

From "Attention Arousal" to "Sustained Attention": Reconstruction of Design Logic for Interactive Interfaces of Children with Autism

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ABSTRACT

Children with autism generally face difficulties in attention arousal and insufficient sustained attention, making effective human–computer interaction a critical challenge in digital intervention systems. Interactive interfaces have become an important carrier for educational and rehabilitation activities, but existing designs still suffer from poor stimulus adaptability and disconnected transitions between attention arousal and sustained attention. Based on attention theory and universal design theory, combined with the cognitive characteristics of children with autism, this study reconstructs the interface design logic from “attention arousal” to “sustained attention”. By analyzing existing design cases, identifying core problems, establishing design principles and phased strategies, and validating the proposed framework through prototype development and controlled experiments, the effectiveness of the reconstructed logic is confirmed. The proposed approach provides practical guidance for interactive interface design for children with autism while offering a systematic reference for intelligent human–computer interaction and multimodal sensing systems in digital rehabilitation scenarios, thereby supporting the development of adaptive assistive technologies for special-needs populations.

INDEX TERMS

Children with autism, interactive interface design, attention arousal, sustained attention, multimodal sensing

I. INTRODUCTION

A. RESEARCH BACKGROUND

1) Cognitive Characteristics and Attention Dilemmas of Children with Autism

AUTISM onset occurs in early childhood, with core symptoms including social communication disorders, language development disorders, narrow interests, and stereotyped behaviors. 75%-80% of children with autism are accompanied by varying degrees of intellectual disability [1]. In terms of attention, children with autism present typical dilemmas: on the one hand, they are difficult to be effectively aroused by external stimuli, respond indifferently to conventional stimuli, and immerse themselves in their own world; on the other hand, even if attention is aroused, it is difficult to maintain continuously, as they are easily distracted by the surrounding environment and cannot focus on a single task or activity [2]. This attention deficit seriously affects the effectiveness of their educational intervention and the development of daily living skills.

2) Core Value of Interactive Interfaces in the Intervention and Education of Children with Autism

With the popularization of digital technology and the maturation of human–computer interaction, handheld interactive interfaces (integrated with sensory-responsive textile accessories for haptic feedback) have become the core carrier for the education and rehabilitation of children with autism. These intelligent fabric-based interfaces leverage tactile feedback and soft-surface interaction to provide a more natural and effective environment for therapeutic intervention and information processing. Obtaining information and providing feedback through interactive dialogue between humans and computers is a very good educational method for children with autism who are not good at communication [3]. Its visualization and interactivity can avoid children with autism’s rejection of complex social scenarios, and achieve goals such as cognitive training and language learning through customized content. Studies have shown that adaptive interactive interfaces can significantly reduce attention arousal latency and improve the learning

participation of children with autism [4,5].

B. DESIGN BOTTLENECKS OF EXISTING INTERACTIVE INTERFACES FOR CHILDREN WITH AUTISM

Most current interactive interfaces for children with autism have obvious design flaws:

First, they excessively apply the design logic of general children's interfaces, failing to fully consider the sensory sensitivity and cognitive limitations of children with autism;

Second, they only focus on the attention arousal link, ignoring the transformation from arousal to sustained attention, leading to a high interaction interruption rate;

Third, they lack adaptation to individual differences, making it difficult to meet the needs of children of different severity levels and age groups. These problems seriously restrict the intervention effectiveness of the interfaces.

C. RESEARCH SIGNIFICANCE

1) Theoretical Significance

This paper focuses on the full-chain design of "attention arousal - sustained attention" by integrating sensory-responsive textile interfaces that align with the cognitive characteristics of children with autism, thereby filling the theoretical gap in attention-oriented design for special groups. By combining intelligent fabric feedback with interface logic, the research provides a new perspective on how functional textile materials can serve as critical interactive mediums in therapeutic design.

2) Practical Significance

By clarifying phased design strategies and verification standards, this paper forms implementable design schemes and evaluation systems, helping designers accurately grasp the interface needs of children with autism, improve the practicality of educational and rehabilitation interfaces, and provide strong support for the digital intervention of children with autism.

D. REVIEW OF DOMESTIC AND FOREIGN RESEARCH STATUS

1) Research on Attention Intervention for Children with Autism

Foreign research on autism is relatively mature compared to domestic research, and now mostly focuses on the combination of behavioral therapy and technology for attention intervention. Zheng *et al.* proposed a joint attention intervention system for children with autism [6]; Nie *et al.* introduced a "Computer-mediated Caregiver-Child Interaction (C3I)" system, which incorporates caregivers into the teaching process while retaining the advantages of human and computerized interventions [7].

China introduced and paid attention to the concept of "autism spectrum disorder" relatively late. At present, the use of robots for auxiliary intervention of children with autism is still in the research stage of practical design, focusing on the localized adaptation of intervention programs,

and most of them stay in traditional rehabilitation scenarios [8, 9], with insufficient integration with interactive design.

2) Research Progress on Interactive Interface Design for Special Children

Research on interactive interface design for special children has formed some consensus, such as emphasizing the principles of visual simplicity and operational consistency [10], but there are few special design studies targeting the attention characteristics of children with autism.

Existing research mostly focuses on the realization of a single function, lacking systematic design thinking on the "arousal-attention" transformation mechanism.

3) Deficiencies of Existing Research and Entry Points of This Study

In summary, existing research has three major deficiencies:

First, it separates the connection between attention arousal and sustained attention;

Second, it lacks precise adaptive design for individual differences of children with autism;

Third, the design effect lacks a standardized verification system.

Taking this as the entry point, this study reconstructs the full-chain design logic of "arousal-attention" and verifies its effectiveness through experiments.

E. RESEARCH CONTENT AND METHODS

1) Core Research Content

The core research content of this paper includes:

(1) Analysis of attention characteristics and interface needs of children with autism;

(2) Diagnosis of problems in existing interactive interface designs;

(3) Reconstruction of design logic from "arousal" to "attention";

(4) Prototype development and effect verification under the reconstructed logic.

2) Research Methods

A multi-method integrated research approach is adopted:

(1) Literature research method: systematically combining literature related to the cognitive characteristics of autism, attention theory, and interactive design;

(2) Case analysis method: selecting 20 mainstream interactive interfaces for children with autism for problem diagnosis;

(3) Experimental method: designing a controlled experiment to verify the effectiveness of the reconstructed design logic.

II. CORE CONCEPTS AND THEORETICAL BASIS

A. DEFINITION OF CORE CONCEPTS

Definition of Children with Autism and Interactive Interfaces Children with autism referred to in this paper are

children aged 3-12 who meet the DSM-5 diagnostic criteria, covering different severity levels and functional levels. Interactive interfaces for children with autism specifically refer to handheld digital interfaces (e.g., mobile apps, tablet applications) used for their education, rehabilitation, and entertainment [11], with core characteristics of adaptability, guidance, and safety. Wearable rehabilitation garments integrated with interactive sensors are discussed as a future extension rather than the current prototype.

Core Connotations of Attention Arousal and Sustained Attention Arousal refers to the process of shifting an individual's attention from a distracted state to a target task through external stimuli, with the core evaluation indicator being arousal duration; Sustained attention refers to the state in which an individual stably maintains attention on a target task, with core evaluation indicators including sustained attention duration and task completion rate. The two constitute the full chain of attention participation and need to form an effective connection through design to avoid disrupted attention continuity.

B. CORE THEORETICAL SUPPORT

1) Attention and Cognitive Development Related Theories

Arousal theory provides support for attention arousal design. This theory holds that individuals have an optimal arousal level; both exceeding and insufficient levels will affect attention performance, and the degree of arousal needs to be regulated through precise stimuli [12]. Cognitive load theory guides the design of sustained attention, emphasizing reducing cognitive load by controlling task complexity to maintain a focused state [13].

2) Interactive Design and Universal Design Theories

The accessibility principle and consistency principle in universal design theory provide the basis for basic interface design, requiring interfaces to support diverse user needs and reduce the cost of operation learning [14]. Self-determination theory, proposed by American psychologists Deci and Ryan, mainly focuses on the degree of voluntariness and self-determination of human behavior [15, 16]. This theory emphasizes promoting sustained participation by enhancing user autonomy and competence, providing theoretical support for the "arousal-attention" transformation design.

3) Adaptability between Theories and Interface Design for Children with Autism

Combined with the characteristics of sensory sensitivity and single cognition of children with autism, the above theories need to be adaptively adjusted:

(1) Arousal theory needs to focus on low-intensity and personalized stimulus design;

(2) Cognitive load theory needs to emphasize task decomposition and visualization;

(3) Universal design theory needs to strengthen sensory adaptation and operation simplification, forming a theoretical application system adapted to children with autism.

III. CURRENT STATUS AND PROBLEM DIAGNOSIS OF INTERACTIVE INTERFACE DESIGN FOR CHILDREN WITH AUTISM

A. SORTING AND CLASSIFICATION OF EXISTING DESIGN CASES

Through app store screening and literature retrieval, 20 mainstream interactive interfaces for children with autism are selected and classified into three categories according to their functions: educational, rehabilitation training, and entertainment. The specific characteristics are sorted out as follows (Table 1):

TABLE 1. Specific Characteristics of Children's Interactive Interfaces

Category	Quantity (Apps)	Core Functions	Typical Design Features
Educational	8	Language learning, cognitive enlightenment	Combination of pictures and texts, task-based challenges, voice prompts
Rehabilitation Training	7	Attention training, social skills development	Structured tasks, immediate feedback, progress recording
Entertainment	5	Sensory stimulation, casual interaction	Rich colors, dynamic effects, simple touch control

B. ANALYSIS OF CORE PROBLEMS IN CURRENT DESIGN STATUS

1) Attention Arousal Link: Insufficient Stimulus Adaptability

Entertainment interfaces generally have the problem of excessive stimulation, such as high-saturation colors and complex dynamic effects, which are likely to cause sensory discomfort in children with autism; Educational and rehabilitation interfaces have insufficient stimulation, adopting single text or static images, which are difficult to effectively arouse attention. Neither type of design regulates stimuli based on the sensory characteristics of children with autism.

2) Sustained Attention Link: Disconnected Design Logic

Most interfaces lack the design of task difficulty gradients; both overly difficult and overly simple initial tasks lead to interrupted attention; At the same time, the feedback mechanism is imperfect, with delayed feedback or single forms, which cannot strengthen the motivation for sustained participation. Some interfaces also have the problem of redundant functions; irrelevant buttons and ad pop-ups frequently distract attention.

3) Overall Design: Ignoring Individual Differences and Scene Adaptation

Existing interfaces mostly adopt a "one-size-fits-all" design, failing to provide customized options for different ages and severity levels of autism; Scene adaptation is insufficient, for example, failing to consider the different usage needs of families and rehabilitation institutions, and interface parameters cannot be flexibly adjusted.

C. ANALYSIS OF THE ROOT CAUSES OF PROBLEMS

1) Deviated Design Perspective: Focusing on General Design, Lack of Precise Adaptation

Most designers rely on the design experience of general children's interfaces, failing to conduct in-depth research on the cognitive and sensory characteristics of children with autism, equating "generalization" with "accessibility", and ignoring the personalized needs of special groups.

2) Insufficient Understanding of Attention Mechanism: Separating Arousal and Attention

In the design process, more attention is paid to the arousal or attention link alone, failing to recognize their progressive relationship, and lacking connection design from arousal to attention, leading to broken attention chains.

3) Lack of Evaluation System: Absence of Targeted Effect Verification Standards

Existing designs mostly rely on subjective experience judgment, failing to establish an evaluation index system based on the attention characteristics of children with autism, and cannot accurately measure the design effect of interfaces in the arousal and attention links.

IV. RECONSTRUCTION OF DESIGN LOGIC FROM "AROUSAL" TO "ATTENTION"

A. CORE GOALS AND PRINCIPLES OF RECONSTRUCTION

1) Core Goal: Achieving Effective Attention Arousal and Sustained Maintenance

The core design goals are divided into two levels: The primary goal is to shorten the attention arousal duration, ensuring that 80% of target users can be effectively aroused within 30 seconds; The advanced goal is to extend the sustained attention duration, increasing the attention duration by more than 50% compared with existing interfaces, while improving the task completion rate.

2) Design Principles (Adaptability Principle, Progressive Principle, Feedback Principle, etc.)

Combined with the characteristics of children with autism and theoretical requirements, four core design principles are clarified as follows (Table 2):

TABLE 2. Design Principles

Design Principle	Core Requirements	Implementation Points
Sensory Adaptation Principle	Matching the sensory threshold of children with autism	Low-saturation colors, soft sound effects, adjustable stimulus intensity
Progressive Principle	Constructing a stepped experience process	Gradient task difficulty, gradual function unlocking, progressive increase in attention load
Immediate Feedback Principle	Quickly strengthening participation motivation	Feedback within 1 second, visualized feedback forms, focusing on positive encouragement
Personalization Principle	Adapting to individual differences	Supporting interface parameter customization, multi-mode operation selection, personalized content recommendation

B. DESIGN LOGIC OF THE ATTENTION AROUSAL STAGE

1) Precise Adaptation of Stimulus Elements (Visual, Auditory, Tactile, etc.)

Visual stimuli mainly adopt individualized saturation adjustment based on pre-assessed sensory profiles: low-saturation warm colors as the default for hypersensitive children, and adjustable high-saturation options for hyposensitive children. Core elements are no less than 1cm in size to reduce irrelevant decorations; Auditory stimuli select soft pure music or natural sound effects; the default volume is set to 70% of the conventional volume, supporting custom adjustment; For tactile stimuli, gentle vibration feedback is designed for touchscreen interfaces, with adjustable intensity to accommodate both hyper- and hyposensitive tactile responses.

2) Personalized Design of Arousal Methods

Based on the characteristic of narrow interests of children with autism, a "interest customization" function is provided, allowing parents or teachers to input elements preferred by children (such as specific animals, graphics). To resolve conflicts between sensory adaptation and interest preferences, the interface integrates a pre-intervention sensory sensitivity assessment (measuring visual, auditory, and tactile thresholds) to adjust the sensory properties of preferred elements—e.g., desaturating a bright favorite character for hypersensitive children or enhancing contrast for hyposensitive ones; Three levels of arousal intensity ("high/medium/low") are provided to adapt to individual sensory differences, aligned with the assessment results.

3) Rapid Feedback Mechanism for Arousal Effects

When a child triggers an arousal operation (such as clicking a core element), feedback is given within 1 second. The feedback form combines multi-sensory design, such as slight enlargement of core elements visually, playing preferred sound effects auditorily, and gentle vibration tactilely, to strengthen the arousal effect and guide attention focus.

C. DESIGN LOGIC OF THE ATTENTION TRANSFORMATION AND SUSTAINED ATTENTION STAGE

1) Progressive Difficulty Gradient of Task Design

Tasks are designed with three gradients: "basic-advanced-challenging". Each level includes several sub-tasks, and the next sub-task can only be unlocked after completing the previous one. Cognitive load classifications are based on the NASA-TLX (Task Load Index) , a standardized cognitive load assessment tool, with "Low" corresponding to a NASA-TLX score of 0-30, "Medium" to 31-60, and "High" to 61-100. Taking the language learning interface as an example, the difficulty gradient design is as follows (Table 3):

TABLE 3. Task Gradient Design

Difficulty Level	Core Tasks	Cognitive Load (NASA-TLX Based)	Completion Standard
Basic	Recognizing voices corresponding to single graphics	Low (0–30)	Accuracy $\geq$ 80%
Advanced	Selecting corresponding graphics according to voices	Medium (31–60)	Accuracy $\geq$ 70%
Challenging	Naming graphics according to scenarios	High (61–100)	Accuracy $\geq$ 60%

2) Construction Strategy of Immersive Experience

An immersive experience is constructed by adopting "minimalist interface + scenario-based narrative": The interface only retains core task elements, hides irrelevant buttons, and disables pop-up ads; Tasks are connected through a continuous story line, such as "helping small animals go home", enabling children to clarify the task significance and improve participation; At the same time, the interface layout and operation logic are fixed to reduce cognitive load.

3) Dynamic Monitoring and Adjustment Mechanism for Focused States

The focused state is dynamically monitored through operational behavior data (such as click frequency, stay duration). When distracted attention is detected (such as no operation for 10 consecutive seconds), an automatic fine-tuning mechanism is triggered: Simplify the difficulty of the current task, play preferred sound effects, or display preferred elements to guide refocusing; If distraction persists, jump to a short arousal mini-game, and return to the core task after arousal.

D. INTEGRATION OF OVERALL DESIGN LOGIC AND CLOSED-LOOP CONSTRUCTION

1) Connection Logic Design of Arousal-Attention

A three-stage connection process of "arousal-transition-attention" is constructed: The arousal stage attracts attention through personalized stimuli; The transition stage designs

simple tasks (such as clicking targets) to gradually improve participation; The attention stage cuts into core tasks, maintaining attention through gradient design and feedback mechanisms, forming a seamless connection.

2) Design Adaptation Schemes for Multiple Scenarios

Adaptive modes are designed for two core scenarios: family and rehabilitation institutions: The family mode simplifies the operation process and adds a parent guidance module; The rehabilitation institution mode strengthens data recording and analysis functions, supports multi-user management, and facilitates teachers to track progress; At the same time, rapid scenario switching is supported to ensure consistent user experience in different environments.

3) Dynamic Response Mechanism for Individual Differences

A user profile database is established to record information such as children's age, severity of autism, interests and preferences, and sensory sensitivity thresholds; The interface automatically adjusts parameters such as stimulus intensity, task difficulty, and feedback form based on the profile; At the same time, manual fine-tuning is supported, allowing parents or teachers to optimize the design according to actual conditions.

V. DESIGN PRACTICE AND EFFECT VERIFICATION UNDER THE RECONSTRUCTED LOGIC

A. DESIGN PRACTICE: PROTOTYPE DEVELOPMENT PROCESS

1) Target User Positioning and Demand Refinement

The target users are positioned as children with mild to moderate autism aged 3-8. Through interviews with 10 parents of children with autism and 5 rehabilitation teachers, the core needs are clarified: quickly arousing attention, maintaining stable focus, simple operation, and supporting personalized adjustment.

2) Prototype Design (Interface Layout, Interactive Process, Stimulus Elements, etc.)

A language learning interface prototype is developed based on the reconstructed logic: the interface adopts low-saturation blue-green as the main color, and the size of core elements is 1.5cm; the interactive process follows the "arousal-transition-attention" logic: the arousal stage displays cartoon images preferred by children, the transition stage designs click interactions, and the attention stage cuts into vocabulary learning tasks; it supports the customization of parameters such as stimulus intensity and task difficulty.

3) Prototype Optimization and Iteration

5 target users are invited for preliminary testing, and feedback is collected for optimization: adjusting the saturation of some colors to adapt to sensory sensitivity; simplifying some operation steps; adding personalized options for feedback sound effects to form the final test prototype.

B. EFFECT VERIFICATION EXPERIMENT DESIGN

1) Experimental Objects and Grouping

20 children with mild to moderate autism aged 3-8 are selected and randomly divided into an experimental group (using the reconstructed logic prototype) and a control group (using a mainstream language learning interface) —"ABC Kids Language", a widely used app with design characteristics including high-saturation primary colors, fixed task difficulty without gradients, and text-heavy feedback). The control group interface lacks sensory adaptation adjustments and personalized interest integration, which are the key flaws targeted by the reconstructed design. Each group has 10 children, with no significant differences in age, gender, and severity of autism between the two groups. This study was approved by the Ethics Committee of Taiyuan University of Technology, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

2) Experimental Variables and Measurement Indicators (Arousal Speed, Sustained Attention Duration, etc.)

The design of experimental variables and measurement indicators is as follows (Table 4):

TABLE 4. Experimental Variables and Measurement Indicators

Variable Type	Specific Variables	Measurement Indicators	Measurement Methods
Independent Variable	Interface design logic (reconstructed logic / traditional logic)	-	Using different interfaces in groups
Dependent Variable	Attention arousal effect	Arousal duration	Recording the time from startup to focusing on the task
	Sustained attention effect	Average sustained attention duration, task completion rate	Video recording + interface data statistics
Control Variable	Task content, experimental environment, experimental duration	-	Uniformly setting tasks, environment, and duration (30 minutes/session)

3) Experimental Process and Data Collection Methods

The experiment lasts for 2 weeks, with each group participating in 3 experiments per week, 30 minutes each time; A dual-channel data collection method of "video recording + interface logging" is adopted: Video recording uses objective operational definitions for arousal, defined as the occurrence of at least two of the following three behaviors lasting ≥ 2 seconds:

- (1) Gaze fixation on the target interface element;
- (2) Voluntary physical interaction (e.g., tapping, swiping) with the interface;
- (3) Verbal response (e.g., repeating a prompt word) related to the task. The interface log automatically counts data such as arousal duration, sustained attention duration,

and task completion rate; After the experiment, parents and children are interviewed to collect subjective experience feedback.

C. EXPERIMENTAL RESULT ANALYSIS AND DISCUSSION

1) Data Processing and Result Presentation

SPSS processing of experimental data shows: The average arousal duration of the experimental group is 21.3 seconds, significantly lower than that of the control group (42.7 seconds); The average sustained attention duration of the experimental group is 8.5 minutes, an increase of 165.6% compared with the control group (3.2 minutes). This comparison is based on the control group's known flaws (fixed high-saturation stimuli, lack of difficulty gradients, and impersonalized feedback), which are directly addressed by the reconstructed design logic; The task completion rate of the experimental group is 78.3%, higher than that of the control group (45.2%). Subjective feedback shows that 80% of children in the experimental group are more interested in the interface, and both parents and teachers recognize its arousal and attention effects.

2) Effectiveness Verification of the Design Logic

Experimental results indicate: The interface under the reconstructed logic effectively shortens the arousal duration through sensory adaptation and personalized design; It significantly improves the sustained attention duration and task completion rate through gradient tasks, immediate feedback, and dynamic adjustment mechanisms; The connection design of arousal-attention realizes the effective connection of the attention chain, verifying the scientificity and effectiveness of the reconstructed design logic.

3) Deficiencies in the Design and Improvement Directions

Two major deficiencies are found in the experiment:

First, the dynamic monitoring mechanism has insufficient adaptability to some children with severe autism, and the effect of attention guidance is limited;

Second, some children show decreased interest after long-term use. Future improvement directions: optimizing personalized adaptation parameters for children with severe autism; adding content update modules and interactive forms to improve long-term attractiveness.

VI. CONCLUSIONS AND PROSPECTS

A. MAIN RESEARCH CONCLUSIONS

1) Summary of Core Problems in Interactive Interface Design for Children with Autism

Existing interactive interfaces for children with autism have three core problems: insufficient stimulus adaptability in the attention arousal link, disconnected design logic in the sustained attention link, and overall design ignoring individual differences and scene adaptation. The root causes lie in deviated design perspectives, insufficient understanding of attention mechanisms, and lack of evaluation systems.

2) Core Points of the Design Logic from "Arousal" to "Attention"

The reconstructed design logic takes "effective arousal - sustained maintenance" as the core, following four principles: sensory adaptation, progressiveness, immediate feedback, and personalization; Through precise stimulus design utilizing tactile-responsive textile surfaces in the arousal stage, gradient tasks integrated with dynamic fabric feedback in the attention stage, and seamless connection design between both phases, effective guidance of the full attention chain is achieved. This methodology leverages the haptic properties of functional textiles to ensure a continuous and adaptive sensory experience that stabilizes and directs the user's focus.

3) Effectiveness Conclusion of Design Practice

The interface prototype developed based on the reconstructed logic is significantly superior to traditional interfaces in terms of arousal duration, sustained attention duration, and task completion rate, and has been subjectively recognized by users, verifying the practical value of the reconstructed logic and providing a reference for similar designs.

B. RESEARCH LIMITATIONS

This study has three limitations:

First, the experimental sample size is small (20 people), and it focuses on children with mild to moderate autism. The applicability of the results to children with severe autism (who account for a large proportion of those with intellectual disabilities mentioned in the introduction) needs further verification, leading to potential selection bias that limits the universal applicability claimed by the Universal Design Theory;

Second, the experimental cycle is short (2 weeks), and the long-term use effect and stability need follow-up research.

Third, the current prototype is limited to handheld interfaces, and the integration with wearable textiles requires additional technical development and validation.

C. FUTURE RESEARCH PROSPECTS

1) Design Optimization from the Perspective of Technology Integration (AI, VR, etc.)

In the future, AI technology can be combined with biometric textile sensors to realize the precise construction and dynamic update of user profiles, optimizing functional garment design based on real-time behavioral and physiological data. This integration ensures that intelligent textile systems adapt autonomously to individual user needs through continuous data-driven refinement; Integrating VR technology to construct immersive scenarios to further improve the effect of attention guidance; Exploring the adaptability of multi-modal interaction (such as voice, gestures) with children with autism.

2) Research on Design Adaptation for Larger Samples and Multiple Types of Children with Autism

Expand the experimental sample size to cover children with severe autism and comorbid intellectual disabilities, refine the design needs of different groups, and address the selection bias in the current study; Carry out cross-regional and cross-cultural research to explore the universality and localized adjustment schemes of the design logic.

3) Construction and Improvement of Cross-Scenario Design Systems

Expand the application scenarios of interfaces to cover multiple scenarios such as families, rehabilitation institutions, and schools, and construct a cross-scenario design system; Establish a design resource sharing platform, integrate high-quality design elements and schemes, and promote the standardization and industrialization of interactive design for children with autism.

AUTHOR CONTRIBUTIONS

Conceptualization – Bo Xia and Shouyao Liu; methodology – Bo Xia and Shouyao Liu; investigation – Bo Xia and Shouyao Liu; writing-original draft preparation – Bo Xia and Shouyao Liu. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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HUMAN RESEARCH SUBJECTS

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REFERENCES

- [1] M. Li, Y. Lin, T. Bao, Q. Zhao, Y. Wang, M. Li, et al., "Inclusive education of elementary students with autism spectrum disorders in Shanghai, China: From the teachers' perspective," *BioScience Trends*, vol. 16, no. 2, pp. 142-150, 2022, doi: 10.5582/bst.2022.01104.
- [2] Y. Li, S. Li, X. Lin, B. Sun, and Q. Song, "Promoting Health and Well-Being: Environment Design of Rehabilitation Centers for Autistic Children Under the Theory of Restorative Environment," *Buildings*, vol. 15, no. 21, pp. 3932, 2025, doi: 10.3390/buildings15213932.
- [3] K. Zhang, J. Chen, and Z. Yang, "Use of human-computer interactive games for the dynamic assessment of language skills of children with autism spectrum disorder," *British Journal of Educational Technology*, vol. 55, no. 5, pp. 2383-2402, 2024, doi: 10.1111/bjet.13438.
- [4] R. Canete, S. López, and M. E. Peralta, "KEYme: Multifunctional smart toy for children with autism spectrum disorder," *Sustainability*, vol. 13, no. 7, pp. 4010, 2021, doi: 10.3390/su13074010.
- [5] A. Duquette, F. Michaud, and H. Mercier, "Exploring the use of a mobile robot as an imitation agent with children with low-functioning autism," *Autonomous Robots*, vol. 24, no. 2, pp. 147-157, 2008, doi: 10.1007/s10514-007-9056-5.

- [6] Z. Zheng, H. Zhao, A. R. Swanson, A. S. Weitlauf, Z. E. Warren, and N. Sarkar, "Design, development, and evaluation of a noninvasive autonomous robot-mediated joint attention intervention system for young children with ASD," *IEEE Transactions on Human-Machine Systems*, vol. 48, no. 2, pp. 125-135, 2017, doi: 10.1109/THMS.2017.2776865.
- [7] G. Nie, A. Ullal, Z. Zheng, A. R. Swanson, A. S. Weitlauf, Z. E. Warren, et al., "An immersive computer-mediated caregiver-child interaction system for young children with autism spectrum disorder," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 29, pp. 884-893, 2021, doi: 10.1109/TNSRE.2021.3077480.
- [8] J. Lin, J. Li, Y. She, L. Lin, H. Wu, E. Zhang, et al., "Using a social robot for children with autism: A therapist-robot interactive model," *Computer Animation and Virtual Worlds*, vol. 33, no. 5, pp. e2109, 2022, doi: 10.1002/cav.2109.
- [9] S. S. Yun, J. S. Choi, S. K. Park, G. Y. Bong, and H. J. Yoo, "Social skills training for children with autism spectrum disorder using a robotic behavioral intervention system," *Autism Research*, vol. 10, no. 7, pp. 1306-1323, 2017, doi: 10.1002/aur.1778.
- [10] H. J. Cai and F. Q. Kong, "Interface Design of Rehabilitation Products for Special Children," *Art and Design (Theory)*, vol. 2, no. 12, pp. 125-126, 2011, doi: 10.16824/j.cnki.issn1008-2832.2011.12.033.
- [11] F. Ke, J. Moon, and Z. Sokolij, "Virtual reality-based social skills training for children with autism spectrum disorder," *Journal of Special Education Technology*, vol. 37, no. 1, pp. 49-62, 2022, doi: 10.1177/0162643420945603.
- [12] G. Zantinge, S. V. Rijn, L. Stockmann, and H. Swaab, "Physiological Arousal and Emotion Regulation Strategies in Young Children with Autism Spectrum Disorders," *Journal of Autism & Developmental Disorders*, 2017; 47(2):2648-2657, doi: 10.1007/s10803-017-3181-6.
- [13] L. L. Cheong, M. J. Y. Kee, and P. L. Chen, "How attentional resources of the same or across sensory modalities and task load affect cognitive performance? A multi-sensory integration study," *Journal of Cognitive Psychology*, vol. 35, no. 8, pp. 812-820, 2023, doi: 10.1080/20445911.2023.2249627.
- [14] Y. H. Zhao and Y. Zeng, "Discussion on Product Design to Promote Communication of Children with Autism," *Industrial Design*, vol. (04), pp. 61-62, 2020, doi: CNKI:SUN:GYSH.0.2020-04-038.
- [15] J. Zhang, J. B. Zhang, Y. Li, et al., "An Effective Path to Promote Work Motivation: From the Perspective of Self-Determination Theory," *Advances in Psychological Science*, vol. 18, no. 05, pp. 752-759, 2010, doi: CNKI:SUN:XLXD.0.2010-05-007.
- [16] X. Chen, "An Intervention Study on Enhancing Positive and Active Communication Behaviors of Children with Level 3 Autism Based on Self-Determination Theory," *Sichuan Normal University*, 2019, doi: 10.27347/d.cnki.gssdu.2019.000115.