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BOOK REVIEW

Toward an AI-Empowered Ecosystem in Special Education: A Commentary on *AI-Enhanced Adaptive Intervention for Individuals with Autism*

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1 Introduction: AI-Empowered Technologies Usher in a New Paradigm for Autism Intervention

AI-enhanced adaptive intervention for individuals with autism (hereafter referred to as *AI-empowered autism intervention*) represents a seminal work that advances the transformation of special education through technological innovation. Authored by a pioneering "AI + special education" research team led by Professor Jingying Chen of the National Engineering Research Center for Educational Big Data at the Faculty of Artificial Intelligence in Education at Central China Normal University (hereafter referred to as Professor Chen's team), this groundbreaking work introduces an intelligent educational intervention framework for individuals with autism.

The proposed methodology establishes a self-adjusting educational intervention process in which iterative cycles of intervention and assessment enable adaptive, personalized learning tailored to the individual needs of children with autism. By integrating AI, this approach—termed AI-enhanced adaptive intervention for autism individuals $(AI)^3$—significantly enhances intervention efficacy through continuous data-driven refinement.

Adhering to the innovative concept of AI for good, Professor Chen's team has focused on overcoming key technological challenges, including personalized representation, process intervention, and quantitative evaluation. The team independently developed the Star-Future intelligent learning system, which constructs a comprehensive technical system for screening–assessment–intervention through multimodal data perception and fusion, as well as agent-based technologies. This system forms a closed-loop adaptive educational intervention that has demonstrated significant advantages in improving core symptoms of individuals with autism, such as social interaction and cognition.

Within the strategic framework of China's dual initiatives on digital transformation in education and technology-assisted disability support, *AI-empowered autism intervention* provides actionable implementation pathways for individualized education program policy through theoretical and technological innovations coupled with paradigmatic case studies, effectively advancing educational equity and quality.

In talent cultivation, Professor Chen's team pioneered an innovative industry–academia–research–application collaborative model in special education. By establishing industry–academia joint research initiatives, project-driven pedagogy, and practice-oriented training, the team has achieved seamless alignment between industry needs and graduate education requirements.

The team's research outcomes have not only accelerated the modernization of special education—providing critical references for students and faculty in education, psychology, and special education to conduct autism-related studies—but also established a practical paradigm for cultivating researchers in "AI + special education" at universities and research institutes.

2 Traditional Challenges and AI-Driven Breakthrough Innovations

Children with autism exhibit marked individual variability, complex developmental trajectories, and multidimensional ability profiles. However, current educational intervention approaches suffer from insufficient

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intelligence integration and suboptimal efficacy, which are primarily manifested through the absence of personalized interventions and reliance on subjective, coarse-grained assessment methodologies. To address these critical limitations, three fundamental technological barriers must be overcome.

Cognitive modeling limitations: Conventional learner models fail to accurately characterize cognitive–psychological states and their dynamic evolution, severely constraining the precision of personalized interventions.

Adaptive intervention deficits: Rigid learning activity patterns and fixed intervention protocols lack the capacity for self-adjustment, resulting in poor alignment with individual needs.

Quantitative assessment gaps: The evaluation of intervention efficacy relies excessively on expert questionnaires and behavioral observations, resulting in highly subjective outcomes and insufficiently objective quantitative indicators.

To address these three critical technological challenges, $(AI)^3$ framework proposes three key innovative pathways.

Multidimensional cognitive–psychological modeling: Develop a multimodal information fusion method based on cognitive–psychological model guidance to understand the cognitive–psychological state of individuals with autism and accurately construct a personalized model.

Adaptive human–AI interaction: Establish an adaptive intervention mechanism based on a child's personalized model to achieve precise and intelligent intervention.

Dual-scale evaluation system: At the micro level, task assessment methods based on specific learning objectives and activities are established. At the macro level, comprehensive assessment indicators for social skills development and scene migration are designed to realize a multidimensional and accurate quantification of intervention effects.

The book not only theoretically elucidates the application prospects of AI-empowered technology in autism—effectively overcoming the limitations of conventional intervention approaches—but also provides an in-depth exploration of leveraging AI to achieve precise modeling, targeted intervention, and refined assessment for individuals with autism. This work establishes novel technological pathways for theoretical advancement in special education.

3 AI-Empowered Intelligent Special Education Intervention Implementation Framework

AI-empowered autism intervention systematically outlines AI-empowered personalized educational intervention methods for individuals with autism. Addressing fundamental scientific questions in educational intervention under human–AI interaction conditions, it practically demonstrates AI's key technological innovations and significant advantages in three areas: personalized representation modeling, intervention paradigm reconstruction, and dimensionality expansion in efficacy assessment.

3.1 | Personalized Representation Modeling: From Ambiguous Profiling to Precise Computational Characterization

Traditional learner models lack the capability to characterize cognitive–psychological states and their dynamic evolution, resulting in unreliable accuracy in capturing the individualized expressions of children with autism. Professor Chen's team innovatively proposes a multimodal cognitive–psychological modeling technique that collects individual's behavioral data—such as facial expression changes, movement frequency, and social interaction patterns—in real time through wearable devices and visual sensors while incorporating physiological monitoring tools to acquire indicators such as heart rate and electrodermal activity to quantify emotional fluctuations and stress levels.

The technique employs deep neural networks to achieve real-time fusion and feature extraction of multisource heterogeneous data, addressing the spatiotemporal alignment challenges of different modal data through adaptive weighting algorithms. A reinforcement learning-based dynamic modeling framework continuously optimizes cognitive maps, enabling the AI system to evolve with individual's development. By analyzing interaction data—such as response delays and selection preferences during human–AI interaction—it reveals in depth individual's cognitive preferences and behavioral patterns. Through fusion analysis of multidimensional data, the AI system constructs dynamic cognitive maps and generates a digital twin model for each child, accurately mapping their cognitive characteristics and individual developmental trajectories.

3.2 | Intervention Paradigm Reconstruction: From Standardized Protocols to Personalized Adaptation

Individuals with autism exhibit complex and diverse developmental trajectories, requiring multiple phases of social interaction learning across varied scenarios and involving intricate intervention processes. Uniform learning activity patterns and fixed intervention methods are often inadequate. Professor Chen's team

addresses the multidimensional characteristics of cognitive development in individuals with autism by introducing process-oriented interventions based on human–AI interactive games and proposes personalized intervention techniques powered by avatar technology, achieving a paradigm shift from "standardized protocols" to "personalized adaptation."

To realize personalized intervention, the approach first constructs a theoretical framework for learning activities based on child development theories. It then identifies core needs at different developmental stages and generates age- and ability-appropriate training content through multimodal behavioral analysis. This enables the development of intervention methods tailored to individualized child models, ultimately establishing an adaptive, intelligent intervention mechanism that synchronizes with child's neurodevelopmental trajectory. This "theoretical stratification–demand identification–dynamic optimization" intelligent intervention framework overcomes the homogeneity limitations of traditional methods, thereby achieving smart, individualized intervention.

3.3 | Dimensionality Expansion in Efficacy Assessment: From Unimodal to Multimodal Analytics

Assessment serves as a critical component for both screening and educational intervention in autistic children, ensuring the delivery of effective and individualized support. Unimodal sensory data are insufficient to comprehensively characterize subject features, making the study of autism-specific characteristics from a multimodal data fusion perspective a promising approach. Professor Chen's team details quantitative assessment methods for individuals with autism based on scales and computer games, and subsequently introduces a combined micro- and macro-level quantitative evaluation approach.

At the micro level, the method employs intelligent sensing and multimodal fusion to analyze autistic individuals' explicit behaviors and implicit state characteristics. By integrating task performance metrics—such as assessment activity scores and reaction times—the evaluation results for individuals with autism are derived. At the macro level, the assessment focuses on autistic individuals' overall abilities, particularly their core deficits and key competencies required for social integration. Methods such as questionnaire surveys evaluate their generalization abilities in novel scenarios. Ultimately, combining questionnaire scales with intelligent sensing methods enables the quantitative assessment of individuals with autism, constructing a quantitative model that integrates micro- and macro-level assessments.

4 From Theory to Practice: Implementation Validation of AI-Empowered Solutions

AI-empowered autism intervention systematically introduces the definition, characteristics, etiology, and diagnostic methods. It further emphasizes the application efficacy of AI-empowered technologies in screening, assessment, and intervention for individuals with autism, demonstrating the implementation validation of AI-empowered approaches. This work provides novel perspectives and methodologies for special education.

4.1 | Efficacy Analysis of AI-Empowered Technologies in Autism

The book details various applications of AI-empowered technologies in screening individuals with autism. These technologies significantly improve screening accuracy and efficiency through the comprehensive analysis of multimodal data. Electroencephalogram (EEG) and event-related potentials can identify the early neurophysiological characteristics of individuals with autism. Using multilayer perceptron neural networks to classify resting-state EEG features can effectively distinguish between autistic individuals and typically developing individuals. Regarding behavioral data, the book mentions that through multimodal behavioral monitoring in intelligent learning environments—including head poses, facial expressions, and speech emotion recognition—it is possible to comprehensively assess individuals' behavioral and emotional states. This approach not only identifies behavioral patterns in individuals with autism but also dynamically provides support for early intervention.

4.2 | Application Analysis of AI-Empowered Technologies in Autism Interventions

The authors elaborate on how avatar technology facilitates cognitive transformation from facial expression recognition to social skill transfer through virtual animated scenario training, significantly enhancing both facial expression identification abilities and social engagement willingness in real-world interactions. Augmented reality (AR)-based vocabulary instruction overcomes the limitations of traditional teaching methods through dynamic visual presentation and multimodal stimulation, strengthening the correlation between word acquisition and attention maintenance. This hybrid virtual reality intervention model not only prevents digital addiction but also provides practical

and effective support for the social integration of individuals with autism through precise stimulation and transfer design. Furthermore, deep learning models analyzing individuals' video, audio, and physiological signals can identify early signs of autism, offering evidence for personalized interventions.

Professor Chen's team demonstrates the dual value of AI empowerment. On the one hand, it reduces social anxiety through virtual scenarios to achieve progressive virtual reality transfer; on the other hand, it optimizes cognitive processing pathways by leveraging the dynamic visual presentation mechanisms of AR. Although the irrelevance between speech imitation and cognitive performance highlights the need to focus on active comprehension development, the proposed personalized content customization and multimodal fusion provide crucial insights for optimizing future intervention strategies.

4.3 | Implementation of AI-Empowered Technologies for Autism Assessment

The book deeply integrates the neuroscience and educational technology as its breakthrough point, systematically constructing a quantitative system for assessing core competencies in individuals with autism. Through the multidimensional integration of eye tracking, EEG analysis, and human–AI interaction technologies, the book precisely reveals the dynamic correlation mechanisms in individuals with autism between visual attention, emotional processing, and cognitive tasks—from preferences for nonsocial information to the neural characteristics of insufficient brain region activation and from positive correlations between fixation duration and task performance to quantitative differences in emotional fluctuation intensity. AI-empowered technologies can comprehensively assess individuals' behavioral and emotional states through multimodal behavioral monitoring in intelligent learning environments, including head poses, facial expressions, and speech emotion recognition.

Professor Chen's team propose that social competency assessment based on human–AI interactive games achieves end-to-end coverage—from quantitative measurement of skill deficits to developmental progress tracking—through behavioral and physiological data. The emotion regulation mechanisms revealed by EEG analysis provide neuroscientific foundations for intervention strategy design. This closed-loop screening–assessment–intervention framework not only breaks down translational barriers between laboratory research and clinical application, but also pioneers ecological and precision-oriented future directions for autism education through innovative approaches, including emotion induction and cognitive flexibility training.

4.4 | Performance Evaluation of the Star-Future Intelligent Learning Platform's Assessment System

The book details the Star-Future intelligent learning platform, which integrates three core modules—comprehensive ability assessment, learning training, and information management—to form a distributed ecosystem with front–end interaction, middle-platform processing, and cloud collaboration that achieves a systematic transformation from fragmented tools to an ecological closed loop. The ability assessment system combines intelligent screening, multidimensional profiling, and matching algorithms to support dynamic evaluation; the learning training system incorporates visual tracking, physiological feedback, and immersive simulation to optimize interaction strategies; and the information management system establishes a heterogeneous data warehouse and collaborative decision-making platform for full-cycle tracking.

At the practical level, the book presents numerous educational AI-empowered cases for individuals with autism, demonstrating the technology's significant advantages in enhancing intervention outcomes. The Star-Future intelligent learning platform collaborates with disability organizations to integrate resources from kindergartens, special education institutions, medical facilities, and technology enterprises, building a nationwide service network that enables the large-scale application of AI in autism education. This approach validates intelligent intervention efficacy through real-world translation; innovates digital education theory and practice; and significantly improves equity and quality in special education.

5 Future Perspectives: Building an AI-Empowered New Ecosystem for Special Education

AI-empowered autism intervention is a work of significant theoretical and practical value. It not only provides novel methods for the educational intervention of individuals with autism but also demonstrates the immense potential of AI-empowered technologies in special education. For educators, psychologists, and parents of individuals with autism, this book serves as a valuable reference. It enables them to better understand the needs of individuals with autism while offering practical intervention strategies and technical support. With the continuous advancement of AI-empowered technologies, the concepts and methodologies advocated in

this book are poised to play an even greater role in the future of special education.

The book presents the research progress, latest achievements, and application cases of Professor Chen's team in autism studies through one methodology, one platform, and three technological breakthroughs, with a particular focus on the bottlenecks and technical solutions in AI-enhanced educational interventions for individuals with autism. This work establishes an $(AI)^3$-empowered framework for autism education development encompassing personalized representation, process intervention, and quantitative evaluation as follows.

Personalized representation dimension: Achieve precise construction of individualized child models.

Process intervention dimension: Develop an adaptive, intelligent intervention mechanism tailored to each child.

Quantitative evaluation dimension: Propose a multimodal data-fused assessment combining micro- and macro-level analyses.

The Star-Future intelligent learning platform represents the transition of AI-empowered technologies in special education from laboratory research to large-scale applications. Building upon rigorous academic research and practical case studies, the authors propose that AI-empowered technologies do not replace educators but rather liberate educational creativity through human–AI collaboration, establishing the groundbreaking $(AI)^3$-empowered framework. With advancements in multimodal sensing technologies and computational modeling, personalized child profiling will achieve greater precision and dynamism, enabling individualized instruction. Iterative upgrades to adaptive intelligent systems promise more natural and efficient interactive scenarios. Integrated with Big Data analytics and neuroscience progress, multimodal assessment systems will further enhance the visualization and scientific rigor of intervention outcomes.

Looking ahead, through industry–academia–research collaboration, intelligent learning platforms will expand application scenarios to serve broader special education populations while promoting policy standardization and ethically guided technology development, ultimately advancing educational equity and inclusive growth. The deep integration of AI and special education will not only deliver more precise and compassionate personalized support for autistic individuals but also contribute China's insights and practical paradigms to the global digital transformation of special education.

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