recognition, virtual scenes and interactive games. Supported by early intervention methods for children, this healing product realizes language disorder rehabilitation via cognitive training, provides emotional monitoring and learning feedback, supports parental participation and parent-child collaboration, delivers personalized assistance, improves children's emotional expression and social competence, and extends intervention to daily life for autistic children with language disorders. *Methods:* Based on the audio-visual synesthesia theory, this study constructs a multi-modal intervention system integrating audio, vision and tactile senses. AR scanning and structured perception design are adopted. Through object cognition, emotional companionship and scene interaction, multi-scene linkage covering families and institutions is realized. Game interaction logic is used to make language disorder rehabilitation convenient and precise. *Results:* This study successfully develops an AR healing product based on audio-visual synesthesia and builds an interactive intervention system adapted to multiple scenarios and coordinated multi-sensory functions. Through the linkage of audio and vision plus tactile feedback, cognitive and emotional functions are embedded into interactive processes, realizing professional and scenario-based implementation of language rehabilitation for autistic children and achieving convenient, accurate therapeutic effects. *Conclusion:* This product serves as an innovative auxiliary healing tool for autistic children with language disorders. Featuring simple operation and multi-scenario applicability, it realizes convenient and accurate healing through professional interactive logic.

Keywords: Autistic children; Language barriers; Healing products; Audio-visual synesthesia; AR technology

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1. Introduction

Despite the advancement of science and society, the incidence of autism in China is rising year by year, and

language disorders caused by autism are also growing sharply. Statistics show that autistic children rank first among all childhood mental illness patients in China, and language disorder constitutes the core symptom of autism, with most children suffering from varying degrees of language retardation ^[1]. Surveys indicate that 90% of autistic children have language disorders and struggle to integrate into society. Autistic children have dual demands for spatial environments: sensory stimulation and a sense of security ^[2]. Domestic rehabilitation for autism is still in the experimental research stage with few breakthrough achievements, and the market is in urgent need of targeted rehabilitation products. Based on the idea of audio-visual synesthesia, this paper explores the design methods and key points of teaching aids for autistic children with language disorders, and completes the research and development of new healing products featuring audio-visual synesthesia.

2. Research on autistic children

2.1. Current situation of rehabilitation for autistic children's language disorders

The incidence of Autism Spectrum Disorder (ASD) in China keeps rising, accounting for nearly 1% of the national population, with about 10 million patients, including around 2 million children. Such patients require priority intervention and treatment ^[3]. One of the most prominent characteristics of autistic children is difficulty in verbal communication, manifested as delayed speech and rigid repetitive behaviors. Although autism cannot be cured, early intervention delivers better results, especially before the age of 3 when the brain boasts strong plasticity; intervention becomes far more difficult after this critical window ^[4]. The core of rehabilitation lies in communication, which is also the biggest clinical challenge. When children fail to learn language normally, auxiliary tools such as AR technology can be used to activate image symbols and voice templates, helping children complete tasks and take the initiative to socialize — a function unavailable in traditional rehabilitation training. Fundamentally, we need to build a “communication bridge” to form a cycle of “expression-feedback”, seize the critical period, and lay a solid foundation for children's long-term language competence ^[5].

2.2. Rehabilitation principles for language disorders caused by childhood autism

Autistic children differ greatly in sensory sensitivity, interests and severity of language disorders, while existing universal rehabilitation equipment often produces counterproductive effects. In the process of personality development and social adaptation, affected children tend to show negative resistance, self-denial, social isolation, over-reliance on elders or silent objects, and emotional instability ^[6]. Therefore, targeted dynamic perception and bionic products with customized sounds and adjustable interactive forms are required for children at different language stages, yet related research remains lacking at present.

Language disorder rehabilitation features a long cycle, and children are prone to resistance, making it difficult for parents to sustain intervention. Faced with a large group of patients, innovative teaching aids with low cost, high performance, and child-friendly designs are needed to guarantee long-term intervention.

Rehabilitation must follow scientific rules, reject superstition, and carry out multi-angle innovative practices with standardized procedures and sufficient theoretical basis. The overall goal of scientific research shall be the comprehensive rehabilitation of autistic children, requiring adherence to scientific principles ^[7].

3. Design factors and expected outcomes of audio-visual synesthesia healing tools for autistic children with language disorders

3.1. Key considerations in design

During the development of AR healing equipment, designers shall comprehensively analyze autistic children's cognitive characteristics beyond language disorders and carry out targeted design based on multi-sensory channels.

3.2. Design principles of healing tools

Safety, simplicity and interest.

Children may hurt themselves due to limited cognitive ability. When drawing and listening to music, they generate “resonance” by combining personal emotional experience and aesthetic perception with melody, rhythm and timbre ^[8]. The product shall adopt rounded shapes without sharp corners and green, shatter-resistant, sturdy materials for all joints. Operation logic shall match children's cognitive and intellectual levels for easy use. The exterior adopts high-saturation bright colors, optional sound effects and cartoon & bionic image designs.

3.3. Expected outcomes

Develop a healing teaching aid compatible with all types of autistic language disorders and adjustable based on feedback data. Adopt AR scanning technology to boost children's language development and emotional expression via object recognition, virtual scenes and interactive games. Integrate early intervention and cognitive training to realize low-cost, high-efficiency and easy rehabilitation. The product supports emotional monitoring, learning feedback, parental participation and parent-child collaboration, delivers personalized assistance and improves social competence, and embeds intervention into daily life.

4. Product design

4.1. Function overview

This Augmented Reality (AR) scanning intervention healing tool is specially developed for young children with Autism Spectrum Disorder (ASD) and autistic language disorders ^[9]. Its core function is to trigger dynamic explanations through object scanning and build virtual interactive scenes. Game-based scenario design is adopted to promote children's language development and emotional expression. Audio and video run simultaneously in scenes with relative independence; their emotions remain consistent, while styles and contexts are similar despite asynchronous rhythm and volume gaps ^[10]. Following the usability principle, the product integrates family interaction modules, emotional monitoring and instant feedback mechanisms to improve parent-child communication and relationships. Customized language assistance schemes and diverse interactive games can effectively improve children's language ability, emotional communication efficiency, as well as self-confidence and social skills.



Figure 1. Product effect display diagram.

4.2. Overview of basic module design

The product consists of two parts: a handheld terminal and a base station with a cartoon-style appearance.

- (1) Handheld terminal: Equipped with a front camera, a rear camera (to capture learning scenes and facial expressions during dialogue), structural sensors (to scan objects with cameras), shortcut buttons for scanning and voice narration, a display screen and loudspeaker, plus charging contacts.
- (2) Base station: Equipped with a base display screen (showing time and equipment status), a base auxiliary camera, a loudspeaker, and power contacts.

The complex intelligent AR scanning learning device is packaged into toy-style products suitable for children.

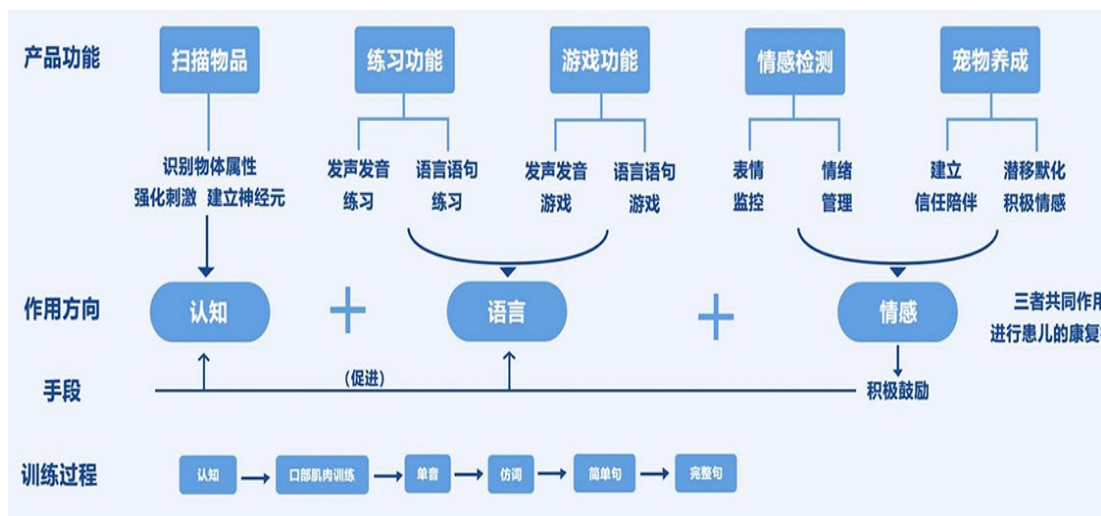


Figure 2. Function architecture diagram.

4.3. Function architecture

The product contains 5 major functions and 3 directional modules.

- (1) Object scanning: Identify object attributes and strengthen sensory stimulation to build neural connections, laying cognitive foundations for language and emotion rehabilitation.
- (2) Training & game functions: Specialized training strengthens oral muscle strength and basic language ability; games reduce learning boredom and provide progressive language training approaches.
- (3) Emotion detection & virtual pet cultivation: Real-time emotional monitoring and positive emotional guidance via virtual pets to accelerate cognitive and language training.

The three modules form a positive guidance cycle that precisely matches the rehabilitation demands of autistic children with language disorders.

产品服务流程



Figure 3. Product service flow chart.

4.4. Product service process

Build cross-scene connections covering families, communities, parks, educational institutions and medical facilities, transforming isolated single-point services into connected service chains to improve product continuity and scalability. Environmental psychology provides feasible design directions for autistic children's healing spaces. Cross-scene data sharing enables targeted treatment and visible rehabilitation outcomes for parents. The product realizes effective rehabilitation with minimal interference to daily life.

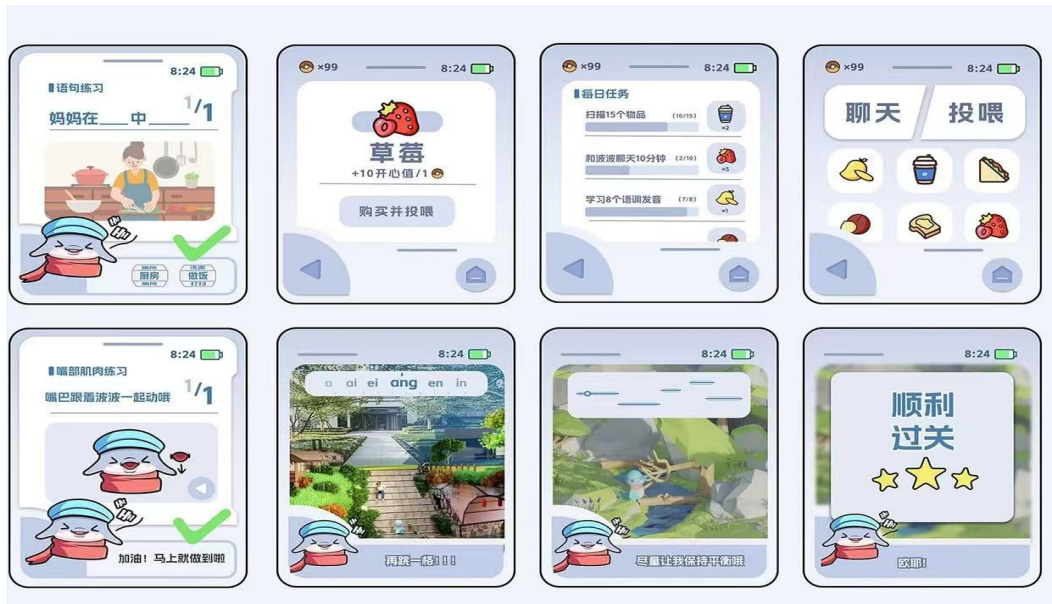


Figure 4. Interactive experience design diagram 1.



Figure 5. Interactive experience design 2.

4.5. Interactive experience design

Centered on virtual cartoon characters for emotional interaction, the product reduces children's resistance. Modular design creates immersive multi-scene learning environments. Real-object scanning stimulates children's curiosity, and game-based incentives encourage active learning. All interactive designs comply with children's cognitive development rules.



Figure 6. LOGO & IP design diagram.

4.6. LOGO and IP design

The design adopts anthropomorphic cartoon animal images, integrating product functions and emotional value. Sound wave elements in the LOGO strengthen brand memory recognition. The IP image can be applied to various physical toys and teaching aids to form consistent brand recognition across all dimensions.

5. Design considerations

(1) Safety Design & Child Protection Mechanisms

Safety is prioritized for scenarios where young children may bite or touch products. The whole machine adopts food-grade silica and antibacterial ABS plastic with fully polished rounded edges to avoid collision injuries; built-in buffer structures mitigate damage from drops. For information security: Camera, microphone and location functions can only be activated/deactivated by parents via dedicated management terminals; data is transmitted with encryption and supports one-click factory reset. High-precision content review and network firewalls block inappropriate content for children. Customizable usage duration prevents addiction, and all in-app payment notifications require parental confirmation to avoid accidental charges by kids.

(2) Functional Design

The product divides functions between handheld and base terminals for practicality: the handheld terminal completes interactive learning, while the base station serves as a supporting carrier. Featuring simple

operations, refined safe structures and sustainable application scenarios, the product delivers maximum rehabilitation effects at low cost for all families in need.

(3) Service Flow Design

The service system covers daily scenarios including families, parks, shopping malls, public transport, schools and rehabilitation hospitals. Data can be interconnected between institutions to adjust rehabilitation plans based on professional evaluation results. Exquisite service design improves product stickiness and facilitates language disorder rehabilitation integrated into daily life.

(4) Interactive Design Considerations

Multi-modal interaction is designed for young children. The system intelligently analyzes each user's learning habits, matches their cognitive levels, attracts children's attention, and strengthens learning effectiveness by linking daily objects with knowledge. A positive reward mechanism delivers emotional satisfaction after task completion, taking advantage of children's desire for recognition to sustain learning motivation.

(5) LOGO and IP Design Considerations

Unified brand images ensure consistent display effects in all scenarios. Diversified IP expressions (different postures, costumes) enrich brand images and support derivative product development, laying a solid foundation for long-term brand growth.

6. Conclusion

Autistic children generally suffer from language retardation, word comprehension barriers and weak social skills, which seriously affect their daily lives. At present, professional rehabilitation products for autistic children are scarce, expensive and complicated to operate, failing to meet market demands. This AR healing device is specially designed for children with language disorders, featuring simple operation and strong immersion. Equipped with triple cameras and image recognition technology, it generates audio and video auxiliary materials by scanning physical objects; cloud-based data storage supports personalized evaluation. All physical buttons prevent accidental operation for young children. Adopting game-oriented positive guidance and cartoon elements to arouse children's interest, the product forms a closed-loop rehabilitation system covering families and hospitals, eases parental burdens and fulfills social responsibilities.

The product still has deficiencies in image recognition and data feedback. Future research will integrate AI to optimize emotional intervention, develop parent-side visual management platforms, upgrade AR experience, and continuously improve healing effects through clinical verification.

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