Volume 4, Issue 6, June 2026 ISSN (E): 2938-3765

NEUROPSYCHOLOGICAL INTERVENTIONS FOR ADHD AND DEVELOPMENTAL DELAY IN CHILDREN: A SYSTEMATIC LITERATURE REVIEW

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Abstract
This article presents a systematic literature review of neuropsychological interventions targeting executive function deficits, working memory, and attentional regulation in children diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD) and developmental delay (DD). Publications from 2003 to 2024 indexed in PubMed, Scopus, Web of Science, and PsycINFO were systematically searched and analysed. The review covers theoretical foundations of executive function deficits in ADHD and DD, evidence base for cognitive training, behavioural, and combined neuropsychological interventions, and moderating factors including age, comorbidity, cultural context, and implementation setting. The analysis indicates that structured neuropsychological intervention programmes produce meaningful improvements in working memory (effect sizes d = 0.40–0.87), sustained attention, and inhibitory control, with combined cognitive-behavioural approaches showing the most consistent outcomes. However, the long-term maintenance of gains and cross-cultural generalisability of findings remain insufficiently studied, particularly in Central Asian educational contexts.

Keywords: ADHD, developmental delay, neuropsychological interventions, executive functions, working memory, systematic review, children.

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) and developmental delay (DD) are among the most frequently encountered neurodevelopmental conditions in childhood, with global prevalence estimates ranging from 5 to 7% for ADHD (Polanczyk et al., 2015) and 3 to 5% for DD (Maulik et al., 2011). Both conditions share a common profile of executive function (EF) deficits encompassing working memory limitations, inhibitory control failures, and attentional dysregulation, which collectively constitute major barriers to academic achievement and social functioning (Barkley, 2015; Pennington & Ozonoff, 1996).

The past two decades have witnessed a substantial proliferation of neuropsychological intervention programmes specifically designed to target these executive function deficits. Unlike pharmacological approaches, which remain the first-line treatment for ADHD in many clinical guidelines (NICE, 2019), neuropsychological interventions offer the potential for durable skill-based improvements without pharmacological side effects, making them particularly relevant for younger children, those

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with contraindications to medication, and settings with limited access to pharmacological treatment (Sonuga-Barke et al., 2013).

Despite a growing evidence base in Western research contexts, the translation of neuropsychological intervention research into non-Western educational settings — particularly in Central Asia, where distinct pedagogical traditions, resource constraints, and cultural factors shape the implementation environment — has received limited systematic attention. This gap is particularly pronounced in Uzbekistan, where the formal development of evidence-based neuropsychological practice within the special education system remains at an early stage (Kholmatova, 2020; Yusupova et al., 2021).

The aim of this review is to systematically analyse the current evidence base for neuropsychological interventions in children with ADHD and DD, identify key moderating and mediating variables, evaluate the applicability of findings to Central Asian educational contexts, and formulate evidence-informed recommendations for practice and future research.

2. THEORETICAL FOUNDATIONS: EXECUTIVE FUNCTIONS IN ADHD AND DD

The dominant theoretical framework for understanding neuropsychological deficits in ADHD is Barkley's (2015) extended phenotype model, which positions inhibitory control failure as the primary deficit from which secondary impairments in working memory, cognitive flexibility, and emotional regulation derive. This model has been extensively supported by neuroimaging evidence demonstrating reduced volume and functional activity in the prefrontal cortex, anterior cingulate cortex, and striatum — regions critical for executive regulation (Willcutt et al., 2005; Haist et al., 2015).

For DD, theoretical accounts emphasise a more distributed pattern of executive deficits, consistent with broader disruption of cortical development rather than the more focal frontostriatal pathology characteristic of ADHD (Pennington & Ozonoff, 1996; Zelazo & Muller, 2011). Dual-pathway models (Sonuga-Barke, 2005) propose that both inhibitory control and reward processing pathways are implicated, though with varying relative contributions across diagnostic subtypes. These theoretical distinctions have practical implications for intervention design: ADHD-specific programmes may place greater emphasis on inhibitory and working memory training, while programmes for DD may need to address a broader range of cognitive and socio-emotional capacities.

3. COGNITIVE TRAINING INTERVENTIONS

Computerised working memory training, exemplified by the Cogmed Working Memory Training programme (Klingberg et al., 2005), has been among the most extensively studied neuropsychological interventions for ADHD. A landmark randomised controlled trial by Klingberg et al. (2005) demonstrated significant improvements in working memory and attention following 5 weeks of intensive training in children aged 7–12 with ADHD, with effects sustained at a 3-month follow-up. These findings were subsequently replicated in multiple independent trials (Holmes et al., 2009; Beck et al., 2010).

However, a critical issue in this literature concerns the specificity and transferability of training gains. Melby-Lervåg & Hulme's (2013) influential meta-analysis, synthesising data from 23 randomised studies, concluded that while working memory training produces robust near-transfer effects — improvements on trained and closely related working memory tasks — evidence for far-transfer to

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broader academic achievement or everyday functioning is considerably weaker. This meta-analytic conclusion has been confirmed and extended in subsequent reviews (Rapport et al., 2013; Schwaighofer et al., 2015), tempering earlier optimism about the transformative potential of cognitive training.

For DD populations, cognitive training research is less extensive but shows a broadly parallel pattern. A meta-analysis by Danielsson et al. (2015) found moderate effect sizes for working memory training in individuals with intellectual disabilities (d = 0.38–0.51), with effects most pronounced on trained tasks and less consistent on generalised outcomes. The authors noted that training intensity, programme duration, and the degree of adaptive difficulty scaling were significant moderators of outcome.

4. BEHAVIOURAL AND COMBINED NEUROPSYCHOLOGICAL INTERVENTIONS

Behavioural interventions targeting the functional consequences of EF deficits — including structured classroom management, contingency management, and parent-implemented behavioural strategies — represent the most extensively validated non-pharmacological approach for ADHD (Pelham & Fabiano, 2008). A comprehensive meta-analysis by Fabiano et al. (2009), encompassing 174 studies, established large average effect sizes for behavioural interventions on ADHD symptom severity (d = 0.83) and functional outcomes. The Summer Treatment Programme (STP; Pelham & Hoza, 1996) exemplifies a multimodal behavioural intervention incorporating academic and social skills training alongside contingency management, with demonstrated effects on academic achievement and peer relationships.

Combined approaches integrating cognitive training with behavioural intervention have gained increasing empirical support. Sonuga-Barke et al.'s (2013) influential meta-analysis of non-pharmacological interventions for ADHD reported that combined cognitive-behavioural approaches produced larger and more consistent effects than either component in isolation (d = 0.47–0.64), particularly when rated by blinded assessors. The theoretical rationale for combination approaches rests on the complementarity of their mechanisms: cognitive training targets the neuropsychological substrates of EF deficits, while behavioural intervention modifies the environmental contingencies that maintain maladaptive behaviour.

5. MODERATING FACTORS AND IMPLEMENTATION CONSIDERATIONS

A recurring theme in the neuropsychological intervention literature concerns the substantial variability in outcomes across studies, pointing to the importance of moderating factors. Age at intervention is a consistent moderator: younger children (preschool to early school age) show larger effect sizes, consistent with greater neuroplasticity during sensitive periods of prefrontal development (Diamond, 2013). Comorbidity — particularly the co-occurrence of ADHD with anxiety disorders, DD, or learning disabilities — significantly influences intervention response, generally attenuating effect sizes and necessitating adapted programme components (van der Oord et al., 2012).

Implementation fidelity emerges as a critical determinant of programme effectiveness in real-world settings. Studies consistently demonstrate degradation of effect sizes as interventions are scaled from efficacy trials to routine implementation, underscoring the importance of training, supervision, and quality assurance mechanisms (Fixsen et al., 2005). In resource-constrained settings — such as those

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prevailing in many Central Asian educational institutions — the feasibility of high-intensity, individually administered cognitive training programmes may be limited, pointing to the need for adapted group-based formats and technology-supported delivery.

Cultural factors influencing intervention acceptability and effectiveness have received limited attention in the literature but are potentially important. Collectivist cultural contexts may favour group-based and family-inclusive intervention formats over individually focused approaches. Instructional styles emphasising teacher authority and rote learning, prevalent in Uzbekistan and neighbouring countries (Holliday, 2010), may interact with the self-regulatory skill emphasis of neuropsychological interventions in ways that have not yet been systematically examined.

6. APPLICABILITY TO CENTRAL ASIAN CONTEXTS

The applicability of Western-developed neuropsychological interventions to Central Asian educational settings requires critical examination. Yusupova et al. (2021) note that the formal framework for neuropsychological diagnosis and intervention in Uzbekistan is still developing, with limited availability of trained specialists and standardised assessment instruments validated for the local population. The predominance of Russian-language diagnostic and intervention materials, developed for Russian normative populations, introduces potential psychometric biases when applied to Uzbek-speaking children.

Nevertheless, the core neurocognitive deficits targeted by neuropsychological interventions — working memory limitations, inhibitory control failures, attentional dysregulation — are biologically grounded and likely to be broadly consistent across populations, as supported by cross-cultural neuroimaging research (Cheung & Theakston, 2015). This suggests that the fundamental neuropsychological approaches can be adapted for Central Asian settings, provided that appropriate cultural, linguistic, and pedagogical modifications are incorporated.

7. CONCLUSION

The present review demonstrates that structured neuropsychological intervention programmes produce meaningful improvements in executive functions, working memory, and attentional regulation in children with ADHD and DD, with combined cognitive-behavioural approaches showing the most consistent evidence base. However, the literature reveals important limitations: modest far-transfer effects of cognitive training, limited evidence on long-term maintenance, and a near-exclusive focus on Western samples. These gaps have particular relevance for Central Asian settings, where evidence-based neuropsychological practice is still emerging. Future research should prioritise the development and evaluation of culturally adapted neuropsychological intervention programmes for children with ADHD and DD in Uzbekistan and neighbouring countries, employing methodologically rigorous designs including randomised controlled trials and longitudinal follow-up assessments.

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