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Effectiveness of the Cognitive Remediation Therapy (CRT) Program on Behavioral Problems in Children Aged 7 to 9 Years with Attention-Deficit/Hyperactivity Disorder

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ABSTRACT

The purpose of this study was to determine the effectiveness of the CRT program on behavioral problems in children with ADHD. This research was a quasi-experimental study using a pretest–posttest design with a control group. The statistical population consisted of all children aged 7 to 9 years diagnosed with ADHD in Ahvaz in 2024. From this population, 30 children were selected through convenience sampling and randomly assigned to experimental and control groups. The CRT intervention was delivered in ten 60-minute sessions, one session per week, for the experimental group, while the control group received no intervention. Data were collected using the Child Behavior Checklist (CBCL). Descriptive statistics (mean and standard deviation) and inferential statistics (multivariate and univariate analysis of covariance) were used for data analysis, employing SPSS version 26. The results indicated that the CRT intervention had a significant effect on the variables of anxiety/depression, withdrawal/depression, social problems, thought problems, attention problems, and aggressive behavior, leading to improvement in these problems in the experimental group compared to the control group ($p < .05$). However, the intervention did not have a significant effect on somatic complaints or rule-breaking behavior. The findings of this study confirm the effectiveness of the CRT program as an intervention method for reducing several behavioral problems in children with ADHD. Accordingly, implementing this program alongside other psychological and educational interventions in clinical and school settings is recommended for this group of children. Nevertheless, the lack of impact on some areas, such as somatic complaints, highlights the necessity of complementing CRT with additional approaches or designing more specialized sessions.

Keywords: *attention-deficit/hyperactivity disorder, behavioral problems, cognitive remediation therapy*

1. Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most prevalent neurodevelopmental conditions of childhood, characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with developmental, academic, and social functioning (Barkley, 2015). Conceptualized as a chronic disorder that emerges early in life and frequently continues into adolescence and adulthood, ADHD is associated with numerous challenges across cognitive, emotional, and behavioral domains. Over the past decades, global epidemiological evidence has demonstrated that ADHD affects approximately 5–7 percent of children worldwide, with significant variability arising from methodological and diagnostic differences across studies (Polanczyk et al., 2014). Such prevalence rates highlight the substantial public health burden of ADHD and the need for evidence-based approaches to assessment, intervention, and long-term management (DuPaul & Stoner, 2014).

The impact of ADHD extends beyond symptom expression and encompasses multiple domains of functioning, including executive functions, academic achievement, emotional regulation, social competence, and parent–child interactions (Barkley, 2012). The executive function model proposed by Barkley posits that ADHD is rooted in impairments in behavioral inhibition, working memory, internalization of speech, and self-regulation of affect and motivation, which collectively disrupt goal-directed behavior (Barkley, 2012). Neurocognitive studies further reinforce this framework by demonstrating structural and functional abnormalities in fronto-striatal and fronto-cerebellar circuits that support attention, inhibitory control, and working memory (Rubia, 2018). Such deficits contribute to the emotional and behavioral manifestations of ADHD, including anxiety, social withdrawal, impulsive decision-making, and aggression, underscoring the need for interventions that directly target underlying cognitive mechanisms rather than focusing exclusively on symptom reduction.

Evidence from large-scale cohort studies has underscored the broader implications of ADHD for safety, health, and well-being. For example, children and adolescents with ADHD face elevated risks of accidental injury, substance misuse, and premature mortality compared to their peers, patterns attributable to impaired self-regulation and difficulties maintaining sustained attention (Dalsgaard et al., 2015). These risks highlight the importance of early identification and comprehensive intervention strategies during developmental periods characterized by rapid brain maturation and heightened plasticity.

Traditionally, the primary mode of treatment for ADHD has been pharmacological intervention, particularly stimulant medications that target dopaminergic and noradrenergic pathways. While medications have robust short-term effects on core symptoms, concerns persist regarding side effects, adherence, limited impact on academic functioning, and inadequate improvement in long-term outcomes for many children (Pliszka, 2015). These limitations have driven increasing attention toward non-pharmacological and multimodal interventions designed to complement or substitute medication. Such approaches include behavioral therapy, parent training programs, mindfulness-based interventions, neurocognitive training, and educational modifications (Sonuga-Barke et al., 2013). Research integrating psychological and cognitive remediation strategies suggests that targeted interventions may directly enhance cognitive processes implicated in ADHD, thereby generating more durable improvements in daily functioning.

Cognitive training and cognitive remediation have emerged as promising approaches that utilize structured, repetitive tasks to strengthen cognitive systems such as working memory, attention, processing speed, and executive function. Systematic reviews of cognitive rehabilitation demonstrate significant effectiveness of structured, evidence-based cognitive exercises for individuals with neurological or neurodevelopmental disorders, particularly when interventions incorporate scientifically validated protocols, individualized training progression, and active engagement strategies (Cicerone et al., 2019). Working memory training programs, including those pioneered by Klingberg, have conceptualized cognitive remediation as a mechanism for harnessing neural plasticity to improve cognitive capacities in children with ADHD, reporting improvements in working memory and sometimes in attention and behavioral regulation (Klingberg, 2010). Although the magnitude and generalizability of transfer effects remain subjects of debate, such programs highlight the potential for cognitive remediation to augment or partially compensate for underlying neurodevelopmental vulnerabilities.

Meta-analytic evidence provides mixed yet encouraging findings regarding the effects of cognitive training on ADHD outcomes. For instance, Cortese and colleagues reported significant improvements in neuropsychological

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outcomes following cognitive training interventions, although effects on overt ADHD symptoms tended to be smaller and more variable across studies (Cortese et al., 2015). This distinction suggests that cognitive remediation may be particularly effective for addressing the cognitive deficits underlying behavioral manifestations rather than directly altering the observable symptoms captured by standard diagnostic criteria. Such findings are consistent with the broader understanding that improvements in memory, attention control, and processing efficiency may take time to generalize to academic and social contexts.

Expectations and motivational factors also play critical roles in shaping the outcomes of cognitive training. Research by Rabipour and Davidson has examined how individuals' beliefs about brain training influence engagement and perceived benefits, highlighting the importance of structured, meaningful feedback and individualized progression within cognitive remediation programs (Rabipour & Davidson, 2015). Similarly, earlier work by Rabipour and Raz distinguishes between scientifically grounded cognitive training programs and commercial "brain training" products, stressing the need for theoretical rigor, evidence-based methods, and cognitive specificity when designing interventions for children with ADHD (Rabipour & Raz, 2012). Effective cognitive remediation programs thus require well-established exercises that target defined neural and cognitive mechanisms, as well as methodological clarity and appropriate dosage to promote neuroplastic changes.

In recent years, studies conducted in diverse contexts have extended cognitive training paradigms to address a range of cognitive and behavioral outcomes in children with ADHD. For example, computerized working memory training has demonstrated meaningful improvements in cognitive performance among children with ADHD and reading difficulties, highlighting its applicability across co-occurring developmental conditions (Poon et al., 2024). Motor-cognitive hybrid interventions have likewise shown promise for enhancing working memory and selective attention in children with ADHD, suggesting that activities integrating motor and cognitive components may maximize engagement and cognitive gains (Izadkhah et al., 2024). Additional work in clinical and educational settings has demonstrated that structured cognitive-behavioral and cognitive-remediation programs can improve sustained, selective, and shifting attention in children with ADHD, underscoring the importance of training approaches grounded in cognitive science and neuropsychology (Shams et al., 2024).

The potential benefits of cognitive remediation extend beyond attention to influence broader domains of socioemotional and behavioral functioning. Research on cognitive-behavioral interventions has shown favorable effects on emotional regulation, behavioral adjustment, and problem-solving skills across various child populations, including those with externalizing behaviors and learning disorders (Vosoughi Kalantari et al., 2025). Other studies highlight the value of cognitive-based skills training for modifying parenting behaviors and reducing parental anger, suggesting that interventions rooted in cognitive mechanisms can also support family-level changes conducive to improved behavioral outcomes in children (Shokoohi Yekta & Motamed Yeganeh, 2024). Similarly, cognitive-behavioral play therapies and related approaches have been shown to reduce impulsivity, enhance cognitive flexibility, and improve behavioral adjustment in children displaying disruptive or aggressive behaviors (Tavakoli et al., 2024).

Within the broader landscape of psychological treatments, cognitive-behavioral therapy (CBT) remains a highly validated approach for modifying maladaptive cognitions and behaviors (World TSRFAC, 2024). Although CBT is not explicitly designed as a cognitive remediation program, its emphasis on cognitive restructuring, behavioral regulation, and skill acquisition aligns with the core principles of cognitive training. Studies comparing CBT with other therapies, such as mindfulness or gestalt-based approaches, have shown substantial improvement in anxiety and affective functioning among children and adolescents, indicating that cognitive-based interventions can exert broad psychological benefits (Shabannezhad, 2024). These findings suggest that integrating cognitive remediation with established therapeutic paradigms may enhance outcomes across emotional and behavioral domains.

At the same time, recent advances also stress the importance of neurocognitive specificity. Research in cognitive neuroscience emphasizes that ADHD involves deficits not only in behavioral inhibition but also in temporal processing, reward mechanisms, working memory, sustained attention, and neural connectivity (Rubia, 2018). In line with this, cognitive remediation programs that target multiple memory modalities—such as visual–spatial memory, auditory–visual memory, motor memory, episodic memory, and metamemory—may facilitate improvements across complex behavioral dimensions. Such multimodal interventions are particularly relevant in the context of behavioral problems commonly observed in children with ADHD, including social difficulties, rule-breaking, emotional dysregulation, thought problems, somatic complaints, and aggression, consistent with findings from clinical and school-based research (DuPaul & Stoner, 2014).

Furthermore, emerging studies in occupational therapy and cognitive-functional models suggest that integrating cognitive remediation principles with everyday functional tasks can improve both cognitive performance and daily functioning among individuals diagnosed with ADHD (Budman et al., 2025). These approaches reinforce the significance of ecological validity, ensuring that cognitive gains translate into meaningful improvements in real-world contexts such as classrooms, peer interactions, and daily routines. Complementary work on paradoxical interventions also highlights the potential of innovative psychological strategies to reshape cognitive-behavioral patterns, enhance self-regulation, and reduce dysfunctional behaviors by modifying individuals' engagement with maladaptive habits (Asayesh & Parsakia, 2025).

Despite these promising developments, the effectiveness of structured cognitive remediation specifically targeting memory-based cognitive systems for reducing behavioral problems in children with ADHD remains insufficiently investigated. Although several studies have demonstrated improvements in attention, working memory, and executive functions following cognitive remediation, fewer have systematically examined whether such cognitive gains translate to reductions in behavioral and emotional problems such as anxiety, depression, social difficulties, aggression, and rule-breaking. Moreover, the heterogeneity of cognitive training protocols across studies underscores the importance of evaluating standardized, evidence-based programs grounded in neurocognitive theory and validated through rigorous research designs.

Considering the need for targeted interventions that address both cognitive deficits and behavioral manifestations of ADHD, structured cognitive remediation programs focusing on memory systems may offer a promising pathway for improving behavioral functioning. Such programs can potentially strengthen the cognitive foundations required for emotion regulation, impulse control, attentional stability, and adaptive decision-making. This perspective is consistent with contemporary frameworks in developmental cognitive neuroscience and clinical psychology, which posit that enhancements in cognitive capacity can produce downstream improvements in behavior and emotional well-being (Diamond, 2012). Furthermore, as research increasingly emphasizes early, developmentally aligned interventions, addressing cognitive vulnerabilities during early school years may generate lasting benefits across academic, social, and behavioral domains.

In light of the theoretical, empirical, and clinical considerations surrounding ADHD and cognitive remediation, and given the documented need for interventions that address both cognitive and behavioral deficits, the present study seeks to contribute to this growing body of literature by evaluating the effectiveness of a structured cognitive remediation protocol based on memory-oriented cognitive exercises for reducing behavioral problems in children with ADHD; therefore, the aim of this study is to determine the effectiveness of a cognitive remediation program on behavioral problems in children with attention-deficit/hyperactivity disorder.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a quasi-experimental design with a pretest–posttest structure and a control group. The statistical population consisted of all male children diagnosed with attention-deficit/hyperactivity disorder (ADHD) in Ahvaz in 2024. Given the interventional nature of the study and access limitations, convenience sampling was used to recruit participants. The initial sample size included 36 individuals who were selected based on the inclusion criteria and then randomly assigned to two groups of 18 participants each (experimental and control).

The inclusion criteria consisted of a confirmed diagnosis of ADHD by a psychiatrist or clinical psychologist, informed parental consent, and the absence of severe comorbid psychiatric disorders. The exclusion criteria included absence from more than two intervention sessions, lack of cooperation in completing assigned tasks, and identification of severe psychological disorders during the study. During the research process, three participants from the experimental group and three from the control group were excluded from the study for various reasons.

The cognitive remediation intervention was implemented based on the protocol of Shulberg and Matier, and Rashidi Asl and Ashouri, delivered in ten 60-minute sessions, one session per week, for the experimental group. The session content included strengthening visual–image memory, auditory–visual memory, visual–spatial memory, numerical memory, episodic memory, temporal–spatial memory, motor memory, and metamemory. The control group was placed on a waiting list during this period and did not receive any intervention.

2.2. Measures

Two standardized questionnaires were used for data collection. The first instrument was the Conners Parent Rating Scale (CPRS-48), which consists of 48 items rated on a four-point Likert scale and is designed to measure the severity of ADHD symptoms. The reliability of this tool in various Iranian studies has been reported with Cronbach's alpha coefficients ranging from .73 to .95 and test–retest reliability of .58. The second instrument was the Parent Report Form of the Child Behavior Checklist (CBCL), which assesses children's emotional–behavioral problems across eight core domains. The reliability of this questionnaire has been confirmed with a Cronbach's alpha of .97 and test–retest reliability of .94.

2.3. Intervention

The cognitive and neurocognitive remediation intervention was delivered across ten structured sessions, each designed to strengthen memory-based cognitive abilities through targeted training. The first session focused on establishing rapport and introducing the program's structure, goals, and cognitive training methods. Session two emphasized enhancement of visual–image memory using mnemonic strategies and recall exercises such as face-memory games. Session three targeted auditory–visual memory by training alertness to auditory stimuli and sustained attention to visual cues. In session four, visual–spatial memory was reinforced through activities involving processing speed and visuospatial coordination. Session five developed numerical memory and verbal association skills through patterned number sequencing, forward and backward pattern recognition, word-completion tasks, and paired associations. Session six focused on event memory and cognitive elaboration by strengthening selective attention, verbal organization, and semantic expansion. Session seven trained temporal and spatial memory using mnemonics and guided imagery based on recent and immediate experiences. Session eight improved motor memory through one-step and multi-step motor instructions requiring categorization and discrimination. Session nine targeted metamemory processes by engaging participants in mental imagery, problem-solving, planning, and the gradual fading of memory cues. The final session reviewed all training components and prepared participants for program completion, ensuring consolidation of skills acquired throughout the cognitive remediation intervention.

2.4. Data Analysis

The collected data were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (multivariate and univariate analysis of covariance) in SPSS version 26.

3. Findings and Results

Demographic characteristics of the sample, including parental age and educational level, were examined across the experimental and control groups. The mean age of mothers was 38.133 years (SD = 6.300) in the experimental group and 37.533 years (SD = 6.947) in the control group, with the highest age distribution in both groups falling within the 31–40-year range (60% in the experimental group and 46.7% in the control group). A chi-square test indicated no significant difference between groups in the distribution of mothers' ages ($p = .755$). Regarding fathers, the mean age was 42.667 years (SD = 6.444) in the experimental group and 43.400 years (SD = 7.670) in the control group. The highest age frequency for fathers in the experimental group fell below 40 years (46.7%), whereas in the control group it occurred in the 41–50-year range (60%); however, this difference was not statistically significant ($p = .492$). Educational levels also showed a similar pattern across groups: the most frequent educational attainment for mothers in both groups was a bachelor's degree (33.3% in the experimental group and 53.3% in the control group), while the highest frequency for fathers was a high school diploma or lower (33.3% in the experimental group and 40% in the control group). Chi-square tests confirmed that parental education levels did not significantly differ between groups ($p = .720$ for mothers; $p = .896$ for fathers).

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Table 1

Descriptive Statistics of Behavioral Problem Scores in Pretest and Posttest

Subscale	Group	Pretest Mean	Posttest Mean
Anxiety/Depression	Experimental	16.533	14.600
	Control	15.867	16.133
Withdrawal/Depression	Experimental	11.400	10.067
	Control	10.867	11.067
Somatic Complaints	Experimental	11.533	10.667
	Control	11.133	11.067
Social Problems	Experimental	13.867	12.533
	Control	13.600	13.467
Thought Problems	Experimental	17.200	15.467
	Control	16.800	16.733
Attention Problems	Experimental	17.200	15.567
	Control	16.667	17.533
Rule-Breaking Behavior	Experimental	20.333	19.267
	Control	19.933	20.067
Aggressive Behavior	Experimental	21.000	19.200
	Control	20.533	20.400

Table 1 presents the descriptive statistics for all behavioral problem subscales across the pretest and posttest phases. In the experimental group, the mean scores for every behavioral subscale decreased from pretest to posttest, including anxiety/depression (from 16.533 to 14.600), withdrawal/depression (from 11.400 to 10.067), somatic complaints (from 11.533 to 10.667), social problems (from 13.867 to 12.533), thought problems (from 17.200 to 15.467), attention problems (from 17.200 to 15.567), rule-breaking behavior (from 20.333 to 19.267), and aggressive behavior (from 21.000 to 19.200). In contrast, the control group showed slight increases in several subscales, including anxiety/depression (from 15.867 to 16.133), withdrawal/depression (from 10.867 to 11.067), and attention problems (from 16.667 to 17.533), while the remaining scores showed minimal change. Overall, these descriptive findings indicate that the Cognitive Remediation Therapy program was associated with reductions in behavioral problem scores exclusively in the experimental group, whereas the control group showed no evidence of improvement.

Assessment of statistical assumptions indicated that the normality of distribution was met for all variables, as Shapiro–Wilk test values across pretest and posttest phases ranged from .882 to .982 in the experimental group and from .886 to .978 in the control group, with all corresponding significance levels exceeding .051, confirming non-violation of normality. The homogeneity of covariance matrices was also supported, as Box's M value of 43.104 with an associated F of .822 was nonsignificant ($p = .765$), indicating equivalence of covariance structures across groups. Furthermore, Levene's test showed that the assumption of homogeneity of variances was upheld for all posttest variables except anxiety/depression, with F values ranging from .001 to 1.796 and significance levels between .021 and .972; the single significant value did not meaningfully affect multivariate robustness. Finally, multivariate test indices including Pillai's Trace (.815), Wilks' Lambda (.185), Hotelling's Trace (4.415), and Roy's Largest Root (4.415), all with $F = 6.174$ and $p = .001$, confirmed that the data met the necessary assumptions for valid interpretation of the MANCOVA results.

Table 2

Results of Multivariate Analysis of Covariance (MANCOVA)

Test	Value	F	Hypothesis df	Error df	Sig.	Effect Size	Power
Pillai's Trace	0.815	6.174	8	13	0.001	0.815	0.994
Wilks' Lambda	0.185	6.174	8	13	0.001	0.815	0.994
Hotelling's Trace	4.415	6.174	8	13	0.001	0.815	0.994
Roy's Largest Root	4.415	6.174	8	13	0.001	0.815	0.994

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As shown in Table 2, the multivariate test results indicated that the CRT intervention produced a statistically significant overall effect on the combined behavioral and emotional outcomes. All four multivariate statistics—Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root—were significant at $p = .001$, demonstrating a strong multivariate impact of group membership. The effect size was large ($\eta^2 = .815$), and the observed statistical power was excellent (.994), indicating that the intervention accounted for a substantial proportion of variance in the set of dependent variables.

Table 3

Univariate ANCOVA Results for Study Variables in the MANCOVA Context

Source	Variable	SS	df	MS	F	Sig.	η^2	Power
Group	Posttest Anxiety/Depression	31.530	1	31.530	7.787	0.011	0.280	0.756
	Posttest Withdrawal/Depression	15.604	1	15.604	7.292	0.014	0.267	0.729
	Posttest Somatic Complaints	1.521	1	1.521	0.413	0.528	0.020	0.094
	Posttest Social Problems	19.183	1	19.183	9.123	0.007	0.313	0.819
	Posttest Thought Problems	27.061	1	27.061	4.541	0.046	0.185	0.527
	Posttest Attention Problems	33.140	1	33.140	10.874	0.004	0.352	0.880
	Posttest Rule-Breaking Behavior	9.463	1	9.463	3.301	0.084	0.142	0.409
	Posttest Aggressive Behavior	23.165	1	23.165	7.298	0.014	0.267	0.729

The univariate ANCOVA results displayed in Table 3 show that the CRT intervention significantly improved several behavioral and emotional outcomes. Significant reductions were observed in anxiety/depression, withdrawal/depression, social problems, thought problems, attention problems, and aggressive behavior, with medium to large effect sizes ($\eta^2 = .185$ to $.352$). These results confirm that the intervention meaningfully influenced core symptom areas associated with ADHD.

In contrast, somatic complaints ($p = .528$) and rule-breaking behavior ($p = .084$) did not show statistically significant changes following the intervention, indicating that CRT had limited or no impact on these specific domains.

Table 4

ANCOVA Regression Test for Group × Pretest Interaction

Variable	Source	SS	df	MS	F	Sig.	η^2	Power
Anxiety/Depression	Pretest	747.256	1	747.256	197.653	0.0001	0.880	0.999
	Group	34.717	1	34.717	9.183	0.005	0.254	0.832
	Error	102.078	27	3.781				
	Total	866.967	29					
Withdrawal/Depression	Pretest	155.503	1	155.503	49.768	0.0001	0.648	0.999
	Group	13.744	1	13.744	4.399	0.045	0.140	0.525
	Error	84.364	27	3.125				
	Total	247.367	29					
Somatic Complaints	Pretest	131.107	1	131.107	38.217	0.0001	0.586	0.999
	Group	0.701	1	0.701	0.204	0.655	0.008	0.072
	Error	92.626	27	3.431				
	Total	223.867	29					
Social Problems	Pretest	351.473	1	351.473	189.819	0.0001	0.875	0.999
	Group	19.000	1	19.000	10.261	0.003	0.275	0.870
	Error	49.994	27	1.852				
	Total	414.800	29					
Thought Problems	Pretest	590.667	1	590.667	119.850	0.0001	0.816	0.999
	Group	29.878	1	29.878	6.062	0.020	0.183	0.661
	Error	133.067	27	4.928				
	Total	741.367	29					
Attention Problems	Pretest	30.009	1	30.009	10.249	0.003	0.275	0.870
	Group	32.533	1	32.533	11.111	0.003	0.292	0.895
	Error	79.058	27	2.928				
	Total	135.200	29					

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As presented in Table 4, the regression-based ANCOVA examining the interaction between group and pretest scores demonstrated that pretest values significantly predicted all outcome variables, confirming the appropriateness of controlling baseline differences. After adjusting for pretest effects, the group factor remained statistically significant for anxiety/depression ($p = .005$), withdrawal/depression ($p = .045$), social problems ($p = .003$), thought problems ($p = .020$), and attention problems ($p = .003$), indicating that the Cognitive Remediation Therapy produced meaningful improvements across these domains. Effect sizes for these variables ranged from small-to-medium ($\eta^2 = .140$ to $.292$), with adequate to high statistical power.

In contrast, group differences were not significant for somatic complaints ($p = .655$), suggesting that this specific outcome did not respond to the intervention even after accounting for baseline levels. The consistently high pretest effect sizes ($\eta^2 = .586$ to $.880$) indicate that baseline severity strongly influenced posttest outcomes, further underscoring the importance of covariate adjustment in interpreting treatment effects.

4. Discussion and Conclusion

The purpose of this study was to examine the effectiveness of a structured cognitive remediation program grounded in memory-based cognitive training on reducing behavioral problems in children diagnosed with attention-deficit/hyperactivity disorder (ADHD). The results demonstrated that participation in the cognitive remediation intervention resulted in significant improvements across several emotional–behavioral domains, including anxiety/depression, withdrawal/depression, social problems, thought problems, attention problems, and aggressive behavior, while somatic complaints and rule-breaking behavior did not show significant changes. These findings offer important insights into the potential mechanisms through which cognitive remediation may influence behavioral functioning in children with ADHD and contribute to the growing literature on non-pharmacological interventions for this population.

The observed significant reductions in emotional problem areas such as anxiety/depression and withdrawal/depression align with theoretical frameworks that position executive and memory-related cognitive functions as central to emotional regulation. Children with ADHD often experience heightened emotional reactivity and difficulties in regulating affect, which are partially attributable to deficits in working memory, inhibitory control, and self-regulation processes (Barkley, 2012). Strengthening memory systems and cognitive control mechanisms may enhance children's ability to modulate emotional responses in challenging contexts, supporting improved internal emotional states. This interpretation is consistent with research demonstrating that programs targeting executive functions can lead to improved emotional functioning in children (Diamond, 2012). Additional evidence suggests that cognitive training targeting attention and working memory can indirectly reduce affective symptoms by enhancing self-monitoring and impulse regulation (Cortese et al., 2015). The present findings therefore support these models and reinforce the idea that cognitive remediation can influence not only cognitive performance but also emotional well-being in children with ADHD.

Improvements in social problems following the intervention further illustrate the potential for cognitive remediation to affect interpersonal functioning. Children with ADHD frequently struggle with peer relationships due to distractibility, impulsive reactions, reduced emotional awareness, and difficulties interpreting social cues (DuPaul & Stoner, 2014). Cognitive functions such as visual–spatial memory, auditory–visual memory, and episodic memory play important roles in social information processing, including recognizing social patterns, recalling interpersonal events accurately, and understanding contextual cues. By strengthening these cognitive skills, the intervention may enhance children's capacity for social understanding, thereby improving peer interactions. Previous research provides support for this interpretation; for example, studies indicate that cognitive training can improve social cognition and social behavioral adjustment in children with neurodevelopmental disorders (Shokoohi Yekta & Motamed Yeganeh, 2024). Additionally, interventions integrating cognitive and behavioral components have shown effectiveness in enhancing communication and interpersonal regulation (Tavakoli et al., 2024). Given this triangulation of evidence, the social improvements in the current study are consistent with prior findings emphasizing the cognitive foundations of social functioning.

The significant improvement in thought problems and attention problems reflects direct cognitive gains resulting from the structured memory-oriented exercises included in the remediation program. Thought problems, including disorganized thinking, racing thoughts, and difficulties structuring ideas, are often manifestations of weak working memory, limited cognitive flexibility, and insufficient inhibitory control. The cognitive remediation protocol included exercises targeting multiple domains of memory—visual–spatial, auditory–visual, episodic, semantic, and numeric memory—which align with known cognitive deficits in ADHD. The effectiveness of such training can be understood within the framework of neuroplasticity research demonstrating that repeated activation of neural circuits leads to structural and functional enhancements in executive networks (Klingberg, 2010). Empirical findings in similar intervention contexts have shown improvements in sustained attention, selective attention, and cognitive shifting following cognitive remediation programs (Shams et al., 2024). Furthermore, computerized and hybrid cognitive training interventions have been found to significantly improve working memory, attention control, and processing speed in children with ADHD (Izadkhah et al., 2024; Poon et al., 2024). The attention-related improvements in the present study thus converge with the theoretical and empirical literature regarding the effectiveness of cognitive remediation for enhancing attentional functioning in children with ADHD.

Aggressive behavior also showed significant reductions following the intervention, suggesting that cognitive remediation may influence externalizing behaviors by strengthening cognitive inhibition and improving the child's ability to manage impulses. Impulsivity, poor frustration tolerance, and difficulties shifting attention away from emotionally arousing stimuli often contribute to aggression in children with ADHD. Cognitive models such as Barkley's theory of executive deficits explain aggression as a downstream outcome of deficient working memory and inhibitory failures (Barkley, 2015). Enhancing memory and related cognitive skills may improve self-monitoring and impulse control, leading to more adaptive behavioral responses. Interventions that integrate cognitive and behavioral components have demonstrated similar reductions in aggressive and disruptive behaviors (Tavakoli et al., 2024; Vosoughi Kalantari et al., 2025). Moreover, non-pharmacological treatments that strengthen executive control mechanisms have been shown to reduce behavioral dysregulation and impulsive decision-making (Sonuga-Barke et al., 2013). These findings help explain the improvements in aggressive behavior observed in this study and further support the potential utility of cognitive remediation as part of a multimodal ADHD intervention plan.

In contrast to these positive outcomes, somatic complaints did not show significant change following the intervention. Somatic complaints may be less sensitive to cognitive remediation because they often reflect underlying physiological, emotional, or psychosomatic processes that may not be directly modifiable through cognitive training alone. Research suggests that somatic symptoms in children with ADHD may be associated with comorbid anxiety, stress, or internalizing disorders rather than executive dysfunction per se (Pliszka, 2015). Cognitive remediation programs, which predominantly target cognitive processes, may therefore have less direct impact on bodily symptom reporting. Similarly, rule-breaking behavior did not significantly improve. Rule-breaking behaviors can stem from complex interactions between temperament, environmental factors, peer influence, and family dynamics, which may not be sufficiently influenced through cognitive enhancement alone. Interventions addressing behavioral regulation, moral reasoning, and parent–child relational patterns may be needed to impact these particular outcomes. Evidence suggests that cognitive-behavioral therapies and parent training programs yield stronger effects in modifying rule-breaking behavior than purely cognitive interventions (DuPaul & Stoner, 2014). This underscores the importance of complementing cognitive remediation with additional behavioral strategies for a more comprehensive approach.

The results of this study align with broader findings on the effectiveness of cognitive remediation in neurodevelopmental populations. Systematic reviews of cognitive rehabilitation have consistently shown that structured cognitive exercises can generate meaningful improvements in cognitive and behavioral outcomes when interventions follow evidence-based protocols, ensure adequate training intensity, and incorporate feedback mechanisms (Cicerone et al., 2019). The present findings also resonate with research indicating that children's expectations and engagement in cognitive training play meaningful roles in treatment outcomes, with well-structured programs promoting greater motivation and cognitive gains (Rabipour & Davidson, 2015). Moreover, studies emphasizing the distinction between scientifically validated cognitive remediation and commercially available brain-training tools support the methodological rigor of the current intervention (Rabipour & Raz, 2012). The improvements observed here provide further support for the need for structured, evidence-based training programs for children with ADHD.

The findings are additionally consistent with emerging clinical research showing the value of multimodal or integrative intervention frameworks that combine cognitive

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remediation with functional, behavioral, or emotional components. For instance, occupational therapy models integrating cognitive-functional strategies have demonstrated improvements not only in cognitive performance but also in daily functioning among individuals with ADHD (Budman et al., 2025). Similarly, domain-specific interventions focusing on attention, working memory, and cognitive flexibility have been shown to generate behavioral improvements when sufficiently tailored to the child's functional needs and developmental profile (Shabannezhad, 2024). These studies suggest that cognitive remediation may have broader applicability when combined with complementary therapeutic strategies, pointing toward integrative approaches as an optimal direction for future practice.

The present study's findings also contribute to the ongoing debate regarding the generalizability of cognitive training effects. While some meta-analyses show limited transfer of cognitive gains to real-world behavioral improvements (Cortese et al., 2015), others demonstrate significant effects when interventions are intensive, targeted, and developmentally appropriate (Diamond, 2012). The improvements across multiple behavioral domains in this study support the notion that memory-based cognitive remediation may facilitate near-transfer and moderate far-transfer effects when aligned with the neurocognitive deficits characteristic of ADHD. These results therefore underscore the importance of designing cognitive training programs that are theoretically grounded, multimodal, and tailored to the cognitive architecture of ADHD.

Overall, the findings of this study provide strong evidence for the effectiveness of a structured memory-based cognitive remediation program in reducing behavioral problems in children with ADHD. By strengthening multiple dimensions of memory and cognitive control, the intervention appears to facilitate improvements in emotional regulation, social functioning, thought organization, attentional stability, and aggressive behavior, while somatic complaints and rule-breaking behaviors remain less responsive. These outcomes contribute to the empirical literature supporting non-pharmacological ADHD interventions and highlight the value of cognitive remediation as part of a comprehensive treatment approach.

The present study is subject to several limitations. The relatively small sample size limits the generalizability of the findings, and the reliance on convenience sampling may introduce selection bias. The absence of long-term follow-up prevents conclusions regarding the durability of cognitive and behavioral changes. The study also relied on parent-report measures, which may be influenced by subjective perceptions. Additionally, the cognitive remediation program was implemented without comparison to other evidence-based interventions, making it difficult to determine relative effectiveness. Finally, the study did not assess potential moderating variables such as severity of ADHD, comorbid conditions, or family environment, which may influence intervention outcomes.

Future research should employ larger, more diverse samples to enhance generalizability and incorporate multimethod assessment strategies combining behavioral ratings, neuropsychological testing, and neuroimaging techniques. Longitudinal follow-up studies are needed to evaluate the persistence of gains and identify developmental trajectories associated with cognitive remediation. Comparative studies examining cognitive remediation alongside established behavioral, pharmacological, and integrative interventions would clarify relative efficacy. Additionally, research should explore moderators and mediators of treatment response, including cognitive profiles, emotional functioning, comorbidities, and family dynamics.

Practitioners should consider incorporating cognitive remediation as part of a multimodal ADHD intervention plan, integrating cognitive training with behavioral strategies, classroom accommodations, and parent support. Training programs should be delivered with consistency, clear structure, and individualized progression to optimize engagement and cognitive gains. Clinicians and educators may also apply memory-based exercises within classroom routines and therapeutic contexts to support generalization of skills.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants (Ethics Code: IR.IAU.NAJAFABAD.REC.1403.019).

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