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Current Status, Progress, and Future Exploration of Autism Rehabilitation: A Review and Analysis of Multiple Intervention Approaches

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Abstract: *Autism is a group of neurodevelopmental disorders characterized by social communication difficulties, stereotyped behaviors, and restricted interests. This paper systematically reviews various intervention approaches in autism rehabilitation, including behavioral and developmental interventions, sensory and neuromodulation therapies, language and communication interventions, creative and art therapies, as well as dietary and health support. In addition to analyzing the characteristics and applications of each type of intervention, the paper also assesses their effectiveness and limitations, aiming to provide clinicians with targeted therapeutic options. While these methods have shown some efficacy in different studies, the outcomes of these therapies vary due to the heterogeneity and individual differences in autism. Moreover, the scientific evidence for certain interventions remains insufficient, and industry standards are still not fully established. The paper also explores the potential of emerging interventions, such as digital therapies, and proposes directions for future research.*

Keywords: *Autism, Behavioral Intervention, Sensory Modulation, Speech Therapy, Art Therapy, Dietary Intervention, Digital Therapy*

1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by deficits in social communication, language limitations, restricted interests, and stereotyped behaviors [1]. The etiology of autism remains incompletely understood and is believed to involve a range of factors, including genetic and environmental influences [2]. The prevalence of autism spectrum disorders (ASD) has been rising annually, posing significant challenges to society, families, and the healthcare system [3]. Although there is currently no cure for autism, numerous studies have shown that early intervention and multidisciplinary rehabilitation have been effective in improving the social, language, and behavioral skills of patients [4].

Recent studies have increasingly demonstrated that combining multiple interventions helps individualize treatment and meet the specific needs of different patients. However, challenges remain in the field, including the lack of strong scientific evidence for certain interventions and the absence of standardized industry guidelines [5]. As technology advances, emerging interventions such as digital therapies offer new possibilities for autism rehabilitation, though clinical validation remains in the early stages [6].

This paper aims to systematically evaluate the primary intervention methods for autism rehabilitation, including behavioral and developmental interventions, sensory and neuromodulation therapies, language and communication interventions, creative and art therapies, and dietary and health support. Additionally, this paper will discuss the effectiveness and limitations of these approaches, as well as explore the future prospects of emerging technologies such as digital therapies. By reviewing the current literature, this paper seeks to provide clinicians and rehabilitation therapists with a broader range of options to help optimize autism intervention strategies in clinical practice.

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2. Behavioural and Developmental Interventions

Behavioural and developmental interventions aim to help individuals with autism make progress in behaviour management, social communication, and cognitive skills through systematic and structured training. These interventions emphasize promoting overall developmental learning through incremental behavioural changes. However, despite the positive results demonstrated in many studies, some limitations exist, such as ethical controversies and potential negative effects of overly structured training models on certain children. Thus, understanding and exploring these limitations is crucial for clinical application.

2.1. Applied Behaviour Analysis (ABA)

Applied Behaviour Analysis (ABA) is one of the most widely used behavioural interventions for autism. Its core concept is to teach a series of skills, such as social, communication, and self-care skills, in a stepwise manner using positive reinforcement. The strengths of ABA lie in its systematic approach and evidence-based support, particularly in early intervention. However, ABA has also faced criticism for its overly structured approach. Some studies suggest that ABA may, in certain cases, overlook the individual differences and emotional needs of patients, leading to emotional resistance in children. Additionally, the high-intensity nature of the training can result in reduced treatment adherence or heightened anxiety [7, 8]. Regarding ethical concerns, the methodology of ABA sometimes places too much emphasis on "normalizing" patients' behaviour, potentially neglecting their autonomy and individual differences [7].

2.2. Pivotal Response Training (PRT)

Pivotal Response Training (PRT) is an important variation of ABA. Unlike traditional ABA, PRT focuses more on training core behaviours in naturalistic settings, particularly in areas such as motivation, response, and social interaction. The goal of PRT is to promote improvements in a wide range of skills in individuals with autism by enhancing these core behaviours. Its flexible training approach makes it easier to integrate into the patient's daily life and reduces the limitations imposed by over-structuring [9, 10]. However, although PRT has demonstrated advantages in personalizing interventions, its effectiveness remains dependent on the patient's motivation and the environment in which the intervention is conducted [9].

2.3. Relationship Development Intervention (RDI)

Relationship Development Intervention (RDI) is an approach that focuses on emotional understanding and social interaction. Compared to traditional behavioural interventions, RDI emphasizes helping patients enhance their self-regulation and their ability to adapt to environmental changes through interactive learning processes. This approach has gained attention for fostering patients' flexibility in dynamic environments, particularly their social adaptability in uncertain situations. However, the long-term effects of RDI are not well-researched, and its applicability to different individuals remains controversial [11].

2.4. Naturalistic Developmental Behavioural Interventions (NDBI)

Naturalistic Developmental Behavioural Interventions (NDBI) combine behavioural intervention techniques with developmental theory, aiming to promote learning and development in individuals with autism through interactions in naturalistic contexts. NDBI not only focuses on behavioural change but also on the enhancement of developmental skills, particularly in fostering social motivation and interaction abilities. The natural embedding of NDBI into everyday activities makes it a seamless approach suitable for use in both home and school environments. However, due to its flexibility, the level of intervention by therapists and parents plays a crucial role in determining the effectiveness of NDBI [12].

2.5. Play-based Interventions

Play-based interventions (such as PRT) are receiving increasing attention in autism treatment. These interventions use games as a training tool to make the intervention process more engaging and interactive, thereby enhancing patient participation and motivation. Play-based interventions are

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particularly well-suited for young children, as they effectively stimulate social motivation and promote communication skills through playful interactions [13]. While this approach shows great potential in clinical applications, its effectiveness in different age groups and symptom profiles needs further validation.

2.6. Section Summary

Behavioural and developmental interventions play a critical role in autism rehabilitation, but their limitations should not be overlooked. Current research and clinical practice suggest that more flexible and diverse approaches, such as PRT, RDI, and NDBI, can mitigate some of the shortcomings of traditional ABA, particularly in addressing individual differences and enhancing patient autonomy. Future research should further explore how to integrate these interventions more effectively and assess their long-term impact across various patient populations.

3. Sensory and Neuromodulation

Sensory and neuromodulation intervention approaches aim to help individuals with autism improve their adaptation to the environment, reduce sensory overload, and promote optimal brain functioning by modulating sensory input or neurological activity. Despite their widespread use in clinical practice, the efficacy and safety of these approaches remain controversial in the literature, particularly as some studies lack the support of randomized controlled trials (RCTs). Conducting in-depth analyses of the scientific evidence for these different approaches will provide clearer guidance for therapists and researchers.

3.1. Sensory Integration Therapy (SI)

Sensory Integration Therapy (SI) focuses on helping children with autism improve their ability to process and integrate multi-sensory information through a variety of motor and sensory activities. SI is based on the hypothesis that individuals with autism often exhibit sensory processing deficits, and that systematic sensory training can therefore improve their ability to adapt to their environment. However, the effectiveness of SI remains a topic of significant debate in the academic community. While there are case reports and small-scale studies suggesting positive effects in some patients, large-scale RCTs are scarce. Ashburner et al. reported that 90% of children with autism have sensory integration deficits, but the effectiveness of SI in addressing these deficits has shown mixed results across studies [14, 15].

Meta-analyses and systematic reviews on the efficacy of SI indicate that while sensory integration therapy may be effective in certain areas (e.g., improving behavioral problems, enhancing emotional regulation), the current level of evidence is limited due to large individual differences and limitations in study design. Future research should prioritize high-quality randomized controlled trials to validate the effectiveness and applicability of SI across different age groups and autism subtypes [14].

3.2. Neuromodulation Therapy

Neuromodulation therapy is an emerging intervention in autism research, which primarily includes Transcranial Magnetic Stimulation (TMS), Transcranial Direct Current Stimulation (tDCS), and focused ultrasound techniques. These methods non-invasively modulate neural activity in specific regions of the brain to improve cognitive, social, and emotional functioning.

However, the long-term safety and efficacy of neuromodulation therapies require further evaluation. While early studies suggest that TMS and tDCS may improve social communication skills and reduce stereotypic behaviors in individuals with autism [16, 17], most of these studies have been small-scale exploratory trials, lacking robust RCT support. Additionally, TMS and tDCS can carry potential side effects, such as headaches and a slight risk of seizures, especially with prolonged and repeated use. These risks must be carefully assessed prior to clinical application [18].

In terms of applicability, the effectiveness of techniques such as TMS may differ depending on the age and symptom profile of individuals with autism. Some studies suggest that TMS may be more effective in adults with autism, whereas its efficacy in children remains uncertain. Therefore, future research should focus on the application of these technologies across different patient groups, particularly in assessing their long-term effects in children with autism [19].

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3.3. Digital Therapy

With technological advancements, digital therapy has become an emerging tool in autism intervention. Specifically, digital therapies that incorporate neurofeedback technology can provide personalized feedback by monitoring patients' EEG activity in real time, helping improve attention, emotional regulation, and self-control [20]. The strengths of digital therapies lie in their high degree of personalization, ease of data collection, and the ability to continuously monitor patients' progress. However, their clinical application is still in its early stages and faces many challenges, including the high cost of equipment, issues with long-term patient compliance, and a lack of large-scale clinical validation [21].

3.4. Section Summary

Sensory and neuromodulation therapies offer diverse options for autism rehabilitation, but their scientific validity and safety still require support from more high-quality research. While sensory integration therapy may have some efficacy in individual cases, its effectiveness varies greatly depending on individual differences, and there is a lack of sufficient RCT data. Although neuromodulation therapies have shown potential in early studies, their side effects, long-term safety, and applicability need further exploration. With ongoing technological progress, digital therapies hold promise for providing more precise interventions for individuals with autism, though their clinical application still faces significant challenges. Future studies should focus on validating the efficacy of these interventions through rigorous clinical trials and exploring their long-term effects in different autism subgroups.

4. Language and Communication Interventions

Language and communication interventions aim to help individuals with autism improve their expressive language and communication skills. The diversity of approaches in this type of intervention reflects the complexity and individualised needs of individuals with autism who have language impairments. Due to significant differences in language development among individuals with autism, personalised intervention programmes are essential. Therefore, in addition to traditional speech therapy, augmentative and alternative communication (AAC) techniques and non-verbal communication strategies are included to address the unique needs of different patients. Furthermore, the use of digital technology in recent years has introduced new directions for language and communication interventions in autism rehabilitation.

4.1. Traditional Speech-Language Therapy (SLT)

Traditional Speech and Language Therapy (SLT) helps children with autism improve their communication skills by focusing on articulation and enhancing language expression. SLT has been widely demonstrated as an effective intervention for children with speech and language delays and is often combined with a personalised programme that is tailored to the patient's language abilities and communication needs. For example, for some non-verbal children with autism, SLT may focus on articulation training and the use of basic sentence structures [22]. However, the effectiveness of SLT varies depending on individual differences, and the improvement of language skills typically requires long-term therapy and family involvement [23].

4.2. Augmentative and Alternative Communication (AAC) and Picture Exchange Communication System (PECS)

Augmentative and Alternative Communication (AAC) technology is designed to help individuals with autism who are unable to communicate verbally by providing alternative methods of expression. AAC includes a range of symbols, pictures, words, and technological devices that facilitate communication. One commonly used AAC technique is the Picture Exchange Communication System (PECS), which is particularly suitable for individuals with severe language developmental delays. PECS enables patients to express their needs and emotions through the exchange of picture symbols. Studies have shown that PECS can effectively help non-verbal autistic individuals develop basic communication skills, especially during early intervention [24].

While PECS has shown significant success in improving basic communication skills, transitioning

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to more advanced AAC tools or spoken language may become necessary as the patient's language abilities improve. Additionally, the long-term success of AAC relies on consistent use within both home and school environments; without this support, patients may struggle to make sustained progress [25, 26].

4.3. Non-verbal Communication (Exemplified by Emotional Dystonic Dialogue in Psychomotor Therapy)

Non-verbal communication strategies are crucial for individuals with autism who have limited verbal abilities or are non-verbal. Emotional dystonic dialogue, a component of psychomotor therapy, involves interacting with patients through non-verbal means such as body movements, muscle tension, and posture to help them express emotions and understand others. This approach focuses on the connection between emotions and movement, allowing patients to interact with the therapist through body language and gradually enhance their ability to perceive and express emotions [27].

This non-verbal approach offers a unique advantage in compensating for the lack of verbal expression, especially for individuals with severe language impairments or those unable to communicate emotions verbally. It helps patients understand others' emotions through movement, thereby improving their social interaction skills [28].

4.4. Digital Augmentative Communication Tools

In recent years, digital augmentative communication tools (such as apps and devices) have become a valuable addition to language and communication interventions. These tools enable non-verbal or language-limited individuals with autism to communicate more effectively using technology. Unlike traditional AAC methods, digital tools offer greater flexibility in adapting to individual needs and provide real-time feedback, facilitating gradual improvement in language skills during interaction [29]. Digital augmentative communication tools are specifically applied to address language and communication needs, focusing on personalised and immediate communication support, distinct from broader neurofeedback or cognitive modulation-based digital therapies [30].

4.5. Section Summary

Language and communication interventions must be highly personalised to meet the individual needs of people with autism. Traditional SLT, AAC tools, and non-verbal communication strategies can provide effective support in different contexts. As technology advances, digital augmentative communication tools and artificial intelligence are rapidly being integrated into the field of autism rehabilitation, offering new possibilities for speech and communication interventions. However, further research and practical exploration are necessary to determine how these new technologies can be effectively combined with traditional therapies and to evaluate their long-term outcomes.

5. Creative and Arts Therapies

Creative and arts therapies aim to help individuals with autism express their emotions, enhance their social skills, and increase their self-awareness through various art forms, such as music, dance, and painting. Although these therapies offer unique advantages in individualized interventions, their effectiveness varies depending on individual differences, and the current literature on efficacy remains incomplete. Further exploration of the underlying mechanisms can contribute to a better understanding of the role of art therapy in autism rehabilitation.

5.1. Music Therapy

Music therapy interacts with individuals with autism through sounds, rhythms, and melodies, aiming to promote emotional expression and improve social communication skills. Research has shown that music therapy can help individuals with autism develop non-verbal communication skills, particularly in the areas of emotional expression and emotion regulation. A systematic review found that music therapy had a positive impact on improving social interactions and addressing behavioral problems in children with autism, especially in promoting eye contact and initiating social interactions [31].

The underlying mechanisms of music therapy may be related to its role in emotion regulation and

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socio-emotional learning. Music has an inherent emotional resonance effect, which can help patients perceive and express internal emotions more effectively by eliciting emotional responses. Additionally, rhythmic interactions in music therapy can foster synchrony between patients and therapists or peers. This synchrony not only enhances social interactions but may also improve attention and behavioral self-regulation [32, 33].

5.2. Dance/Movement Therapy

Dance and movement therapy uses the rhythmic and expressive nature of body movements to help individuals with autism enhance self-awareness, foster a connection between body and emotion, and improve their ability to interact with others. This therapy is especially suitable for individuals who have difficulties with verbal expression, as it promotes self-awareness and social interaction through bodily engagement [34].

Research has shown that dance/movement therapy is effective in improving physical coordination, emotional expression, and social interaction in individuals with autism. For example, Hartshorn et al. [35] found that children with autism who participated in dance therapy demonstrated improved awareness of their bodies and emotions and responded more effectively in non-verbal emotional communication. These therapies help reduce feelings of social isolation and provide a creative and interactive means of self-expression [36].

The core mechanism of dance/movement therapy lies in the enhancement of self-awareness and social interaction through the synchronization of movement and emotion. The rhythmic nature of the body is closely linked to emotional expression, and participation in dance allows individuals to better perceive and express their inner emotions, while improving interaction with others through physical coordination exercises [37]. This approach is particularly useful for individuals who struggle with verbal communication, offering them an alternative channel for emotional and social expression [38].

5.3. Painting and Visual Arts Therapy

Painting and visual arts therapy provide individuals with autism a non-verbal avenue to express their inner feelings and thoughts, helping to reduce anxiety, enhance emotional communication, and improve self-awareness. Visual arts therapy utilizes mediums such as painting and sculpture to help patients express themselves through creative processes [39].

Existing research has demonstrated that visual arts therapy can reduce anxiety, enhance emotional expression, and promote social interaction in individuals with autism. For instance, Evans and Dubowski [40] found that drawing, as a non-verbal form of emotional expression, allowed children with autism to release emotional stress through creativity, while also facilitating more open interaction with therapists or peers. However, large-scale randomized controlled trials are still lacking, although case studies have shown positive effects [41].

The mechanism behind painting and visual arts therapy may relate to the freedom of expression it provides. During the creative process, patients can release inner anxieties and emotional burdens, gradually developing an ability to regulate their emotions. Additionally, creating art allows patients not only to express themselves but also to share their inner world with others, thus fostering social interaction [42]. This non-verbal form of expression is particularly beneficial for individuals who have difficulty expressing their emotions through language [43].

5.4. Section Summary

Creative and arts therapies offer diverse ways for individuals with autism to express themselves and interact with others, encompassing music, dance, and visual arts. Although existing research highlights the potential benefits of these therapies, individualised outcomes are significant, and their effectiveness varies based on the specific needs of each patient. Future research should focus on conducting more high-quality randomized controlled trials to validate the effects of these therapies across different types of autistic individuals. Additionally, a deeper exploration of the psychological mechanisms underpinning art therapies will help to better understand how these approaches promote recovery through emotional expression and social interaction.

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6. Diet and Health Support

Diet and health support aim to improve the overall health of individuals with autism and indirectly affect their behavior and cognitive abilities by modifying their diet and lifestyle. In recent years, dietary interventions such as the gluten-free, casein-free (GFCF) diet and the Specific Carbohydrate Diet (SCD) have garnered significant interest in the treatment of autism. However, the effectiveness of these interventions remains highly controversial in clinical practice, particularly regarding their long-term outcomes. Further research integrating biomedical studies on the effects of dietary interventions on the gut microbiota and behavior may help to elucidate the potential mechanisms behind these approaches.

6.1. Gluten-Free, Casein-Free Diet (GFCF)

The Gluten-Free, Casein-Free (GFCF) diet is hypothesized to improve behavioral performance and gut function in individuals with autism by reducing the intake of gluten and casein. This hypothesis is based on the "gut-brain axis" theory, which suggests that gut dysfunction may be associated with behavioral and cognitive impairments in autism. However, current scientific evidence regarding the GFCF diet remains limited and inconsistent. While some small-scale studies and parent reports indicate improvements in behavior and social interaction following a GFCF diet, large-scale randomized controlled trials (RCTs) have generally not supported these findings [44].

The limited evidence supporting the efficacy of the GFCF diet may be attributed to factors such as small sample sizes, short follow-up periods, and subjective assessments of intervention outcomes. For instance, a systematic review by Keller et al. [45] found no significant behavioral improvements in individuals with autism on the GFCF diet. Furthermore, some studies have reported potential negative effects, such as gastrointestinal discomfort and nutritional deficiencies, particularly in children with pre-existing dietary restrictions [46].

An increasing number of studies have explored the relationship between gut microbiota and behavioral performance in individuals with autism. Research shows that individuals with autism may have different gut microbiota compositions compared to neurotypical individuals, which could be linked to their behavioral symptoms [47]. The GFCF diet may influence neurotransmitter transmission and immune responses via the gut-brain axis by altering the composition of the gut microbiota. However, further research is needed to determine whether these microbiota changes directly translate into behavioral improvements [48].

6.2. Specific Carbohydrate Diet (SCD)

The Specific Carbohydrate Diet (SCD) aims to improve gut health and behavioral performance in individuals with autism by limiting the intake of complex carbohydrates. The SCD hypothesizes that reducing fermentable carbohydrates can lower gut inflammation, thereby improving behavioral symptoms. However, similar to the GFCF diet, scientific support for the SCD remains limited. While some parents report improvements in gut function and behavior, these findings are mostly anecdotal, and there is insufficient evidence from large-scale RCTs to support these claims [49].

Most studies on the SCD are case reports or small-scale trials, lacking rigorous scientific validation. Although some reports suggest that the SCD reduces gastrointestinal discomfort and behavioral problems in individuals with autism, these results are largely based on subjective parental observations and lack objective biomarkers to support them. Additionally, concerns have been raised regarding the long-term sustainability and nutritional balance of the SCD, particularly for children, as prolonged food restrictions may lead to nutrient deficiencies [50].

Similar to the GFCF diet, the efficacy of the SCD may be linked to changes in gut microbiota. Some studies suggest that the SCD can reduce intestinal inflammation by limiting fermentable carbohydrate intake. However, further biomedical research is needed to validate the long-term safety and effectiveness of the SCD for individuals with autism. Future research should focus on exploring the diet's effects on gut microbiota and its relationship with behavioral symptoms in autism [51].

6.3. Section Summary

Dietary interventions, as a complementary approach in autism rehabilitation, have attracted attention from parents and researchers, but their effectiveness remains controversial. Most current scientific evidence for both the GFCF and SCD diets comes from case reports and small-scale studies,

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with a lack of support from large-scale randomized controlled trials. Therefore, the clinical application of such dietary interventions should be approached with caution, particularly when considering long-term effects. Future research should incorporate biomedical studies to further explore the effects of dietary interventions on the gut microbiota and determine whether these changes can lead to real improvements in the behavior and cognitive performance of individuals with autism.

7. Summary and Outlook

Intervention approaches for autism rehabilitation are becoming increasingly diverse, involving multiple disciplines such as behavioral and developmental interventions, sensory and neuromodulation therapies, language and communication therapies, creative and art therapies, and dietary support. Given the significant individual differences among people with autism, a single intervention often cannot meet the needs of all patients. Multidisciplinary integration of various interventions is expected to maximize rehabilitation outcomes. Future research should further optimize these intervention strategies, particularly in the areas of personalized interventions and interdisciplinary integration, to ensure that each patient receives comprehensive treatment tailored to their specific needs.

7.1. Validity and Limitations of Intervention Methods

Although mainstream intervention methods such as Applied Behavior Analysis (ABA) and Sensory Integration Therapy (SIT) have been supported by substantial evidence in improving behavior and sensory functioning in individuals with autism, they still face limitations, such as high resource consumption, low compliance, and varying efficacy due to individual differences. Complementary approaches, such as creative therapies and dietary interventions, while showing positive effects in some individuals, lack robust support in terms of study size and long-term efficacy. Therefore, future studies should prioritize large-scale randomized controlled trials (RCTs) to systematically assess the effectiveness and limitations of these interventions.

7.2. Prospects for Digital Therapies

Digital technologies, particularly virtual reality and neurofeedback, are paving new pathways in autism rehabilitation. These technologies offer significant advantages in real-time data monitoring and personalized interventions, allowing for more precise adjustments to treatment plans. However, their clinical application is still limited by high costs and dependency on technology. Future research should focus on reducing the costs of these technologies, improving affordability and sustainability, and ensuring that digital therapies are widely accessible, particularly in resource-limited settings, to benefit more people with autism.

7.3. The Need for Multidisciplinary Integration and Personalized Interventions

The highly heterogeneous nature of autism necessitates intervention strategies that are not only diverse but also personalized to the specific needs of each individual. Combining multidisciplinary approaches such as behavioral interventions, speech therapy, sensory modulation, and art therapy can better address the wide range of needs across different domains. Future intervention models should strengthen collaboration among families, schools, and healthcare systems, and establish multidisciplinary teams to participate in rehabilitation. Such integrated interventions will not only enhance the stability and effectiveness of treatment but also ensure long-term therapeutic outcomes.

7.4. Future Research Directions

Future research should focus on optimizing the applicability and effectiveness of existing intervention methods, particularly through large-scale, multi-center studies that validate the long-term efficacy of creative therapies, dietary interventions, and digital therapies. Moreover, biomedical research should explore the relationship between gut microbiota and behavioral and cognitive outcomes in autism, providing a more solid theoretical basis for dietary interventions. Future research initiatives could focus on: 1. Optimizing interdisciplinary integration: how to more effectively integrate behavioral, language, and sensory interventions to enhance personalized treatment outcomes. 2. Efficacy assessment: exploring the long-term effectiveness of personalized interventions in different autism subgroups. 3. Biomarker research: combining studies of gut microbiota and neuroimaging to

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identify biomarkers that can predict intervention outcomes and optimize personalized treatment plans.

7.5. Summary

While significant progress has been made in recent years in autism rehabilitation interventions, further advances are needed in multidisciplinary integration and personalized interventions. Future research should focus on optimizing the operability and scientific validity of these approaches and improving the efficacy and sustainability of interventions through technological innovation and rigorous scientific evaluation. With more systematic multidisciplinary collaboration and personalized practice, we can offer more comprehensive and precise rehabilitation pathways for individuals with autism, ultimately improving their quality of life.

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