



Effectiveness of Cognitive Rehabilitation on Adaptive Behaviour in Children with Neurodevelopmental Disorders: A Comprehensive Review

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Abstract: Neurodevelopmental disorders (NDDs) are associated with challenges in cognition, behaviour, social interaction, communication, and adaptive functioning, which can significantly impact children's independence and participation in daily life. Cognitive rehabilitation has emerged as an effective approach for enhancing attention, working memory, executive functioning, metacognition, problem-solving skills, and social understanding. This review examines the efficacy of cognitive rehabilitation and related cognitive-developmental interventions in improving adaptive behaviour among children with NDDs. It considers evidence from randomized controlled trials, systematic reviews, and meta-analyses concerning conditions such as Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), global developmental delay, and other neurodevelopmental conditions. Ahn and Hwang (2018) reported a moderate and statistically significant effect of cognitive interventions on adaptive behaviour across six controlled trials involving 544 children. Klingberg et al. (2005) demonstrated improvements in working memory among children with ADHD, although subsequent evidence indicated a limited impact on broader functional outcomes. Dawson et al. (2010) observed improvements in cognitive and adaptive development in young children with ASD following the 'Early Start Denver Model' intervention. Bombonato et al. (2023/2024) reported a significant 'far-transfer effect' on activities of daily living, whereas Faja et al. (2022) demonstrated that cognitive changes do not necessarily translate into improvements in daily functioning. Sadozai et al. (2024) confirmed the presence of executive function deficits in NDDs. Recent evidence from Lin et al. (2025) and Fan et al. (2026) indicates improvements in certain cognitive abilities; however, the application of these gains to real-life situations (ecological transfer) remains a challenge. Overall, cognitive rehabilitation appears most effective when it is individualized, functionally relevant, family-centred, and integrated across home, school, and community settings. Future research should prioritize adaptive behaviour, participation, and long-term outcomes.

Key Words: Adaptive behaviour, ADHD, autism spectrum disorder, cognitive rehabilitation, executive functioning, functional outcomes, neurodevelopmental disorder.

1. INTRODUCTION:

Neurodevelopmental disorders (NDDs) are conditions that begin during the developmental period and cause difficulties related to personal, social, academic, occupational, or adaptive functioning. The 'Diagnostic and Statistical Manual of Mental Disorders' (DSM-5) includes intellectual disability, communication disorders, autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), specific learning disorder, motor disorders, and other developmental conditions under this category (American Psychiatric Association [APA], 2013). Although the clinical characteristics of these disorders vary, children typically experience difficulties with attention, memory, executive functioning, communication, social interaction, emotional regulation, learning, and independent functioning. The primary goal of rehabilitation is not merely to improve performance on standardized cognitive tests, but to enhance children's ability to function and participate effectively in their everyday environments. Therefore, adaptive behaviour is a crucial outcome, as it reflects the practical application of learned skills for independent functioning and social participation. Adaptive functioning encompasses conceptual skills (such as communication and functional academic abilities), social skills (such as interpersonal relationships and social understanding), and practical skills (such as self-care, safety, household activities, and community participation) (Schalock et al., 2021). Cognitive functioning and



adaptive behaviour are deeply interconnected but distinct; a child might succeed in a structured cognitive task yet struggle to apply those learned skills in real-life situations. Consequently, modern rehabilitation emphasizes functional outcomes, generalization, environmental supports, and participation rather than focusing solely on cognitive improvement. Cognitive rehabilitation involves activities designed to strengthen cognitive processes or develop alternative strategies to cope with cognitive difficulties. For children with neurodevelopmental disorders (NDDs), these activities may focus on attention, working memory, processing speed, planning, inhibition, cognitive flexibility, metacognition, problem-solving, and self-monitoring. Implementation can occur under the guidance of a therapist through various modalities, such as specific activities, computer-assisted training, game-based tasks, classroom-based interventions, structured practice, socio-cognitive activities, and functional training for daily living. Empirical evidence supports this approach. Ahn and Hwang (2018) reported a moderate, significant effect of cognitive interventions on adaptive behaviour based on six controlled trials involving 544 children, with a total effect size of 0.64. Similarly, Scandurra et al. (2023) found that executive-function training has a significant "far-transfer" effect on everyday functioning. Therefore, this review examines the concepts, mechanisms, intervention methods, evidence, limitations, and future directions of cognitive rehabilitation aimed at improving adaptive behaviour in children with neurodevelopmental disorders.

1.1. Neurodevelopmental Disorders :

Neurodevelopmental disorders (NDDs) are associated with the atypical development of cognitive, behavioral, communicative, motor, and social systems; they typically manifest in childhood and can impact functioning throughout the lifespan. Their impact varies based on severity, co-occurring conditions, environmental factors, educational opportunities, family support, and access to rehabilitation. Intellectual developmental disorders specifically affect conceptual reasoning, learning, communication, self-direction, social judgment, and practical skills, with adaptive functioning serving as the focal point of their classification. In Autism Spectrum Disorder (ASD), difficulties in social communication, flexibility, sensory processing, executive functioning, and social cognition can limit everyday participation. Attention-Deficit/Hyperactivity Disorder (ADHD) typically involves challenges with sustained attention, inhibition, working memory, organization, planning, and self-regulation. Developmental Coordination Disorder can affect motor planning and execution, thereby impacting self-care and participation. Supporting these observations, Sadozai et al. (2024) reported—through a systematic review and meta-analysis of 180 studies—a moderate difference in executive functioning across neurodevelopmental conditions, with a more pronounced effect observed in children with comorbidities. These findings highlight executive functioning as a crucial target for rehabilitation aimed at improving functional and adaptive outcomes.

1.2. Adaptive Behaviour :

Adaptive behaviour refers to the set of learned behaviours that enable an individual to function effectively in their everyday environment. Unlike intelligence tests, which typically measure performance under standardized conditions, adaptive behaviour assessments examine how individuals actually perform in their natural environments. Sparrow, Balla, and Cicchetti (1984) defined adaptive behaviour as the performance of “daily activities required for personal and social sufficiency”, reflecting how effectively an individual meets the demands of everyday life and functions independently within his or her social and cultural environment.

Conceptual Skills: Conceptual skills include receptive and expressive communication, reading and writing, basic arithmetic, understanding time and money, problem-solving, self-direction, and functional academic skills.

Social Skills: Social adaptive behaviours include social communication, interpersonal relationships, understanding social rules, social judgment, emotional regulation, cooperation, empathy, and avoiding social vulnerability.

Practical Skills: Practical adaptive behaviours include personal hygiene, dressing and eating, household activities, mobility, safety, use of community resources, money management, vocational preparation, and independent living skills.

1.3. Cognitive Rehabilitation :

Cognitive rehabilitation is a systematic approach aimed at improving cognitive abilities or helping children cope with cognitive deficits. In paediatric rehabilitation, the approach should be developmentally appropriate, individualized, functional, and family-centred. It is grounded in executive function theory, information processing models, ecological perspectives, and the 'International Classification of Functioning, Disability and Health' (ICF). Executive functions—such as working memory, inhibition, cognitive flexibility, planning, monitoring, and self-regulation—are essential for goal-directed behaviour (Diamond, 2013; Miyake et al. 2000). The ICF emphasizes functioning, participation, and environmental interaction rather than focusing solely on impairment or disability (WHO, 2001).



Key Components of Cognitive Rehabilitation

Attention Training: Activities include visual scanning, auditory attention, sustained and selective attention, inhibition, and the gradual extension of task duration. For children with ADHD, these can be combined with behavioural strategies and necessary classroom accommodations.

Working-Memory Training: Children practice retaining and manipulating verbal or visual information, recalling sequences, following multi-step instructions, and updating information. Klingberg et al. (2005) reported improvements in working-memory capabilities among children with ADHD following training, although the broader impact requires further consideration.

Executive-function training: Abilities such as planning, organization, flexibility, inhibition, problem-solving, goal setting, error detection, and self-monitoring are developed through structured activities and daily routines.

Metacognitive training: Children learn to set goals, select strategies, monitor performance, identify errors, and adjust strategies. These skills can aid in academics, self-care, and social activities.

Problem-solving training: Children learn to identify problems, explore options, select appropriate solutions, implement them, and evaluate outcomes, thereby fostering independence.

Social-cognitive rehabilitation: Techniques such as social narratives, role-playing, imitation, emotion recognition, perspective-taking, and joint-attention activities can assist children with ASD and related conditions.

Functional and task-oriented rehabilitation: Cognitive skills should be practiced within meaningful daily activities, such as remembering the steps to brush one's teeth, packing a school bag, preparing a snack, or following classroom routines.

Therefore, the goal of cognitive rehabilitation should be to promote independence, participation, and adaptability in real-life situations.

2. LITERATURE REVIEW:

The strongest direct evidence comes from Ahn and Hwang (2018). They conducted a meta-analysis of six randomized controlled trials involving 544 children and found a moderate and statistically significant effect on adaptive behaviour. This finding supports the potential of cognitive and developmental interventions to improve functional outcomes. However, variations in diagnoses, intervention methods, and participant characteristics limit the generalizability of these findings.

Research on ADHD provides significant evidence regarding both the potential and limitations of cognitive training. Klingberg et al. (2005) demonstrated that computerized working-memory training in 53 children with ADHD improved working-memory performance, response inhibition, and complex reasoning abilities, alongside parental reports of symptom reduction. However, van Dongen-Boomsma et al. (2014) found that improvements following working-memory training were not always reflected in functioning at home or school. Similarly, in a meta-analysis of 16 trials involving 759 children and adolescents, Cortese et al. (2015) reported improvements in verbal and visual working memory and parent-rated executive functioning, but found limited evidence of improvements in academic achievement and broad ADHD symptoms. These findings suggest that cognitive training should be combined with behavioural, educational, organizational, and functional strategies.

Evidence from ASD further underscores the importance of ecological and naturalistic interventions. Dawson et al. (2010) observed significant improvements in cognitive and adaptive development among 48 young children with ASD following the 'Early Start Denver Model.' This intervention—combining developmental, behavioural, communication, social, and parental involvement approaches—demonstrates how cognitive gains can be more effectively translated into adaptive functioning when teaching occurs within meaningful, everyday contexts.

Similarly, Bombonato et al. (2023/2024) provided evidence of 'far transfer.' Their systematic review and meta-analysis of 17 studies (15 of which were included in the quantitative analysis) revealed significant effects on daily life functioning and clinical symptoms. The findings indicate that intervention intensity, frequency, and the relationship between training and real-life settings influence whether cognitive gains translate into functional outcomes.

In contrast, Faja et al. (2022) found that while executive-function training altered neural responses in 70 children with ASD, it did not lead to consistent improvements in laboratory-based executive-function performance or caregiver-reported daily functioning. This result suggests that biological or cognitive changes alone do not constitute sufficient evidence of functional improvement. Sadozai et al. (2024) further established the importance of executive functioning by synthesizing 180 studies and identifying a mean difference in executive functioning within neurodevelopmental conditions. Although this study did not directly evaluate the effectiveness of rehabilitation, it provides a robust foundation for focusing on executive processes such as attention, inhibition, planning, cognitive flexibility, and working memory.



Recent research highlights the growing role of technology-assisted and structured executive-function interventions. Lin et al. (2025) observed improvements in select cognitive domains—including social cognition, executive functioning, and attention—across 15 computerized cognitive-training studies involving 763 children and adolescents with ASD. However, limited long-term follow-up and concerns regarding ecological validity constrain conclusions concerning adaptive behaviour. Similarly, Fan et al. (2026) reported improvements in task-based executive functioning, inhibition, and working memory following structured executive-function training in 72 preschool children with ASD, yet found no significant improvements in parent-reported executive functioning or other secondary outcomes.

3. DISCUSSION:

Findings from this study indicate that cognitive rehabilitation is a promising, albeit context-dependent, approach to enhancing adaptive behaviour—the ability to adjust behaviour according to the situation—in children with neurodevelopmental disorders (NDDs). Interventions focused on working memory, attention, executive functioning, metacognition, social cognition, and problem-solving skills demonstrate that cognitive abilities can be modified through systematic intervention. However, an improvement in a specific cognitive process does not automatically guarantee a generalized improvement in adaptive behaviour. Therefore, understanding the distinction between cognitive improvement and functional transfer is crucial for assessing the effectiveness of rehabilitation.

The strongest direct evidence comes from Ahn and Hwang (2018), who analysed six randomized controlled trials involving 544 children with NDDs. Their mean effect size of 0.64 for adaptive behaviour provides significant evidence that cognitive and developmental interventions can contribute to meaningful functional improvements. Nevertheless, the limited number of eligible studies and the heterogeneity regarding diagnostic groups, interventions, and participant characteristics suggest that these results should be interpreted with caution. Evidence from ADHD presents a more nuanced picture. Klingberg et al. (2005) demonstrated that computerized working-memory training could improve working-memory performance and associated cognitive processes. However, van Dongen-Boomsma et al. (2014) and Cortese et al. (2015) showed that improvements on cognitive measures do not always translate into changes in symptoms, academic performance, or broader daily functioning. These results suggest that cognitive training can be more effective when combined with behaviour management, organizational strategies, necessary classroom modifications, and functional practice. Evidence from ASD research similarly highlights the importance of the intervention context. Dawson et al. (2010) reported significant improvements in cognitive and adaptive development following the 'Early Start Denver Model'; its naturalistic, behavioural, social, and parent-mediated components likely facilitated transfer beyond isolated cognitive performance. In contrast, Faja et al. (2022) observed changes in neural responses but did not see consistent improvements in laboratory-based executive-function measures or caregiver-reported daily functioning. This discrepancy indicates that improvements in adaptive behaviour cannot be expected from cognitive and neural changes alone.

The findings of Bombonato et al. (2023/2024) are particularly significant because their meta-analysis examined far-transfer outcomes. The significant impact on daily life functioning indicates that executive function training can extend beyond the specific cognitive tasks trained, provided the conditions are appropriate. Factors such as training intensity, frequency, and the relationship between intervention activities and real-life contexts appear to influence transfer. Therefore, generalization should be deliberately planned rather than expected to occur automatically. Evidence from Sadozai et al. (2024) further strengthens the theoretical basis for cognitive rehabilitation. Their analysis of 180 studies demonstrated substantial executive function difficulties associated with neurodevelopmental conditions. Although the study did not directly evaluate intervention effectiveness, it establishes executive functioning as a clinically meaningful rehabilitation goal. Similarly, Lin et al. (2025) reported improvements in selected cognitive domains following computerized cognitive training for children with ASD, while highlighting limited long-term evidence and concerns regarding ecological validity. Fan et al. (2026) reported improvements in task-based executive functioning, inhibition, and working memory among pre-schoolers with ASD; however, the absence of significant improvements reported by parents once again underscores the challenge of translating cognitive gains into everyday functioning. Collectively, these findings support an ecological and task-oriented model of cognitive rehabilitation. Interventions should progress from structured cognitive exercises to activities that mirror the children's actual daily needs. Working memory training can be linked to following classroom instructions, remembering self-care sequences, completing homework steps, and managing household routines. Executive function training may involve planning activities, organizing materials, managing transitions, solving everyday problems, and monitoring task completion. Family and school involvement is also essential. Parents can reinforce strategies during self-care, household, and community activities, while teachers can provide opportunities to apply cognitive strategies during academic tasks, classroom transitions, peer interactions, and functional routines. For children requiring high levels of support, functional exercises and environmental adaptations may be more meaningful than intensive abstract cognitive drills. Therefore, rehabilitation



should be individualized based on developmental level, cognitive ability, communication skills, adaptive needs, and environmental demands. Another significant finding is that adaptive behaviour should be viewed as a primary outcome rather than merely a consequence of cognitive improvement. Cognitive measures can establish whether a targeted process has improved, whereas adaptive behaviour measures determine whether that improvement holds practical significance. Consequently, future studies should assess communication, self-care, functional learning, social participation, community functioning, and independence alongside cognitive outcomes. Overall, the reviewed evidence indicates that cognitive rehabilitation is most effective when cognitive strategies are integrated with meaningful functional activities and opportunities for generalization. Thus, cognitive rehabilitation should be understood as a bridge between cognitive capacity and everyday participation, supporting greater independence and adaptive functioning across home, school, and community environments.

4. CONCLUSION:

This comprehensive review concludes that cognitive rehabilitation is a promising approach for improving adaptive behaviour and functional outcomes in children with neurodevelopmental disorders (NDDs), although its effectiveness may vary depending on clinical characteristics, intervention methods, and outcome measures. Evidence from Ahn and Hwang (2018) directly supports moderate improvements in adaptive behaviour, while studies by Klingberg et al. (2005), Dawson et al. (2010), and Bombonato et al. (2023/2024) demonstrate that working memory, cognitive functioning, and executive processes can be enhanced and, under the right conditions, translated into broader functional outcomes. However, findings from van Dongen-Boomsma et al. (2014), Cortese et al. (2015), Faja et al. (2022), Lin et al. (2025), and Fan et al. (2026) indicate that improvements in targeted cognitive abilities do not automatically translate into improvements in everyday adaptive behaviour. Therefore, generalization and functional transfer should be explicitly incorporated into rehabilitation programs rather than assumed to occur naturally. Consequently, cognitive rehabilitation should be individualized, developmentally appropriate, functional, family-centred, and ecologically oriented. Skills such as attention, working memory, executive functioning, metacognition, problem-solving, and social cognition should be developed through meaningful activities relevant to the children's daily lives. Opportunities must be provided to practice and broadly apply newly acquired skills across home, school, and community environments. Ultimately, the success of rehabilitation should be evaluated not only through performance on cognitive tests but also through improvements in independence, communication, self-care, functional learning, social participation, problem-solving, and adaptive functioning. Future research should employ large randomized controlled trials, standardized measures of adaptive behaviour, blinded assessments, long-term follow-ups, and ecologically valid outcomes.

Thus, the evidence supports a shift from a "cognition-first" model to a "cognition-to-function" model, wherein cognitive abilities are intentionally translated into meaningful daily participation. Such an approach offers a greater likelihood of improving independence, quality of life, and long-term participation for children with NDDs.

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