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The Dilemma and Strategies of Educational Intervention on the Plasticity of "Social Brain" in Children with Autism Spectrum Disorder

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Abstract

The core impairment in children with Autism Spectrum Disorder (ASD) lies in impaired social interaction abilities, rooted in dysfunctions of the "social brain" -key brain regions including the medial prefrontal cortex, superior temporal sulcus, and amygdala. Current research confirms the social brain's remarkable plasticity, providing a critical foundation for educational interventions. However, existing interventions for ASD children's social brain plasticity face practical challenges: misaligned intervention targets with brain functions, inadequate personalized adaptation, lack of multi-scenario coordination, and oversimplified outcome evaluation. There is an urgent need to develop systematic intervention strategies tailored to educational practices. This study clarifies the developmental patterns of social brain plasticity in ASD children and proposes a four-in-one intervention framework: refined functional-targeted training, personalized tiered design, multi-scenario coordination mechanisms, and multidimensional closed-loop assessment. Theoretical advancements strengthen the practical logic chain from social brain plasticity to special education interventions, enriching applied research in special education. Practically, it provides actionable intervention solutions for teachers and parents, fostering coordinated development of ASD children's social skills and social brain functions.

Keywords

Autism Spectrum Disorder (ASD), social brain, neuroplasticity, educational intervention

1. Introduction

Autism Spectrum Disorder (ASD) is a prevalent neurodevelopmental disorder characterized by persistent deficits in social communication and restricted repetitive behavioral patterns. The symptoms manifest early and exhibit significant heterogeneity, severely impairing children's social adaptation and lifelong development. Neuroscientific research has established that the root cause of ASD's social impairments lies in the dysfunction of the "social brain" -the social cognitive neural network formed by core brain regions such as the medial prefrontal cortex and amygdala. This identification has pinpointed key biological targets for educational interventions.

The theory of neural plasticity provides a cornerstone for ASD intervention, demonstrating that neural circuits can dynamically reshape through environmental stimuli and experiential learning. Particularly during the critical 0-5 year developmental period when the social brain exhibits heightened sensitivity to social

interaction stimuli, early intervention can significantly enhance its functional development. Recent years have seen the emergence of diverse approaches including traditional behavioral interventions and technology-assisted therapies. While some solutions have been proven effective in approximating typical social brain function, practical implementation faces four major challenges: 1) Interventions often focus on generalized social behaviors, failing to address the specific functional reshaping needs of social brain regions; 2) Lack of personalized adaptation makes it difficult to accommodate individual differences among children with varying support levels; 3) Limited intervention scenarios and insufficient collaboration between families, schools, and communities result in fragmented social stimulation; 4) Effect evaluation overemphasizes behavioral performance while neglecting neurophysiological functional remodeling, creating an ineffective feedback loop. These issues hinder the transfer of intervention outcomes to real-world social contexts, highlighting the urgent need for a scientifically grounded and systematic intervention framework.

This study adopts an interdisciplinary perspective integrating neuroscience and special education, with a focus on the principles of social brain plasticity. It aims to address current intervention challenges by developing a four-pronged strategy encompassing functional targeting, individualized adaptation, scenario integration, and multi-dimensional assessment. Theoretically, it enhances the logical chain from social brain plasticity to special education interventions, while practically providing actionable solutions for special education practitioners and parents. This approach facilitates the coordinated improvement of social brain functions and social skills in children with ASD, laying a foundation for their social integration.

2. Definition of Core Concepts and Theoretical Foundations

2.1 Definition of Core Concepts

2.1.1 Autism Spectrum Disorder (ASD)

The core clinical features of Autism Spectrum Disorder were first systematically described by Leo Kanner in 1943, who summarized it as severe developmental delays in interpersonal communication abilities, accompanied by significant language impairments, compulsive insistence on maintaining identity, and symptoms that must manifest before 30 months of age (Kanner, 1943). The contemporary authoritative diagnostic criteria, DSM-5, defines ASD as a neurodevelopmental disorder that must meet five diagnostic criteria simultaneously: persistent deficits in social communication and interaction; restricted, repetitive patterns of behavior, interests, or activities; symptoms that must emerge during early development; symptoms that cause clinically significant functional impairment; and these symptoms cannot be better explained by intellectual disability or pervasive developmental delay. Based on the severity of social communication impairments and the extent of restricted repetitive behaviors, DSM-5 further categorizes ASD into three support levels: Level 1 patients exhibit social communication deficits leading to significant functional impairment but may have partial compensatory abilities, with repetitive behaviors causing difficulties in social or occupational areas only in specific contexts; Level 2 patients demonstrate marked deficits in social communication, with frequent repetitive behaviors that are easily noticed by observers and interfere with normal functioning; Level 3 patients exhibit severe deficits in social communication skills, with extremely low verbal and nonverbal communication abilities, and repetitive behaviors severely impairing their functioning in various aspects (American Psychiatric Association, 2013). With advances in neuroscience, understanding of autism has deepened from behavioral observation to the level of brain mechanisms. Bauman and Kemper demonstrated that the brains of individuals with autism exhibit abnormal widespread distribution across multiple brain regions and neural circuits (Bauman and Kemper, 2005). These diffuse neuroanatomical findings support conceptualizing autism as a diffuse developmental disorder of the central nervous system, rather than a focal pathology.

2.1.2 “Social Brain”

The social brain hypothesis originated from the theory proposed by Blazes in 1990. Based on primate research, it posits that the human brain contains an evolutionarily conserved neural network composed of regions such as the amygdala, orbitofrontal cortex, and frontal cortex, specifically responsible for social cognition. This network is termed the “social brain.” (Brothers, 1990). Its core functions include adapting to complex social environments, attributing psychological states of oneself and others, and encompassing mental

interpretation, empathetic responses, and social norm processing. Studies indicate that the lateral geniculate nucleus and dorsomedial prefrontal cortex form a neural circuit regulating social competition (Shi et al., 2024, Fan et al., 2023), while the processing of social semantic information relies on networks formed by the anterior temporal lobe, temporoparietal junction, and precuneus (Shi et al., 2024). During development, the social brain becomes particularly active during adolescence, with significant development in the processing capacity of social information by regions such as the temporoparietal junction cortex and posterior superior temporal sulcus (Kreidell and Duell, 2023). Currently, social brain research has evolved from theoretical concepts into an interdisciplinary field with substantial empirical support. Its core framework has been continuously validated and expanded by evidence from neuroimaging, developmental psychology, and other fields, providing a solid theoretical foundation for understanding the biological basis of social cognition (Chen et al., 2008).

2.1.3 Educational Intervention

To avoid terminological confusion, the concept of "educational intervention" discussed in this paper is strictly defined within the core connotation of special education. In academic discourse on this field, scholars have defined this term from multiple perspectives. Calderwood proposed that intervention generally refers to conscious actions taken in challenging situations to produce positive outcomes. Specifically, educational intervention can be defined as measures implemented by school personnel to address students 'learning difficulties, aiming to help them progress in age-appropriate curricula (Calderwood, 2023). Lestrud further clarified the scope of intervention, emphasizing that educational intervention should provide students with the necessary support to acquire skills taught by the education system. It should encompass functional skills, academic abilities, cognitive abilities, behavioral skills, and social skills that directly impact children's educational capacity (Lestrud, 2021). Heward offered a more structured definition, highlighting that special education itself is a purposeful, systematic intervention process aimed at preventing, correcting, or compensating students' learning difficulties to promote their comprehensive participation in learning and life. Its core framework includes three fundamental types: preventive intervention, corrective intervention, and compensatory intervention (Heward, 2013). Integrating these perspectives, this paper defines the core connotation of "educational intervention" as: in special education, it is a purposeful, planned educational action system based on assessment. Through systematic preventive, corrective, and compensatory pathways, this system aims to provide professional support across multiple skill domains for students with developmental disorders or learning difficulties, thereby facilitating their effective participation in learning and personal development.

2.2 Theoretical Basis

2.2.1 Theories of Neural Plasticity

The core concept of neural plasticity theory originates from Hebb's neural learning theory established in "The Organization of Behavior". This theory reveals that plasticity possesses dual cognitive and structural essence: the dynamic generation of concepts and thoughts is closely related to changes in synaptic connection strength. Its core mechanism is summarized as the "Hebb's Law", which states that when neuron A continuously participates in triggering the excitation of neuron B, the connection between them will be enhanced due to growth or metabolic changes, thereby enabling "co-activated neurons to unite as a relatively independent unit" (Hebb, 1949) . This principle is further elaborated at the cognitive level: the generation of a single concept depends on the activation of specific "cellular combinations", while a series of thoughts are achieved through the sequential activation of event chains stored in "sequential order" (Huang, 2015). Research published by Matsuzaki et al. in the journal Nature provides single-cell resolution evidence, clarifying the causal relationship between dendritic spine morphological changes and long-term potentiation effects, offering microscopic evidence for understanding the pathological mechanisms of synaptic plasticity abnormalities in neurodevelopmental disorders such as ASD (Matsuzaki et al., 2004). This fundamental mechanism also elucidates the development of the social brain at the mechanistic level: neuroscience research confirms that the social brain is not entirely determined by innate factors, as early social experiences and environmental interventions play a crucial role in reshaping the refinement of its neural circuits (Liu et al., 2013). Therefore, the neural plasticity theory provides a fundamental theoretical basis for educational interventions targeting the social brain functions of ASD.

2.2.2 Neuroeducational Theory

Neuroeducation, as an emerging interdisciplinary field, integrates research methodologies and theoretical frameworks from neuroscience, psychology, and pedagogy. Scholars like Fischer have identified three core characteristics: First, bidirectionality-using neuroscience to explain educational phenomena while guiding research through real-world educational challenges; second, contextual embeddedness-testing neuroscience findings in actual educational settings to avoid detached "brain myths"; third, developmental perspective-focusing on dynamic changes in brain plasticity throughout education (Battro et al., 2008) . This framework aligns perfectly with social brain education interventions. Its bidirectional nature directly supports practical applications: For example, functional neuroimaging techniques like fMRI and ERP precisely identify functional deficits in specific social brain regions of ASD children, converting these physiological data into evidence for targeted educational plans. By integrating technologies such as virtual reality, EEG feedback, and interpersonal interaction, interventions can achieve neuroscientifically guided functional reshaping, with their effectiveness continuously validating and refining hypotheses (Zhou, 2013). Neuroeducational theory not only provides an interdisciplinary methodological foundation for social brain interventions but also ensures scientific precision, contextual authenticity, and developmental appropriateness in practice.

2.2.3 Special Education Intervention Theory

The theory of special education intervention integrates neuroscience and psychological development theories, providing systematic theoretical support for promoting social cognitive development through behavioral interventions. First, the theory of neural plasticity establishes the physiological foundation for intervention, indicating that the brain can be shaped by environment and experience during critical developmental periods (0-5 years old), and the neural circuits corresponding to social cognition can be strengthened and reshaped through rich and appropriate social interactions. On this basis, the "use it or lose it" and functional compensation theories further clarify the necessity of early intervention-lacking social interaction may lead to atrophy of corresponding neural connections, while targeted training can activate residual or compensatory mechanisms to promote functional development even in cases of congenital defects. The interaction theory of genetics and environment establishes the practical direction of intervention, emphasizing that within the genetic framework, early environmental and experiential factors play a crucial role. Behavioral interventions systematically regulate environmental factors to holistically promote children's brain function development. These theories collectively form a complete logical framework from mechanisms, necessity to practical pathways, laying a solid foundation for subsequent intervention strategy design (Wang, 2000). Building on this, Zhou Nianli constructed the "Applied System Integration Intervention Model." This system adopts a system integration strategy, combining the efforts of educators, medical professionals, and parents. Through information sharing to avoid data silos and implementing multi-scenario integrated interventions, it synchronously collects qualitative and quantitative data in kindergarten, family, and medical settings, ensuring intervention consistency and ecological validity. This forms a complete intervention framework bridging neural mechanisms to educational practice (Zhou, 2013).

3. Current Status and Challenges of Social Brain Plasticity Education Intervention for Children with ASD

In recent years, the interdisciplinary integration of neuroscience and pedagogy has significantly advanced research on social brain plasticity interventions for children with autism spectrum disorder. These efforts have achieved substantial progress in both theoretical frameworks and practical implementation. Such explorations have not only uncovered the neural mechanisms underlying social brain development but also established crucial foundations for scientifically designed intervention strategies (Zhou, 2013). While a diversified system of educational interventions targeting ASD children's social brain plasticity has been developed, numerous structural challenges remain in their practical application.

3.1 Current Status of Intervention Practices

Current social brain plasticity interventions for ASD children are grounded in neural mechanisms, with behavioral training as the core and a trend toward multi-dimensional collaboration, primarily encompassing

four intervention pathways:

The first category is traditional interventions, which focus on critical periods of social brain development and primarily employ behavioral interventions. This model remains the most widely used foundational approach in current practice. Early behavioral interventions, serving as golden-period interventions, initiate intensive training and family support immediately after ASD diagnosis. Through structured teaching methods, these programs enhance children's core abilities such as emotional recognition and social interaction. Neuroscience evidence supports their effectiveness-research by Dawson et al. confirms that such interventions can drive ASD children's brain activity toward typical developmental levels (Dawson et al., 2012). On the other hand, family-participatory interventions extend therapeutic scenarios into daily life through parent training and family activity guidance, significantly improving intervention continuity. However, outcomes remain constrained by external factors like parents' educational levels and family economic conditions (Zhou, 2013). Additionally, specialized social skills training-utilizing games, role-playing, and scenario simulations-helps children understand social rules and practice interaction techniques, becoming a core component of school and institutional interventions.

The convergence of technology and special education has positioned technology-assisted interventions as a key focus. VR technology creates immersive social environments, providing ASD children with secure practice spaces. Neurotechnologies like electroencephalography (EEG) offer physiological monitoring tools for evaluating intervention effectiveness (Zhou, 2013). For instance, fMRI studies have mapped brain activity patterns during social tasks to assess changes in social brain function (Dawson et al., 2012). While these interventions precisely address the social brain's need for "real-world social stimuli", challenges persist, including insufficient validation of efficacy, high implementation costs, and limited accessibility.

Multidisciplinary collaboration has become an inevitable trend to address complex intervention needs. Intervention teams composed of professionals such as educators, psychologists, and neuroscientists can provide comprehensive solutions for children with ASD, ranging from neurological assessments to behavioral interventions and family support (Wong et al., 2015). Studies have shown that such collaborative interventions can significantly enhance the stability of social skill improvements. However, practical implementation faces operational challenges, including high cross-disciplinary communication costs, uneven resource allocation, and difficulties in aligning intervention goals.

3.2 Core Dilemmas of Intervention

Despite the increasing diversification of intervention pathways, current practices have yet to adequately address the core contradiction between educational interventions and insufficient social brain function adaptation, which manifests in four major dilemmas and is directly correlated with the aforementioned intervention status quo:

First, interventions face a critical misalignment between their targets and the core functions of the social brain. Many approaches focus on generalized social behaviors rather than precisely targeting the social brain's core functions. Scholars like Vivanti note that traditional social skill training often emphasizes imitation and superficial etiquette, failing to reshape the social brain's functional architecture (Vivanti and Dissanayake, 2018). While early behavioral interventions have demonstrated neuroplasticity effects, some programs still neglect to address the "development of social brain functional zoning" as a targeted objective. This misalignment makes it difficult to transfer intervention effects from lab settings to real-world social contexts, ultimately hindering the sustainable improvement of social interaction capabilities.

The primary challenge in intervention design lies in inadequate personalized adaptation. While children with autism spectrum disorder exhibit significant individual variations in social brain function, current interventions predominantly employ a "one-size-fits-all" approach that fails to adequately address each child's unique needs (Vivanti and Dissanayake, 2018). For instance, research indicates that differences in ASD children's social brain function may lead to varied responses to the same intervention measures (Zhou, 2013). Consequently, the absence of tailored intervention designs not only diminishes effectiveness but may also leave some children without access to beneficial support.

A key challenge in intervention implementation is the lack of multi-scenario coordination. The development of the social brain requires sustained, authentic social stimulation environments, yet current interventions are

predominantly confined to single settings like schools or homes, lacking collaboration among families, schools, and communities. For instance, families and schools often have inconsistent goals and methods, resulting in fragmented stimuli for children with ASD across different settings, which ultimately hinders the development of social brain functions (Wong et al., 2015).

In terms of effectiveness evaluation, the issue of partiality is particularly prominent. Current assessments predominantly focus on behavioral performance, lacking comprehensive evaluation of social brain functions. For instance, many studies evaluate intervention effects solely through behavioral scales, while neglecting the neurophysiological changes in social brain functions (Dawson et al., 2012). This one-sided evaluation approach fails to accurately reflect the remodeling effects of interventions on social brain functions, resulting in difficulties in dynamically adjusting intervention strategies based on actual outcomes.

In summary, current educational interventions for ASD children's social brain plasticity have formed a diversified practice framework. However, the core challenges are concentrated in: the disconnect between intervention targets and social brain neural mechanisms, lack of personalized design adaptation, insufficient multi-scenario coordination in implementation, and one-sided evaluation. These intertwined challenges make it difficult to achieve a closed-loop effect from neural functional remodeling to behavioral capability enhancement and real-world scenario transfer. There is an urgent need to establish an intervention system that better aligns with the principles of social brain plasticity.

4. Principles for Constructing Strategies Based on Social Brain Plasticity

4.1 Principle of Functional Targeting

The effectiveness of educational interventions leveraging social brain plasticity is largely determined by the principle of functional targeting. This principle originates from the concept of functional specificity within neuroplasticity, which posits that distinct neural circuits are selectively tuned to and adapt in response to specific types of experience. This neural specialization is exemplified in the social brain-a distributed network comprising key regions such as the medial prefrontal cortex, superior temporal sulcus, and amygdala, whose functions are closely linked to social cognition, biological motion perception, and emotional processing, respectively (Adolphs, 2009). Neuroimaging studies have confirmed that difficulties in social information processing in children with ASD are frequently associated with atypical activation or inefficient connectivity within these very regions (Hahamy et al., 2015). Therefore, educational interventions must move beyond traditional behavioral correction and adhere to the principle of functional targeting. This entails: first, clearly defining the training objectives targeting the social brain system; second, designing activities tailored to these objectives; and finally, through meticulous design, establishing a direct "intervention–brain function–social behavior" linkage to precisely address the needs of functional remodeling in the social brain.

4.2 Principle of Personality Adaptation

The social brain does not follow a uniform developmental path. Its individual differences and critical period characteristics necessitate interventions that transcend standardized models (Kolb and Gibb, 2011), with the principle of personality adaptation serving as a practical response to this feature. Research reveals distinct resting-state brain network connectivity patterns in individuals with ASD (Hahamy et al., 2015), and the key value of early intervention lies in providing appropriate experiential input during neuroplastic developmental windows such as preschool years (Zhou, 2013), which maximizes neural circuit optimization. Therefore, educational practices should be grounded in precise assessment of individual neurodevelopmental stages and functional characteristics, implementing "developmental stage assessments" and "functional level evaluations". This involves combining scales and observations to identify strengths and weaknesses in social information processing, then designing intervention plans based on assessment stratification. Through the "assessment-individualized design-dynamic adjustment" cycle, interventions can align with individual neurological traits and developmental windows, thereby maximizing the potential of neural plasticity.

4.3 Principle of Scene Integration

The principle of scene integration is directly related to the experiential dependence of neural plasticity.

Specifically, the functional optimization of social brain neural networks requires continuous and diverse social experience input from various natural environments. Studies indicate that a single structured training environment can only establish preliminary neural connections, resulting in rigid representations that struggle to adapt to real-world complex social scenarios (Zhong et al., 2011). The adaptive development of brain functions fundamentally stems from sustained interaction with diverse environments. Therefore, generalizing acquired skills across school, family, and community settings essentially guides the brain to link specific neural circuits with broad contextual cues, forming abstract and flexible functional representations. Consequently, educators must serve as builders and coordinators of cross-scenario interventions. This involves designing classroom activities that integrate social brain training objectives, collaborating with multiple stakeholders to clarify intervention priorities and methods, establishing information synchronization mechanisms, and providing ASD children with coherent and progressively complex social experiences. These efforts enhance the functional connectivity and adaptive capacity of social brain neural networks in real-world contexts.

4.4 Principle of Multiple Evaluations

The principle of multi-dimensional evaluation originates from the multi-layered dynamic process characteristics of the social brain. The improvement of social cognitive functions is a continuous process ranging from micro-level neural remodeling to macro-level behavioral changes, where behavioral progress often lags behind adaptive changes at the neural level (Loth et al., 2017). Relying solely on single post-intervention behavioral assessments cannot accurately determine whether interventions trigger functional changes in target neural circuits, nor can it reveal underlying mechanisms. Although tools such as electroencephalography (EEG) and eye-tracking enable multi-dimensional monitoring, their applicability and operability in educational practice remain limited, necessitating the development of a more practical evaluation system. Based on this, the principle advocates an evaluation framework integrating “process indicators” and “outcome validity”. In process monitoring, teachers should systematically collect micro-level behavioral indicators reflecting neural functional efficiency. In outcome evaluation, emphasis should be placed on the application effects of skills in various contexts, promoting a precise closed-loop of “evaluation-intervention-re-evaluation” to avoid teaching adjustments relying on subjective experience.

5. Specific System of Educational Intervention Strategies

5.1 Intervention Strategies Targeting Core Functions of the Social Brain

5.1.1 Intervention Strategies for Emotional Recognition Function

Children with Autism Spectrum Disorder (ASD) exhibit significant difficulties in processing complex emotions. This study proposes a dual-modality approach combining emotional awareness training with paradoxical situation analysis. The first component involves synchronizing visual, auditory, kinesthetic, and proprioceptive cues of specific emotions during instruction. For example, when teaching “anger”, educators demonstrate angry facial expressions and body language while playing intense background music, guiding students to experience, describe, and imitate the emotion. This method strengthens neural connections between brain regions involved in emotional processing, fostering more integrated and stable emotional representations. The second component escalates the challenge through paradoxical situation analysis. Teachers create videos with mismatched facial expressions, tones, and contexts, prompting students to analyze real-life emotions and their causes. This exercise enhances the prefrontal cortex’s top-down regulation of emotional information, improving both the depth and flexibility of emotional understanding.

5.1.2 Intervention Strategies for the Intention Interpretation Function

Children with Autism Spectrum Disorder (ASD) exhibit neurodevelopmental deficits in the medial prefrontal cortex and temporoparietal junction, often manifesting as difficulty in perspective-taking. The core of instructional interventions lies in transforming abstract implicit mental states into concrete, observable, and actionable teaching materials. On one hand, visual thinking tools can be employed by pausing at pivotal moments during story reading or video viewing, guiding students to fill in characters ‘mental activities, thereby reducing reasoning complexity and training attribution thinking. On the other hand, collaborative tasks with

information gaps can be designed, where paired students hold partially overlapping information and must integrate it through questioning and reasoning to complete tasks. During this process, children continuously infer their peers' cognitive states and adjust communication strategies based on feedback. Through real social feedback interactions, this approach naturally and powerfully drives the activation and functional optimization of brain networks related to theory of mind.

5.1.3 Intervention on the Social Clue Capture Function

Children with Autism Spectrum Disorder (ASD) often exhibit reduced attention to social stimuli and excessive focus on non-social details, which correlates with abnormal processing of biological movements in the superior temporal gyrus and dysregulation of attention networks. This strategy proposes a dual approach combining technical assistance with daily joint attention training. The technical assistance utilizes interactive software to amplify easily overlooked social cues, such as identifying gaze targets in videos, highlighting key non-verbal signals in social videos, or slow-motion replays, to guide students in reassigning attention. The joint attention training integrates into routine teaching practices and teacher-student interactions, such as educators using guiding language with finger gestures to establish shared attention focal points, or requiring "observing peers' readiness before speaking" during group activities. Through frequent, low-intensity natural practice, this method repeatedly activates the superior temporal gyrus-frontal lobe neural network, promoting functional automation and laying the foundation for more complex social interactions.

5.2 Stratified Intervention Strategies for Personality Adaptation

5.2.1 Preliminary Assessment: Establishing the "Social Brain Function Assessment System"

In school education settings, comprehensive neuroimaging assessments are not feasible. Therefore, it is necessary to develop a teacher-centered, indirect yet effective functional assessment toolkit. This toolkit should integrate the following elements: First, use standardized behavioral screening tools such as the Social Response Scale-2 (SRS-2) to quickly identify students' core social impairments (Prizant et al., 2006). Second, systematically record children's micro-behaviors like social attention, initiating and responding to interactions through structured natural observation methods during daily scenarios such as breaks or group activities. Finally, employ carefully designed simple cognitive tasks to indirectly infer the efficiency of their social information processing pathways (Prizant et al., 2006). By comprehensively analyzing these three types of data, teachers can move beyond single behavioral descriptions to form hypothetical models of children's social brain function strengths and weaknesses, providing scientific basis for subsequent intervention stratification.

5.2.2 Stratified Intervention Protocol

Based on the above evaluation results, children can be preliminarily categorized into three intervention support tiers with continuity in social cognition and behavioral development levels. Centered around the core axis of social function development, each tier corresponds to differentiated intervention objectives, teaching priorities, and environmental support intensity. The foundational support tier targets children with difficulties in social information perception and weak social motivation. The intervention objective is to establish basic social participation willingness and response abilities through highly structured procedures, visual prompts, and individualized reinforcement. Simple interactions are designed based on special interests to reduce environmental complexity and establish primary positive associations in social behavior. The skill-building tier targets children with basic social perception and response abilities but difficulties in understanding social rules and flexibly applying social skills. The objective is to systematically construct social skills and promote their application in structured contexts through direct rule instruction, role-playing, and moderately structured peer collaboration. The social adaptation tier targets children who have mastered basic social skills but struggle with complex situation adaptation. The objective is to enhance the flexibility of social cognition and autonomous adaptation to complex situations through social support groups and "learning diaries" for self-management. Teachers' roles shift from direct instructors to behind-the-scenes counselors, coordinators, and facilitators. These three tiers form a dynamic, nonlinear continuum. Children are not fixed at any tier, and teachers must conduct periodic reassessments based on their progress to dynamically adjust support objectives and intensity, achieving personalized intervention adaptation.

5.3 Multi-Scenario Integrated Intervention Model

5.3.1 School Scenario

Schools serve not only as primary venues for implementing precision teaching strategies but also as crucial environments for fostering inclusive social ecosystems and enhancing skill development (Huang et al., 2013). Educators must evolve from traditional knowledge transmitters into cultural guides and facilitators of classroom social dynamics. Their responsibilities include two key aspects: First, embedding social brain intervention goals into curriculum activities-such as analyzing characters' emotional motivations and psychological conflicts in Chinese literature classes, emphasizing non-verbal cues in group experiments, and designing interactive elements for collective activities. Second, cultivating supportive social ecosystems through peer support programs and interest clubs, providing ASD children with low-stress, high-motivation social entry points to facilitate their integration into groups.

5.3.2 Family Settings

The core function of family settings lies in consolidating daily skills and providing an emotional safety base. With its intimacy, persistence, and emotional connection characteristics, it becomes a critical field for the acquisition and internalization of social skills. Scientific home-school collaboration serves as the core guarantee for maintaining and strengthening intervention effects. To achieve this goal, educators need to promote home-school collaboration through three aspects to enhance parents 'professional capabilities and implementation effectiveness as co-interveners, helping them become "informed and effective co-interveners": First, establish a structured parent training system to systematically explain principles of social brain plasticity, children's individual functional profiles, and the core logic of school interventions, enabling family intervention practices to be grounded in scientific understanding rather than empirical intuition. Second, provide parents with a series of goal-oriented interactive activities that can be integrated into daily routines, such as designing emotional expression sessions during family activities or practicing perspective expression and negotiation skills through collaborative problem-solving. Third, establish regular two-way communication channels to periodically exchange information about children's performance and developmental dynamics in different scenarios, jointly analyze challenges, and promptly adjust support strategies, thereby forming a sustained educational synergy.

5.3.3 Community Scenarios

Community settings serve as crucial platforms for fostering social functioning and positive identity development in children with autism spectrum disorder (ASD). The scope and authenticity of these environments determine the effectiveness of assessing ASD children's social adaptation abilities, while directly influencing their transition from passive recipients to active social participants. Key strategies at this level include resource coordination, situational role-playing, and community advocacy. Practically, educators should first assist families in planning and implementing structured community engagement activities through phased implementation. For specific community tasks like using public transportation or participating in cultural events, schools can conduct simulated role-playing exercises to break down tasks into manageable steps, practice social norms and coping strategies, thereby reducing uncertainty and anxiety in real-life scenarios. Secondly, schools should proactively collaborate with community institutions such as libraries and youth centers to provide staff with basic inclusive training and co-develop neurodiversity-friendly programs. By creating supportive community engagement opportunities, children can gradually apply acquired skills in safe environments, accumulate positive experiences, build confidence and competencies for social participation, and ultimately achieve long-term social integration goals.

The functional remodeling of social brain is highly dependent on the coherent and high-quality social experience in diversified real situations. Therefore, effective intervention must break through the physical and conceptual boundary of classroom and construct a comprehensive support network of "school-family-community" with coordinated objectives and shared responsibilities.

5.4 Epilogue

The social skill challenges in children with Autism Spectrum Disorder (ASD) stem from developmental

abnormalities in core "social brain" functions, with neuroplasticity theory providing crucial insights. This study, combining neuroscience and special education perspectives, systematically addresses key issues in current ASD education interventions: misaligned targets, insufficient personalization, lack of multi-scenario coordination, and one-dimensional assessments. It establishes an integrated intervention framework featuring "function-specific targeting, personalized adaptation, scenario integration, and multi-dimensional evaluation". By refining core social brain training, tailoring approaches to individual differences, coordinating home-school-community collaboration, and incorporating multidimensional assessments, the system creates a complete logical chain from neural mechanisms to intervention strategies, behavioral outcomes, and real-world transfer. This not only bridges the gap between traditional interventions and social brain function rehabilitation needs but also provides actionable practical solutions. Future research should deepen the integration of technology and interventions, explore cost-effective implementation pathways, and strengthen long-term follow-up studies to continuously improve the framework's adaptability. Only through combining scientific rigor with practical implementation can we fully unlock ASD children's developmental potential and lay a solid foundation for their lifelong social adaptation and integration.

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Conflicts of Interest

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